Business, Training and Education: Sheffield circa 1880-1940

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Abstract

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by

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This thesis contributes to two important debates: the historical debate on the role of education and training in Britain's relative economic decline; and the debate on the relationship between education, training and business performance. Much of the research on education, training and economic growth has focused at the macro-level and been heavily informed by neo-classical assumptions which fail to take account of the dynamism and uncertainty inherent in the business environment. The relationship between education, training and business performance is therefore explored by developing a historical case-study approach based upon the Sheffield metal and engineering trades, c1880-1940. These were industries that were of strategic importance to the British economy and such a study allows for an exploration at the micro-level of the firm. The historical analysis is informed by the theory of business strategy. Unlike the neo-classical synthesis, this theory locates the firm in a specific historical context, defining it as a collection of related productive resources: physical and human. Thus the theory may be used as an analytical tool to examine the impact of product, process and organisational innovations upon human resource requirements. The thesis is founded on a strong empirical base and a major empirical building block is formed by developing a database which charts the career profiles of applied science graduates from the Sheffield University and its antecedent, the Sheffield Technical School. A key finding is that the relationship between education, training and business performance is a highly complex and contingent one and that simply more education and training is not the necessary medication for the nation's economic ills. Indeed, the education and training system must be carefully monitored in order to ensure that it provides the skills and knowledge that are appropriate to changing business needs. Another significant discovery is that education and training provision, prior to World War One, was generally adequate to Sheffield's business requirements; technical education became crucial to the manufacture of specialist steels, and in this key industry of the 'second industrial revolution', Sheffield firms recruited metallurgy and engineering graduates and acquired a commanding technological lead over their German and American competitors. This sectoral analysis stands in stark contrast with the received wisdom which claims that Britain's relative economic decline was causally related to an under-investment in technical education and a failure to recruit scientific personnel. However, economic depression in the 1920s and consequent spending cuts led to a general weakening of the education and training system, not only in Sheffield but throughout the nation. Business demands for graduate metallurgists began to exceed the supply and, as the economy recovered in the 1930s, Sheffield firms experienced acute shortages of skilled labour. Shortages of technologists, technicians and craftsmen persisted into the 1950s and it appears that Sheffield entered the second half of the twentieth century with insufficient skilled human resources and without the necessary educational infrastructure to rapidly remedy this problem. In consequence, firms were unable to meet orders and product quality began to fail, creating a window of opportunity for foreign competitors to exploit. Two points follow from this finding: firstly, too much emphasis has been placed upon alleged educational inadequacies prior to World War One, whilst insufficient attention has been paid to the inter-war years and, secondly, the relationship between education, training and business performance appears to have a high degree of reciprocity, at least over the long-run.

Contents

Preface

There now appears to be a general consensus that investment in human resources, through programmes of education and training, will make a significant contribution to macro-economic growth, and that Britain has been characterised by a long-term under-investment in human capital which has underpinned her deteriorating performance in world markets. Indeed, such arguments have become something of an orthodoxy. However, the links between education, training and economic growth are far from conclusive. The aim of this thesis therefore is to contribute to this debate by focusing upon a case-study of education and training in a key industrial sector, namely the Sheffield metal and engineering trades during the period 1880 to 1940. This thesis has been a long time in the making and would not have been possible without the financial support provided by the Economic and Social Research Council, and the Paul Nunn memorial fund, to both of which I am deeply grateful. Similarly the advice of my supervisors, Roger Lloyd-Jones & Myrrdin Lewis, who first stimulated my interest in the British economic decline, should be commended here, as should the diligence of my proof-reader Mark Harrison, the technical support of Paul and the assistance of numerous archivists. I also wish to acknowledge the love and encouragement of my fiancée Nicola and of my family who have supported me throughout the trials and tribulations of the research process. A final mention should be made of the studies that were undertaken in connection with the programme of research. I followed several units on Sheffield Hallam University's MA in Twentieth Century British History: Research Methods (1994), The Political Economy of Decline (1994), and Theoretical Issues for Historians (1995). In addition I took a BSc Computer Studies unit on Databases, which enabled me to design and interrogate my database which charts the career profiles of applied science graduates from the Sheffield University.

Chapter 1: Education, Training and Economic Growth.

Education and training reform have acquired a central role in the debate over Britain's long-run economic growth. It has been argued that inadequacies in the education and training (ET) system are causally related to Britain's poor performance, vis-à-vis, her major competitors. In particular, it is alleged that economic change has been constrained by a lack of skilled personnel. Nevertheless, as Ewart Keep and Ken Mayhew point out, despite the growing conviction that inadequacies in education and training have hampered the U.K.'s long-run economic performance, there is scant evidence of any precise linkage between education, training and economic growth.[1] This thesis contributes to this debate and critically examines the role of education and training in Britain's alleged economic decline, c1880 to 1940. It adopts an industrial case-study approach which focuses at the micro-level of the firm, and which is based upon the Sheffield metal and engineering trades. This chapter consists of a critical review of the literature on education and economic growth, together with an evaluation of the case-study approach and of the theories of business strategy and organisational culture - all of which have a direct bearing on this thesis.

Human Capital

The concept of 'human capital', with its assumption that education contributes to economic growth, has a long history; indeed, its origins may be located during the age of classical political economy, in the writings of Adam Smith and John Stuart Mill - the former having equated the value of an educated man to an expensive machine. Nevertheless, the classical economists did not specify how education and training contributed to economic growth, and empirical research into human capital formation is a much more recent phenomenon.[2] Since the late 1950s, a number of economists have

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[1] E. Keep & K. Mayhew, "The Assessment: Education, Training and Economic Performance", *Oxford Review of Economic Policy*, vol.4, no.3, (Autumn 1988), p.IV. (Special edition on education, training and business performance.) For a general review of the role of education in Britain's alleged economic decline, see other contributions in this volume and number. See also, D. Ashton & F. Green, *Education, Training and the Global Economy* (Cheltenham, 1996), p.2; A. Daly, "The Contribution of Education to Economic Growth in Britain: A Note on the Evidence", *National Institute Economic Review*, vol.101, (1982); A. Daly et al, "Productivity, Machinery and Skills in a Sample of British and German Manufacturing Plants", *National Institute Economic Review*, vol.111, (1985); D. H. Aldcroft, "Investment in and Utilisation of Manpower: Britain and Her Rivals, 1870-1914", in B. M. Ratcliffe (eds.), *Britain and Her World, 1750-1914* (Manchester, 1975); D. H. Aldcroft, *Education, Training and Economic Performance* (Manchester, 1992).

[2] A. Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations* (London, 1776), book 1, ch.10, pt.1; S. Pollard, *Britain's Prime & Britain's Decline: The British Economy 1870-1914* (London, 1989), p.136; see also G. Tortella & L. Sandberg, "Education and Economic Development since the Industrial Revolution: A Summary Report", in G. Tortella (eds.), *Education and Economic Development since the Industrial Revolution* (Valencia, 1990), p.3; M. Blaug, *The Economics of Education: A Selected Annotated Bibliography* (Oxford, 1978), p.18; Ashton & Green, *Education and the Global Economy*, p.14, Ashton and Green focused upon the South East Asian 'Tiger' economies, some of which followed a high-skills route and others which grew on the basis of cheap labour.

used computer technology and statistical techniques to examine the relationships between education and the economy, and there has developed a distinct discipline known as the 'economics of education.'[3] These economists have deployed variants of 3 techniques in their research and these techniques, together with some of their findings are examined below.

A. Statistical Correlation

Bowman and Anderson used statistical correlation techniques to compare the literacy rates and per capita national incomes of 83 very different countries. They made two important discoveries: first, the 32 poorest countries, whose G.N.P. per capita never exceeded $300, all had literacy rates below 40 per cent. Second, in the 24 wealthiest countries, which had per capita incomes in excess of $500, more than 90% of the population were classed as literate. Their research, and similar research carried out by Harbison and Myers, clearly demonstrated a positive correlation between literacy and national wealth, and suggested a relationship between education and economic growth.[4]

B. Cost-Benefit Analysis (The Returns to Education)

Numerous economists have subjected education to cost-benefit analysis, or, in other words, have measured the returns on educational investment. It is argued that this return operates at two levels: there is a private return to the individual, and a social return to the economy as a whole. In relation to the private rate of return, it is a relatively simple task to examine the earnings an individual foregoes by remaining in education, and to balance this with rewards which could be reaped by obtaining higher wages at a later date, and many studies have revealed that graduates tend to receive higher wages. But what of social returns? In their calculations, economists assume that product and factor markets operate in equilibrium and that a worker's wage rate is therefore commensurable with his or her marginal product. In this scenario the higher

[3]According to Tortella and Sandberg, research into human capital can be dated from 1957, Tortella & Sandberg, "Education and Economic Development", p.3; Sheehan claims that, "the development of the 'economics of education' as a separate subject has been quite recent, many would date it from the publication of John Vaizey's, *The Economics of Education* in 1962", J. Sheehan, *The Economics of Education* (London, 1973), intro.; M. Blaug, *An Introduction to the Economics of Education* (London, 1970); T. G. Geske, *The Economics of Education* (Oxford, 3rd Edition 1990); J. Vaizey, *The Economics of Education* (London, 1962); According to Ashton & Green, "econometric theory has developed an impressive and sophisticated battery of statistical techniques", Ashton & Green, *Education and the Global Economy*, p.33.

[4] M. J. Bowman & C. A. Anderson, "Concerning the Role of Education in Development", in B. F. Kiker (eds.), *Investment in Human Capital* (Columbia, 1971), pp.111-113; Blaug, *Intro. Economics of Education*, pp. 62-64; F. Harbison & C. A. Myers, *Education, Manpower & Economic Growth* (New York, 1964); a discussion of Harbison and Myer's work can be found in Sheehan, *Economics of Education*, p.61.

wages paid to graduates simply become an index of their greater efficiency, which is attributed to their superior education, and which provides a fillip to economic growth.[5]

C. Total Factor Productivity (The Residual)

By using a Cobb-Douglas production function, and its neo-classical assumptions of market equilibrium, payment to factors in accordance with marginal productivity and disembodied technical change, economists have consistently demonstrated that increases in the traditional factors of production (land, labour and capital), as conventionally measured, account for no more than 60 per cent of the observed economic growth in the advanced capitalist nations. Or, in other words, they have identified a considerable residual of unexplained growth. Many researchers have linked at least part of this residual with qualitative improvements in the labour input; that is, to the effects of education and training. E. F. Denison, for example, who integrated cost-benefit analysis with his T. F. P. calculations concluded that in America, during the period 1930 to 1960, educational improvements accounted for 23 per cent of the total economic growth, a larger figure than any other source except for the increase in size of the labour force in whom the education was embodied.[6]

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[5] J. R. Hough, *Education & the National Economy* (Kent, 1987), p.72; see the *Journal of Political Economy*, Vol. 70, 1962, whole volume on human capital; Sheehan, *Economics of Education*, pp.59-68; Geske, *Economics of Education*, p.157; Blaug, *Intro. Economics of Education*, pp.61-62; Arrow considers an alternative perspective: one could argue that education has no tangible effects whatever, rather it is simply functions as a sieve ordering 'natural' talent, K. J. Arrow, "Higher Education as a Filter", *Journal of Public Economics*, vol.2, (1973).

[6] E. F. Denison, "Education, Economic Growth and Gaps in Information", *Journal of Political Economy*, vol.70, no.5, Part 2, (1962), pp. 124-128; Denison achieves precision in measuring the sources of economic growth by equating the elasticity of labour with its relative share in national income. Thus, although Denison never states it explicitly, his calculations are based upon the use of a Cobb-Douglas production function, which in its simplest form can be expressed as follows:

Q = AL@K1-@

Where:

Q = Physical output

L = Inputs of Labour measured in man hours

@ and 1-@ are constants to be estimated representing the elasticites of L and K

A = Shift parameter representing technical progress - the part of the total output that cannot be explained by the growth of K and L

Detailed discussions of Denison's work can be found in Blaug, *Intro. Economics Education*, pp.92-100; Hough, *Education & National Economy*, pp.52-72; Sheehan *Economics of Education*, pp.62-63; J. Vaizey, K. Norris & J. Sheehan, *The political Economy of Education* (London, 1972), pp.32-45; for a discussion of similar work carried out by Solow, who noted that "...by far the largest share of economic growth in the recent history of the United States" could not be "attributed to physical inputs (land, labour and capital), as conventionally measured", see Tortella & Sandberg, "Education and Economic Development", p.3. For those interested in the econometric approach to the relationship between education, training and economic growth, the following texts are also worth consulting: M. Blaug, *Where are we now in the Economics of Education?*, a special professional lecture delivered at the University of London Institute of Education (16th June 1983), pp.17-28; F. Harbison & C. A. Myers, *Education, Manpower and Economic Growth* (New York, 1964); T. W. Schultz, *Investment in Human Capital: The Role of Education and Research* (New York, 1971); T. W. Schultz, *Investing in People: The Economics of Population Quality* (Chicago, 1981); G. Becker, *Human Capital* (New York, 1964); E. Cohn, *The Economics of Education* (New York, 1972); H. M. Groves, *Education and Economic Growth* (Washington, 1961); B. F. Kiker, *Human Capital in Retrospect* (Columbia, 1968); M. Blaug, "The

The work of these economists has been impressive, but what has been the cumulative effect of their research? A major international conference held in Valencia in 1990 concluded that the weight of the evidence was overwhelmingly in support of the hypothesis that a relationship between education and economic growth does exist.[7] Thus, statistical correlation, cost-benefit analysis and total factor productivity calculations have made a significant contribution to our knowledge, and there now appears to be a general consensus that investment in human resources through education and training programmes will deliver long-run benefits to the economy.[8] Nevertheless, I will argue that there are problems with these techniques, in particular they are limited in what they can tell us about the nature of the relationship that we seek to understand.

International comparisons of the correlation between literacy and per capita national incomes are problematic. To begin with, concepts such as literacy are ambiguous and definitions may vary from country to country, it is therefore unlikely that Bowman and Anderson were comparing like with like. Moreover, correlation should not be conflated with causation: one could argue that increased national wealth led to enhanced education and greater levels of literacy, rather than vice-versa. Of course, it is probable that causation is reciprocal, but statistical correlation techniques are essentially a tool of analysis rather than an explanatory mechanism, and while they may help to pose new questions about education and economic growth they will not provide the answers.[9]

Similarly, T. F. P. and cost-benefit analysis are geared towards measuring the contribution of education to economic growth, rather than towards an analysis of the form and content of the relationship. Measurement has proved extremely difficult because education is both consumption and investment, and is ultimately intangible apart from the people in whom it is invested. Moreover, the econometric focus of these studies has led to a disproportionate emphasis on quantitative indicators, such as student numbers and years spent at school. The quality of the educational provision,

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Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey", *Journal of Economic Literature*, vol. XIV, (Sept. 1976), pp.827-855.

[7]Tortella & Sandberg, "Education and Economic Development", p.12.

[8]"Now as twentieth century capitalism draws to a close, a new consensus is emerging among politicians of many different persuasions, among scholarly writers and among popular feeling, a consensus that the salience of a nation's education and training system is...the key item in the struggle for competitive superiority", Ashton & Green, *Education and the Global Economy*, p.1.

[9]*Ibid.*, p.12; M. J. Bowman and C. A. Anderson, "Concerning the Role of Education in Economic Development", in B. F. Kiker (eds.), *Investment in Human Capital* (Columbia, 1971), p.113; Sheehan, *Economics of Education*, p.61; Hough, *Education & the National Economy*, p.51; Tortella & Sandberg, "Education and Economic Development", p.10.

the subjects studied, and the training provided in the workplace has received much less attention.[10]

In addition, in order to generate their T.F.P. and cost-benefit calculations, economists have relied upon neo-classical assumptions that all firms are profit-maximisers; that there is perfect knowledge; that factors are paid according to their marginal productivity; that the external environment is given and that there is no past or future, just a timeless present. These assumptions produce a static world which requires the system to be in the process of being in, or moving towards equilibrium, and reduces the business firm to the level of a passive calculator, which simply processes inputs into outputs within given cost and revenue parameters. Real economic systems are more dynamic, and the long-run performance of an organisation is linked to its capacity to respond to uncertainty and change in its environment. Neo-classical theory thus assumes away the very conditions which create a need for entrepreneurship, manpower planning and education and training for change.[11] Furthermore, as H. M. Boot points out, in Britain (and one presumes elsewhere) almost all pay structures have contained elements of artificiality, which have hindered the freedom of earnings to reflect levels of skill and productivity.[12] This raises serious questions about cost-benefit and T. F. P. calculations, for, as Blaug argues, "it is one thing to make certain strong assumptions in order to display the logic of the growth process and quite another to use assumptions to estimate the contribution of the various components to growth in the real world."[13] In

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[10]Ashton & Green, *Education and the Global Economy*, p.66; Pollard, *Prime & Decline*, p.136-137; Vaizey, *Economics of Education*, p.26; Blaug, *Intro. Economics Education*, pp.17-19, 61, 100; Sheehan, *Economics of Education*, p.59; K. Burgess, "British Employers and Education Policy, 1935-45: A Decade of Missed Opportunities?", *Business History*, vol.36, no.3, (July 1994), p.31; It should be noted that more recent research has begun to consider the importance of on-the-job-learning, for example, see J. Bradford De Long, "Productivity Growth and Machinery Investment: A Long-Run Look", 1870-1980, *Journal of Economic History*, vol.52, (1992), pp.314-315.

[11] Fonda & Hayes have stressed the importance of education and training in enabling the firm to develop the capability to respond to uncertainty and change in its environment, N. Fonda & C. Hayes, "Education, Training and Business Performance", *Oxford Review of Economic Policy*, vol.4, no.3, (Autumn 1988), p.108; for a discussion of the problems with neo-classical theory see: D. Hutchinson & S. Nicholas, "Modelling the Growth Strategies of British Firms", *Business History*, vol.29, no.4, (1987), p.48; R. Lloyd-Jones & M. J. Lewis, *Manchester and The Age of the Factory* (London, 1988), esp. pp.194-196; M. J. Lewis, "The Growth and Development of Sheffield's Industrial Structure, 1880-1930" (Unpublished PhD, Sheffield City Polytechnic, 1989), p.14; M. Casson, *The Entrepreneur: An Economic Theory* (Oxford, 1982), pp.9-12, 158; S. Moss, *An Economic Theory of Business Strategy* (Oxford, 1981), pp.8-12.

[12]According to Boot, "deliberate restrictions on entry, prejudice, custom, a sense of fair play or a just wage, and ideas that certain classes of work should be restricted to persons from particular social classes, and be accorded an income appropriate to the class, were all forces which affected wages but have little to do with the skill or productivity of a worker", H. M. Boot, "How Skilled were Lancashire Cotton Factory Workers in 1833?", *Economic History Review*, vol. XLVIII, no.2, (May 1995), p.287; "...it is clear that not all forms of training lead to higher wages or productivity, and the links with profitability or with economic growth are still largely in the realm of theoretical belief or just plain hope", Ashton & Green, *Education and the Global Economy*, p.5.

[13]Blaug, *Intro. Economics Education*, p.97; According to Hough, "Various scholars have attempted to identify and even to quantify the precise contribution that education can make to economic growth but the

any case, answers to the key question of how education and training may interact with other factors to promote economic growth remain unclear. Therefore, as the conference in Valencia acknowledged, "The challenge now is to pinpoint with more precision the nature of this connection."[14]

A useful starting point is to ask the fundamental question: to what extent does an education and training system satisfy business needs in both a quantitative and qualitative sense? These needs will vary enormously from country to country, as each nation will have a distinctive institutional context; for example, its own specific resource endowments, industrial structure, political system and legal arrangements. This makes international comparisons of education systems highly problematic. Indeed, within a nation, different industries and even different branches of the same industry, will have different educational needs. This thesis therefore suggests an alternative approach to analysis at the macro-level of the national economy, which shifts the focus to the micro-level of the firm and the industry, and allows us to examine how grass-roots business needs are served by education and training provisions. Owing to the intense regional concentration of industries in the period 1880-1940, one can effectively explore this issue through the aegis of a local business community; indeed a local approach appears to be particularly appropriate since "the development of technical education was mainly left to local initiative."[15] This thesis therefore tests the relationship between education, training and business performance by adopting an historical case-study approach, which, unlike neo-classical theory, clearly takes institutional factors into account.[16] The case-study is based upon the industrial city of Sheffield. One reason for choosing Sheffield as a focus for this study is that it was a key industrial centre of international importance. In 1870, for example, the city accounted for 70 per cent of all U.K. steel production.[17] Secondly, Sheffield's industrial

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results must be described as rather mixed and uncertain", Hough, *Education and Economy*, p.5; Pollard considers that, "there is at best a measurable correlation", Pollard, *Prime and Decline*, p.138.

[14]Tortella & Sandberg, "Education and Economic Development", p.12.

[15]Fox and Guagnini argue that, "for well over a century the comparative method has been used predominantly to bring out the distinctiveness of the different national patterns in education, often for the purposes of identifying the causes of economic success or failure. We believe that there is a dangerous one-sidedness in this way of handling the evidence....Superimposed on general national characteristics in the development of technical education there were also recognisable regional patterns", R. Fox & A. Guagnini, "An Introduction", in R. Fox and A. Guagnini (eds.), *Education, Technology and Industrial Performance in Europe* (Cambridge, 1993), pp.1-2, 7; as Gospel and Okayama point out, "technical education was mainly left to local initiative", H. F. Gospel & R. Okayama, "Industrial Training in Britain and Japan, An Overview", in H, F. Gospel (eds.), *Industrial Training and Technological Innovation: A Comparative and Historical Study* (London, 1991), p.13.

[16]It is clear that human capital theory, informed by neo-classical economics, "...treats the education and training process as a 'black box' in which skills are produced", Ashton & Green, *Education and the Global Economy*, pp.18-21.

[17]As Lloyd-Jones and Lewis point out, in 1870 Sheffield accounted for 70% of U. K. steel production. Since iron and steel has always occupied a central place in the literature on Britain's relative economic decline, it would appear to be a key city to study, R. Lloyd-Jones & M. J. Lewis, "Personal Capitalism &

base was variegated and its industries possessed very different human resource requirements. There were the basic producers of steel, but also engineering and armaments firms, cutlery and small tool producers and, by the turn of the twentieth century, numerous manufacturers of high-speed and specialist steels.[18] Finally, Sheffield was locked into world trade and the city's businessmen experienced an acute need to devise effective responses to increasing foreign competition, particularly from large and technically efficient U.S. and German producers.[19]

The thesis tests the level and appropriateness of Sheffield's educational (technical and commercial) provision in the context of changing business needs. It is divided chronologically into 2 parts, viz. c1880-c1918 (chapters 2 to 4) and c1918-1940 (chapters 5 to 8). In each part, I explore whether business needs for technical and commercial education were clearly articulated, and how and why they changed, before examining the extent to which local education institutions were able to satisfy perceived business needs, both quantitatively and qualitatively. (see chapters 2, 3, 5 & 6) In particular, chapter 2 explores how technical education came to be defined prior to World War One and challenges the received wisdom that British business adopted a dismissive attitude towards it. Indeed, it is argued that although cutlery manufacturers were largely unimpressed by the technical education movement, many steel and engineering manufacturers came to regard technical and commercial education as strategic weapons in the fight for competitive superiority. In particular, they demanded metallurgy and engineering graduates to support the development of high-speed and specialist steels. However, chapter 3 emphasises that although Sheffield University provided high-quality technical education it was undermined by quantitative and qualitative deficiencies in the secondary education system, which placed severe constraints on the number of students capable of studying for degrees and therefore on the output of graduates. Nevertheless, until World War One, the supply was able to keep pace with industrial demand, as Sheffield firms were able to procure the majority of the university's graduates. However, as chapter 5 will argue, because of the development of stainless-steel and increased mechanisation during the inter-war years, more cutlery manufacturers became committed to technical education and the development of acid- and heat-resistant alloys in local steel firms led to a burgeoning demand for graduate scientists. In fact, as chapter 6 demonstrates, the industrial demand began to outstrip the supply, particularly as more and more metallurgy and engineering graduates turned to careers outside of Sheffield firms and outside of

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British Industrial Decline: The Personally Managed Firm and Business Strategy in Sheffield, 1880-1920", *Business History Review*, vol.68, no.3, (Autumn 1994), p.367.

[18]For a more detailed discussion of Sheffield's variegated industrial base, see S. Pollard, *A History of Labour in Sheffield* (Liverpool, 1959)

[19]Lloyd-Jones & Lewis, "Personal Capitalism", esp. p.358-367.

manufacturing in general. Moreover, economy drives, arising from the depression in the inter-war years, compounded pre-war weaknesses in the secondary education system and resulted in the university's curriculum and equipment, becoming antiquated, thereby undermining the quality of the students' learning experience. [20]

However, how did all this impact upon business performance? The thesis explores this issue through the analysis of a cluster of case-studies: chapters 4 and 7 explore the role of education and training in the growth and development of a number of Sheffield firms that were engaged in the engineering, armaments, and specialist steel trades. These firms varied considerably in size, from small- to very large-scale organisations; some were managed personally by their owners and remained tied to the local economy, whilst others developed extensive managerial hierarchies, and built branch-plants overseas.[21] In these case-studies I attempt to explore how the types and levels of training received by the different sectors of the workforce changed, and how these changes related to changes in the firms' size-structure, plant, equipment, processes, products, research methods, and overall business environment. In other words, I examine how policies of training and education were integrated into the evolving business strategies of these very different firms, and explore whether these policies were a key factor in determining organisational effectiveness.

Analysis at the level of the firm would appear to be particularly appropriate, for as Coleman has pointed out, "the business company is now and has been over the past one

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[20]The thrust of the evidence accumulated in chapters 2, 3, 7 & 8 will suggest that the current orthodoxy in British economic history, which portrays businessmen as largely indifferent to technical and commercial education and which claims that the British education system consistently failed to provide for business needs, requires some systematic revision. According to Kirby, British businessmen "adopted a dismissive, almost cavalier attitude towards technical education....Practical experience in the workshop was raised to the level of a mystique and 'college-trained' men were treated with disdain", M. Kirby, *The Decline of British Economic Power since 1870* (London, 1981), p.7; Allen claims that , "It was not only in the application of scientific knowledge to industry that Britain fell behind in the decades before 1914. The same was true of business education...even by...1926...this education was 'second-rate'.", G. C. Allen, *The British disease* (Hertfordshire, 1976), p.45; Cotgove comments on "The apathy of industry towards technical education in the inter-war years", S. Cotgrove, *Technical education & Social change* (London, 1958), p.99; Crouzet considers that, "it does seem that Britain failed to achieve the marriage of science and industry....Much of the responsibility lies at the door of the education system which could not give to entrepreneurs, managers, executives, foremen and operatives the scientific and technical training which they needed", F. Crouzet, *The Victorian Economy* (Translated by A. S. Forster, London, 1982), p.414; Aldcroft claims that, "...educational provision in Britain has never been, by any stretch of the imagination, geared to the world of work and industry", D. H. Aldcroft, "Education and Britain's Growth failure, 1950-1980", in Tortella (eds.), *Education & Economic Development*, p.226.

[21]Personally-managed firms include, "those administered without the benefit of an extensive administrative hierarchy" and those in which "founding entrepreneurs or families assembled smaller managerial teams but retained a personal style." It should be noted that, "though the majority of personally-managed firms were small, there were also large personally-managed firms." A. D. Chandler Jr., has argued that, "the persistence of the personally-managed firm, what he calls 'personal capitalism', may be causally related to Britain's long-term industrial decline", See A. D. Chandler Jr., *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass. 1990);Lloyd-Jones & Lewis, "Personal Capitalism", esp. pp.364-371.

hundred years, the single most important organisational unit in the British economy."[22] It is here that the individual's skills and knowledge are put to work, and perhaps enhanced by in-house training programmes. Nevertheless, as the *Oxford Policy Review* pointed out in 1988, detailed empirical studies of the micro variety are rare.[23] Indeed, as Gospel has argued, "economic historians have long pointed to weaknesses in education and training in Britain and how they may have retarded economic growth, but at a more disaggregated level where one would expect these relationships to be investigated in detail, very little work has been done."[24] The thesis therefore seeks to exploit this niche in the literature; it does not merely provide a narrative account of firms' histories, but analyses and compares the records of different companies, in order to address the vexed question of the relationship between education, training and business performance[25]

Nevertheless, the thesis does not simply focus on the level of the firm, but on the industry more generally. Chapter 8, for example, provides a sectoral analysis of education and training in the inter-war cutlery trades. This is achieved by two main methods. First, the analysis of business records, firm monographs, newspapers, technical journals and the minute books of organisations, such as the Sheffield Chamber of Commerce, and the Sheffield Trades Technical Societies. And, second, the interrogation of a database constructed from Sheffield University alumni lists, and its precursor the Sheffield Technical School. These lists, usually published annually from 1900 until 1929, name the firms that metallurgy and engineering graduates entered and, on occasion, the positions they assumed. By cross-referencing my database with Myrrdin Lewis' database on Sheffield's industrial structure, this thesis is able to explore recruitment patterns in the steel, engineering and cutlery trades, and the inter and intra-firm movement of graduates.[26] One important discovery made in this thesis is that,

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[22]D. C. Coleman, "The Uses and Abuses of Business History", *Business History*, vol.24, no.2, (1987) p.147.

[23]Keep and Mayhew, "Education, Training and Economic Performance", p.IV.

[24]"...business historians have usually only touched on training in their chapters on management and technical staff, and have devoted only a few words to training in chapters on blue-collar workers. For their part, labour historians have usually only dealt with apprenticeship systems and how they have underpinned the activities of craft unions. The study of training has often been left to historians of education who have been particularly interested in schooling and formal education rather than industrial training and its effects on firms and the economy." H. F. Gospel, "Industrial Training and Technological Innovation: An Introduction", in Gospel (eds.), *Training and Innovation*, pp.3-4.

[25]The thesis follows Coleman's advice for the writing of a better type of business history. Coleman claims that one road of advance in business history is the gaining of access to the records of companies for the purpose of "tackling specific questions, analysing the results and making comparisons." He considers that, "research of this nature is likely to yield much more valuable results for our historical understanding of how British business has functioned both successfully and unsuccessfully than will the mere compilation of narrative company history." Another key road of advance he has identified is "...historical research into issues seen as relevant to current problems", Coleman "Uses and Abuses", pp.149-150.

[26]See Lewis, "Industrial Structure", esp. Appendix A.

whilst cutlery firms fit the received wisdom of limited graduate recruitment, Sheffield's specialist steel and armaments firms were major recipients of graduates, who acquired important positions as researchers, works managers and even directors. The approach to the construction of the database was model, rather than source, driven and the conceptual design, or, in other words, the blue-print of the database, was developed by a process known as 'entity relationship modelling'. Details of the design process, methodological issues, and a glossary of technical terms can be found in Appendix A. However, I now consider the question of what theory informs this thesis?

The inappropriateness of orthodox neo-classical theory for an analysis of the growth and development of the firm as an historical process has already been emphasised.[27] Thus, if we are to examine the role of education and training in the evolution of the firm's business strategy, we require an economic theory which clearly links the human and physical resources of business activity, and which relates the firm's decision-making process over time, to the framework of markets and institutions in which it actually takes place; that is, a theory which locates the firm in its historical context. The theory of business strategy, as developed by Scott Moss, appears to meet both these criteria and will therefore be explored and utilised here.[28]

The Theory of Business Strategy

Moss defines the firm as a collection of productive resources. Two classes of productive resources are identified: physical resources, tangible things, such as plant and equipment; and human resources, the firms skilled and unskilled labour, technical, clerical and administrative staff.[29] Moss emphasises that "these productive resources cannot be co-ordinated without an organisational structure."[30] But what is organisational structure? According to Moss, it is "not itself a resource rather it is a central unifying principle derived from the services rendered by the human and physical resources of the firm."[31] Chandler defines it as "the design of the organisation through which the enterprise is administered." He claims that there are 2 key facets of this design: first, the lines of authority and communication between the different administrative offices and officers, and, second, the information and data that flow

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27"...even when modified to take account of varying sorts of market imperfection, neo-classical theory is not about firms as entities, rather it is about price-adjustment for products and factors in varying assumed conditions of competition", Coleman, "Uses and Abuses", p.151.

28Coleman has called for a greater symbiosis of economic theory with historical context, and has pointed to the work of Chandler, Penrose, Andrews and Moss has been especially suited to the needs of the business historian, *Ibid.*, p.151; as Lipartito points out, evolutionary models, such as the one developed by Moss, "unlike neo-classical ones, allow economic activity to unfold through time and be constrained by history", K. Lipartito, "Culture and the Practice of Business History", *Business and Economic History*, vol.24, no.2, (Winter 1995), p.7.

29S. Moss, *Business Strategy*, p.16.

30*Ibid.*, p.18.

31*Ibid.*, p.18.

through these lines of command and authority.[32] At the heart of this structure, however, lies the management team. This team comprises the individuals who hold collective responsibility for co-ordinating the activities of the firm, and for taking decisions with regard to business strategy; which is defined as the firm's overall expression of its main objectives and its key means to accomplish them.[33] In other words, the management team are the entrepreneurs: the people who "specialise in taking judgmental decisions about the co-ordination of scarce resources."[34] Moss argues that this management team must recruit and train workers who possess the skills, knowledge attitudes, behaviours and even temperaments which are appropriate to the utilisation of the firm's plant and equipment, and that the firm must develop and maintain a resource-mix, or capital-labour ratio, in line with the needs of its business strategy. A key proposition of the theory of business strategy, therefore, is that those recruitment, education and training practices which provide the appropriate skills, knowledge and behaviour, will enable the organisation to achieve its goals and enhance its business performance. It follows, therefore, that one of the key functions of the management team is to co-ordinate the firm's human resources in relation to the changing demands of the work environment, and the changing needs of the firm in a competitive world.[35]

The underlying rationale for establishing a match between human resources and business strategy is that different business strategies will have different job specifications, and, in turn, different skill, knowledge and behavioural requirements.[36] Sumita Raghuram has developed a conceptual model, derived from the theory of business strategy, which links certain staffing and training practices with specific business strategies. In particular, she has identified 2 strategic types, and the recruitment and training practices which she considers necessary for their efficient functioning and the optimisation of business performance. The 2 strategic types are 'prospectors', or paradigm shifters, and 'defenders', or paradigm settlers. Raghuram claims that, firms which pursue a defender type strategy will possess a relatively stable and narrow product line, and will focus attention upon increasing the efficiency of

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[32] A. D. Chandler, *Strategy and Structure: Chapters in the History of the American Industrial Enterprise* (London, 1962), p.14.
[33] Moss, *Business Strategy*, pp.19-20; C. Scholz, "Corporate Culture and Strategy: The Problem of Strategic Fit", *Long Range Planning*, vol.20, no.4, (1987), p.79.
[34] Casson, *The Entrepreneur*, p.23.
[35] Moss, *Business Strategy*; According to Raghuram, the firm must have "...the right number of people in the right place at the right time doing the right things.", S. Raghuram, "Linking Staffing and Training Practices with Business Strategy: A Theoretical Perspective", *Human Resource Development Quarterly*, vol.5, no.3, (Fall 1994), p.242.
[36] See especially Moss, *Business Strategy*, p.17; Raghuram, "Staffing & Training Practices", pp.237-238, 240; see also, G. C. Tokesky & J. F. Kornicles, "Strategic Human Resource Management is Vital", *Personnel Journal*, (Dec. 1994); G. P. Latham, "Human Resource Training and Development", *Annual Review of Psychology*, vol.39, (1988), pp.545-582; W. Sandy, "Link your Business Plan to a Performance Plan", *Journal of Business Strategy*, vol.11, no.6, (1990), pp.4-8.

current operations, which will often be based upon a single capital intensive technology. Firms which develop a prospector strategy, on the other hand, will possess a diverse product line and will continually search for new product and market opportunities by experimenting with emerging environmental trends. Thus, she considers that these strategies will have very different human resource requirements, and she has outlined a number of hypotheses describing the staffing and training practices which she considers most appropriate for each strategy:

<u>Hypothesis 1 (Skill Source: Recruitment *v.* Training)</u>
Since efficiency and internal stability are important to the defender strategy, building skills through in-house training programmes will contribute to higher business performance. However, since prospectors compete on the basis of new products, and therefore require new and diverse skills unavailable within the organisation, frequent recruitment will contribute to higher business performance.

<u>Hypothesis 2 (Functional Emphasis on Skills)</u>
The key to the defender strategy is efficiency in production, therefore an emphasis on staffing and training for the production and finance functions, will lead to higher performance, but for prospectors, which seek new markets and new products, an emphasis on staffing and training for marketing, sales and R and D will enhance business performance.

<u>Hypothesis 3 (Narrow *v.* Broad Skills)</u>
Prospectors are likely to have ill-defined job requirements, and will therefore require employees with flexible skills. It follows therefore, that staffing and training for broad-based skills relevant to a number of jobs within the organisation, will contribute to higher business performance. Whilst training which provides each employee with a narrow range of skills appropriate to one particular job, will optimise the performance of firms which pursue a defender type strategy.

Raghuram has claimed that a test of the above hypotheses will determine the extent to which staffing and training practices are effective in achieving higher performance.[37] Thus, Chapter 7 examines the growth and development of 2 firms which pursued a prospector type strategy: Thomas Firth & Sons Ltd and Edgar Allen Ltd. It is shown that both firms invested in education and training for broad skills, and placed a particular focus upon the development of their research staff. However, Firth's failed to

[37] See Raghuram, "Staffing & Training Practices", pp.240-249.

make an adequate investment in the technical training of its salesmen, and it is argued that this undermined the efficient functioning of the prospector strategy.[38]

While possessing considerable analytical value, a weakness of Raghuram's model is its failure to address the question of how firms move between different business strategies, in response to changes in their business environment. For example, a major problem for Sheffield firms after World War One, was the need to diversify out of armaments production. Armaments giants, such as Vickers, were forced to drop defender characteristics very quickly and assume more and more the role of the prospector. Chapter 7, therefore, uses the theory of business strategy as an analytical tool, to explore the ramifications of this change in direction for human resource requirements, and, in particular, it examines how Vickers' accumulation of a particular type of human resources frustrated the strategy of moving down-market and producing a wide range of low-priced peace products.[39] However, how can the theory of business strategy aid our understanding of the process of change?

Moss claims that the theory is "largely about firms and the determinants of their growth."[40] Indeed, according to Moss, the role of the theory is to identify the broad forces which constrain firms and to explore how managers may circumvent these constraints and exploit business opportunities.[41] However, what constraints may the firm face in its business operations? Moss identifies three key constraints:

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[38]This chapter draws upon the human capital literature on firm-specific and general skills. Briefly, it has been argued that it is not rational for firms to invest in general training which will enhance a worker's productivity in a number of employments and that, in consequence, those firms that invest in training tend to invest in training for firm-specific skills. It has been argued further that those firms which invest heavily in firm-specific training will have an obvious interest in retaining and motivating their workers, and that in order to achieve this they may create internal labour markets, characterised by internal promotion and extensive welfare benefits. However, Edgar Allen's and Firth's invested heavily in general training to support their business strategy, and they developed embryonic internal labour market arrangements to keep workers with general rather than firm-specific skills. For a more detailed discussion of internal and occupational labour markets, firm-specific and general skills, consult the following: Y. Walter, "Labour as a Quasi Fixed Factor", *Journal Of Political Economy*, vol.70, no.6, (Dec. 1962), pp.538-555, see esp. p.540, 544; G. S. Becker, "Investment in Human Capital: A Theoretical Analysis", *Journal of Political Economy,* vol.LXX, (Oct. 1962); see especially, H. F. Gospel, *Markets, Firms and the Management of Labour in Modern Britain* (Cambridge, 1992), p.2; Gospel points out that the motivation and management of labour is crucial because "there is a difference between labour-power and labour. What the employer buys in the labour market is labour-power, or, in other words, the potential to work, but employers' continuing problem is how to get actual labour or effort in the workplace."

[39]"History constrains the direction of future change...when a society's firms have only learned how to produce certain sort of goods it is unlikely that firms will have the skills to produce other items", Lipartito, "Culture and Business History", p.7.

[40]Moss, *Business Strategy*, p.16.

[41]*Ibid.*, p.14.

Resource constraints

These are constraints which prevent a firm from expanding when there are unsatisfied demands for its outputs, or, when there is an under-utilisation of certain resources because other complementary resources are fully utilised. In particular, machinery may stand idle, or may be used inefficiently, because of a lack of skilled personnel.[42] For example, chapter 8 argues that some cutlery manufacturers believed that their machines were being worked inefficiently due to the lack of technical knowledge on the part of their workmen.

Organisational constraints

These result from inadequate, or incomprehensible information flows, and are related to administrative structures which are unable to cope with the scale and scope of the firms business activities.[43] As chapter 7 will demonstrate, Vickers' attempt to control its huge and diverse business operations on holding company lines during the inter-war years, created major problems for the company; however, there was no discussion amongst senior management of developing a more sophisticated multi-divisional form.

Market constraints.

These prevent a firm from expanding as rapidly as its resources allow, because the demand for its outputs is growing too slowly, or because it cannot acquire the inputs necessary to sustain the existing or growing activities of the firm.[44] The Sheffield cutlery industry in particular, confronted severe market constraints during the inter-war years. In part, these constraints arose from the spread of protectionism in important foreign markets, but as chapter 8 argues, the manufacturers' problems were also related to changes in demand patterns. In particular, customers increasingly turned against Sheffield's high quality decorative knives, preferring a cheaper, more functional product.

It will be evident that resource and organisational constraints turn upon forces which result from imbalances among the resources comprising the firm, or, more accurately, among the services rendered by these resources. They are therefore purely internal to the firm, and they focus the attention of the firm's management team upon particular bodies of knowledge and particular objectives. Moss labels these, 'focusing effects': they focus managerial attention upon the elimination of bottlenecks within the firm's business operations.[45] Market constraints, on the other hand, turn upon the technological linkages among the production activities of different firms, and forces

[42]*Ibid.*, p.38.
[43]*Ibid.*, p.38.
[44]*Ibid.*, pp.38-39.
[45]*Ibid.*, pp.53-58.

arising from competition among firms, and they are forced upon the firm as a result of changes taking place in its external environment. Moss argues that these changes produce an 'inducement effect', of which the Schumpeterian notion of 'imitation' is a good example. Schumpeter argues that, when a technical innovation enables a firm to reduce its costs, and, hence, output prices relative to its competitors, the forces of competition will induce other firms in the industry to employ either the same innovation, or innovations yielding equivalent cost reductions, in order to improve, or at least maintain, their positions within the market.[46] Thus, the activities of firms in markets focus the attention of management upon new markets, or new ways of producing commodities for existing markets. Moss argues that, in this respect, inducement effects pre-empt internal imbalances as objects of managerial attention. However, he adds that the response of a firm to changes in its market configuration, depends upon the resources and administrative structure by which it is distinguished. Thus, particular imbalances within the firm, and the character of the knowledge and experience of its personnel, will focus the attention of management upon particular criteria in the selection of the means by which to meet the problems, or the opportunities created by inducement effects. He concludes that one may define focusing effects as the result of purely internal factors, whilst inducement effects turn upon competitive pressures and focusing effects operating conjointly.[47]

The role of managerial decision-making is to respond to these focusing and inducement effects, and to develop strategies which will eliminate or circumvent constraints on the existing activities of the firm, or on the expansion of these activities.[48] The choice of strategy will turn upon the motivation of the firm. Neo-classical theory, with its assumption of perfect knowledge, considers firms to be omnisciently rational, and claims that the universal goal of all managers is the search for maximum profits. However, behavioural scientists have consistently demonstrated that real business firms are constrained by the uncertainty of their environment, and the limitations on their capacity for assessing, processing and utilising information. It is argued therefore, that firms are boundedly rational, and that, in a world of imperfect knowledge, they often satisfice and adopt merely adequate solutions in the face of constraints. This links with the work of managerial and organisational theorists, who claim that firms frequently rely upon past experiences as a source for structuring the future, that is, they rely upon organisational routines and experienced-based formulas in conducting their business operations.[49] These routines and formulas characterise the company and are related to

[46] *Ibid.*, pp.45-49.
[47] *Ibid.*, p.45, pp.62-64.
[48] *Ibid.*, p.38.
[49] Lipartito considers that, "the fact of decision-making in the face of imperfect and costly information, and the need to act before outcomes are known, force firms to create heuristics, but the stuff from which they are made is an underlying set of beliefs and symbols...culture", Lipartito, "Culture and Business

its particular culture, which some authors link to business performance. The idea that organisations are either cultures, or possess cultures, has been one of the dominant themes of management literature in recent years, and it has been suggested that companies can use policies of recruitment, training and education to manage their organisational culture, and ensure that employees behave in a manner appropriate to the efficient utilisation of plant and equipment. This thesis therefore, integrates a cultural approach with the theory of business strategy.[50] The concept of 'organisational culture' and the content of a cultural approach, are discussed in detail later in this chapter, but for now I will focus upon the objectives of the firm and the concept of business performance.

The theory of business strategy maintains that, no "single assumption can describe the hopes, desires and ambitions of individuals in a wide variety of circumstances" and that whilst the first goal of any management team is to survive, beyond this, firms may choose to pursue any number of goals, for example, maximum growth or maximum sales.[51] This has important ramifications for the assessment of business performance. In particular, it reminds us that business performance is a complex multi-dimensional phenomenon that incorporates diverse achievements, thus holding that performance in

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History", pp.6-7; Coleman also emphasises the "powerful influence upon current experience of inherited attitudes and traditional practices...", Coleman, "Uses and Abuses", p.153; for a discussion of the concept of 'bounded rationality', see the following: S. Zukin & P. Dimaggio, "Introduction", in S. Zukin & P. Dimaggio (eds.), *Structures of Capital: The Social Organisation of the Economy* (Cambridge, 1990), p.6; D. Hutchinson & S. Nicholas, "Modelling the Growth Strategies of British Firms", p.53; T. R. Gourvish, "British Business and the Transition to a Corporate Economy: Entrepreneurship and Management Structures", *Business History*, vol.29, no.4, (1987), pp.18-19; I. M. Kirzner, *Competition & Enterpreneurship* (Chicago, 1973), pp.10-12, 26; R. M. Cyert & J. G. March, *A Behavioural Theory of the Firm* (London, 2nd. Edition 1994); As Brown and Starkey argue, "the economic theory of social institutions analyses institutional structures in terms of the encapsulation of past experiences in a manner that act as a source of knowledge for structuring the future", A. D. Brown & K. Starkey, "The Effect of Organisational Culture on Communication and Information", *Information Journal of Management Studies*, vol.31, no.6, (Nov. 1994), p.809.

[50] According to Scholz, "Corporate culture is the implicit, invisible, intrinsic and informal consciousness of the organisation which guides the behaviour of individuals", C. Scholz, "Corporate Culture and Strategy: The Problem of Strategic Fit", *Long Range Planning*, vol.20, no.4, (1987), p.80; Similarly, Toulson suggests that, "in accordance with the anthropological view that a society's culture dictates what people are to learn and how they are to behave, an organisation's culture dictates what people have to know and the way things are done", P. Toulson and M. Smith, "The Relationship between Organisational Climate and Employees' Perceptions of Personnel Management Practices", *Public Personnel Management*, vol.23, no.3, (Fall 1994), p.436. In recent years some business historians have become interested in the cultural aspects of organisational life, which are not covered by Chandler's structure/strategy paradigm: J. Griffiths, "Give My Regards to Uncle Billy: The Rites and Rituals of Company Life at Lever Brothers, c1900-1990", *Business History*, vol.37, no.4, (Oct. 1995), pp.25-45; R. Church, "Deconstructing Nuffield: The Evolution of Managerial Culture in the British Motor Industry", *Economic History Review*, vol.XLIX, no.3, (Aug. 1996), pp.561-583; M. Rowlinson, "Strategy, Structure and Culture: Cadbury Divisionalisation and Merger in the 1960s", *Journal of Management Studies*, vol.32, no.2, (March 1995), pp.121-40. Chandler's numerous publications include: A. D. Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass. 1995); A. D. Chandler, *Strategy and Structure: Chapters in the History of the Industrial Enterprise* (London, 1962)

[51] Moss, *Business Strategy*, pp.28-29.

one dimension, which often represents the interests of a specific stake-holder within the firm, may run counter to performance in another, depending on the time-frame studied. For example, attempts to increase market share by expensive advertisement projects might hurt short-term profits. This thesis thus shares Dubelaar's belief, that "performance variables (net profit, market share and non-financial measures such as, quality, and customer and employee satisfaction, etc.) may act as dimensions, forming a frontier of performance, and that firms may lie along or below that frontier, choosing to move between different dimensions of performance for fulfilling the firms objectives and long run survival."[52] In assessing business performance, therefore, this thesis primarily focuses on measures related to the operative goals; or, in other words, the business strategy that the firms pursued, whilst recognising that high performance is not about exceptional achievement on one or two measures, but the production of satisfactory results along a broad set of criteria, each of which partly competes and conflicts with others over time.[53] For example, as chapters 4 and 7 argue, many Sheffield steel firms performed well in terms of product quality customer-service and the value of their sales, but their willingness to meet small orders and produce on a bespoke basis, meant that they were never likely to be as efficient as mass producers in Germany and the United States, which quickly surpassed Sheffield firms in the quantity of their output, and the volume of their sales.

However, what strategies can a firm employ: what responses can be made to market, resource and organisational constraints and, in particular, what implications do these responses have for recruitment and training practices? The theory of business strategy focuses upon 3 strategic responses: resource development, market expansion and organisational innovation.

Organisational Innovation

Moss claims that, in order to eliminate organisational constraints, new structures must be developed, which provide managers with information concerning limited aspects of the firm's activities and which require fewer decisions from each manager. As Lewis has argued, therefore, the development of effective information flows becomes a key area of managerial decision-making.[54] Clearly, the firm which is able to process the most appropriate information can acquire a significant competitive advantage, and, its ability to do this, will turn upon the success of organisational innovations, which maintain administrative structures in line with the scale and scope of the firm's business

[52]M. Bhargava & C. Dubelaar, "Reconciling Diverse Measurement of Performance", *Journal of Business Research*, vol.31, (Oct.-Nov. 1994), pp.235-239; R. G. Eccles, "The Performance Measurement Manifesto", *Harvard Business Review*, (Jan.-Feb. 1991), p.131.
[53] P. Doyle, "Setting Business Objectives and Measuring Performance", *Journal of General Management*, vol.20, no.2, (Winter 1994), pp.7-8.
[54]Lewis, "Industrial Structure", p.11.

activities. However, it is precisely in this sphere that British management is alleged to have failed. Chandler, for example, argues that managements could not develop organisational capabilities, and that this weakened British industry and with it the British economy. He claims that, in the inter-war years, although everyone agreed upon the need to merge, rationalise and centralise administratively, managements were neither strong enough, nor competent enough, to make the necessary investment and to create the necessary organisation.[55] What Chandler is suggesting here, is an entrepreneurial failure, a recurrent theme in British economic history, and it raises interesting questions about the quantity and quality of managerial education and training. Moss has argued that, since the management (entrepreneurial) team occupies such an important position in the firm, it can provide either the central impetus, or the principal impediment to change.[56] The quality of their education and training is therefore of paramount importance. [57] However, as Payne points out, "the concept of entrepreneurship will alter within the changing structure of industry and enterprise." Thus, the entrepreneurial role in the small family firm and the precise mix of skills required to fulfil it, will be different to that in a large corporate organisation.[58] Chapter 4, therefore, examines the education and training of sons in Sheffield's family and personally-managed firms, whilst chapter 7 examines the education and training of managers in the English Steel Corporation and United Steels Ltd. The latter were large corporations which arose through a process of rationalisation in the inter-war steel industry, and which had their headquarters in Sheffield. In particular, chapter 4 challenges the received wisdom that education and training for managerial succession in family firms was poor; arguing that some owner-managers received an excellent industrial training, which combined broad-based practical instruction with foreign travel and technical education. Some sons even graduated as engineers or metallurgists. However, chapter 7 will argue that the city's largest firms were slow to develop formal programmes for the training of their functional specialists, and this adds support to Chandler's claim that British firms failed to support the growth of their business activities with an adequate investment in management.[59]

Resource development

Such strategies may take various forms, but, of particular interest to this thesis, is human resource development. If a firm is prevented from achieving optimum

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[55]Chandler, *Scale and Scope*, p.334.
[56]Moss, *Business Strategy*, p.19.
[57]Casson has identified a number of qualities ranging from self-knowledge, or knowledge of the principal objectives of the enterprise, through imagination, practical knowledge, analytical ability, search skill, foresight and computational skill to instruction formulation which he considers necessary for the entrepreneurial function, Casson, *The Entrepreneur*, p.29.
[58]P. L. Payne, *British Entrepreneurs in the Nineteenth Century* (London, 1974), p.14.
[59]Chandler, *Scale and Scope*, pp.334-340.

efficiency in the manufacture of its products, because of qualitative deficiencies in its labour force (that is, a lack of skills and knowledge necessary to manipulate its plant and machinery) it may embark upon a recruitment and training programme to ensure the development of the necessary expertise. Thus, chapter 4 examines how Firth's embarked upon a training programme, in order to ensure that its workforce acquired the skills and, more particularly, the metallurgical knowledge required for the production of specialist alloys, and the manipulation of new and improved technology such as the electric arc furnace.[60] In addition, chapter 8 examines the impact of increased mechanisation in the inter-war cutlery industry. It is demonstrated that this did not lead to de-skilling *per se*, but created a need for different skills, and in particular, a demand for trained engineers and technically-educated workers who could maintain and repair the machines. Since the industry appeared to have entered a terminal decline, however, new apprentices were not forthcoming, and management had to focus upon the re-training of adult workers. As More points out, re-training has received little or no attention in the literature on human capital formation. Thus, chapter 8 explores new ground by focusing upon the Sheffield Cutlery Trades Technical Society which became a vital medium for re-skilling.[61]

Market Expansion

Strategies of market expansion require the opening up of new areas of trade, or new forms of dealing with existing markets. It is often alleged that, c1880 to 1940, British businessmen displayed an unhealthy aversion to meeting competition where it was most intense. Rather than compete in the advanced markets, they retreated into the satellite world of the formal and informal empire.[62] The majority of Sheffield firms did develop their empire trade, but, as Lewis has argued, this was no soft option. Competition particularly in the informal empire, such as Latin America, was intense. Indeed, chapter 2 will argue that steel manufacturers considered that success in this market required enhanced commercial education, and especially salesmen trained in the Spanish language, culture and customs.[63] Nevertheless, besides seeking to expand empire trade, a number of Sheffield firms also sought to combat increased competition and tariff barriers, by devising new methods of dealing with 'hard' markets, in particular the establishment of foreign subsidiaries. Chapter 4, therefore, examines the outcome of Firth's direct investments in Russia and the United States. It is argued that, the

[60]There is a clear need for such case -studies, for, as Gospel claims, "traditionally the study of industrial training and the study of technological innovation have not been combined. On the one hand, studies of industrial training have concentrated on the detailed institutional arrangements of education and training systems....On the other hand, research on technical change has dealt mainly with the hardware", Gospel "Industrial Training and Innovation", p.2.
[61]C. More, "Re-skilling and Labour Markets in Britain, c1890-1940: Questions and Hypothesis", Historical Studies in Industrial Relations, vol.2, (Sept. 1996), pp.93-110.
[62]E. J. Hobsbaun, *Industry & Empire: an Economic History of Britain since 1750* (London, 1968), p.191.
[63]See chapter 5 of Lewis," Industrial Structure".

American venture was far more successful, because the skilled human resources necessary for the manufacture of high-quality steels and projectiles were already in place. In Russia, on the other hand, Firth's was forced to embark upon a large scale education and training programme. It took 2 years to train the Russians to the necessary level but in the context of a scarce labour market, they immediately struck for higher wages, and in consequence the subsidiary soon ran into financial difficulties.

The three strategies have been discussed here in isolation for the sake of simplicity, however, it will be obvious that they are all interrelated, and that all have important human resource implications.[64] Indeed, the thrust of the theory of business strategy is that changes in physical and human resources are causally linked and related to changes in the business strategy that the organisation is pursuing. However, it has been alleged that business strategy and ET provision also shape, and are shaped by, the company culture, and it is to an analysis of this concept that I now turn.

Organisational Culture

What is 'organisational culture', also known as 'company culture'? Alvesson has argued that, "a glance at even a few works that use the term organisational culture will reveal considerable varieties in its definition..."[65] Nevertheless, there would appear to be a general consensus that cultural phenomena "have some depth, are difficult to grasp...are collective and shared by members of groups and are primarily ideational in character having to do with values, understandings, beliefs knowledge and other intangibles."[66] Indeed, we can identify 3 levels of culture. Firstly, the surface manifestations of culture that is, physical , written and behavioural artefacts, such as technology, company structure, stories and ceremonies. Secondly, values; that is, the evaluational basis that organisational members use for judging situations, objects and people. And, thirdly, key assumptions which can range from the nature of human activity, to the firm's relationship with its environment. These assumptions compose the deepest level of culture, indeed, they are "the abstract axioms that determine the organisation's values and beliefs"[67] and they are "invented, discovered or developed by a group as it learns to cope with its problems of external adaptation and internal integration."[68] Culture is

[64]For example, organisational innovations which lead to ever increasing specialisation within a multi-divisional firm will require improved means of accommodating information flows, that is additional physical resources such as telephones, type writers and computers, and, in turn, additional human resources in the shape of telephonists, typists and of course functional specialists, who have to be educated and trained to meet the firms needs.

[65]M. Alvesson, *Cultural Perspectives on Organisations* (Cambridge, 1993), p.1; Scholz, "Culture and Strategic Fit", p.80.

[66]Alvesson, *Cultural Perspectives*, p.2.

[67]E. Schein, *Organisational Culture and Leadership* (Oxford, 1989), pp.13-16, 86; C. C. Lundberg, "On the Feasibility of Cultural Intervention", in P. J. Frost et al (eds.), Organisational Culture (London, 1985), pp.169-185.

[68]Schein, *Organisational Culture*, pp.9, 55, 121.

thus "related to history and tradition", indeed it arises as an "historical process."[69] Nevertheless, definitions such as these "do not tell us very much about complicated topics", such as company culture, as "one and the same definition can be used by writers with very different outlooks."[70] Thus, the literature on company culture is characterised by many different approaches and points of view. In particular, one can discern a clear schism between those authors whose interests are primarily interpretative, and those whose concerns are functional. The interpretative, ethnographic approach seeks to "understand the world as it is." There is no concern with the utility of knowledge or causation, rather, culture is used as a point of entry for a broader, deeper and "more critical reflection upon organisational life." In other words, culture becomes a root-metaphor that is a "fundamental image for understanding organisations."[71] Functionalists, on the other hand, have a pragmatic orientation, that is, they are concerned with the utility of knowledge.[72] My interest in organisational culture, like that of the majority of authors, is primarily functional. This thesis is particularly interested in 2 key questions: firstly, does organisational culture have an impact upon education and training and business performance, and if so, can we identify possible lines of causation? Secondly, can culture be managed and, if so, how; in particular, what role may be played by recruitment, education and training?[73]

A cursory glance at the literature will reveal very different answers to these questions. In terms of culture's impact upon business performance, those authors who have sympathy with the ethnographic approach take an agnostic stance; that is, cultural manifestations have no impact, either negative or positive. Others have argued that, either a strong, or strategically appropriate culture, will have a positive impact upon employees' commitment and productivity, and, in turn, upon business performance. However, other researchers have argued that organisational culture can also have a

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[69]Alvesson, *Cultural Perspectives*, p.2; M. Ward, *Why Your Corporate Culture Is Not Working* (Aldershot, 1994), p.137; see also Toulson & Smith, "Organisational Climate and Personnel Management", p.456.

[70]Alvesson, *Cultural Perspectives*, pp.1-2. The only consensus is that, "the adoption of a corporate culture approach brings an organisation's values, assumptions and belief systems to the forefront, it regards people as the basic unit of organisational life and views organisations as communities of people", Gonyea, J. G. & Bradley, K. G., "Make Business Culture a Family Affair", *Work Study*, vol.43, (Sept. 1994), p.9.

[71]Alvesson, *Cultural Perspectives*, pp.43, 62; G. Burnell & G. Morgan, *Sociological Paradigms & Organisational Analysis* (London, 1979), pp.28; L. Putnam, "The Interpretative Perspective: An Alternative to Functionalism", in L. Putnam and M. Pacanowsky (eds.), *Communication and Organisation: An Interpretative Approach* (London, 1983); a classic example of the interpretative approach is L. Smircich, "Is the Concept of Culture a Paradigm for Understanding Organisations and Ourselves?", in Frost et al (eds.), *Organisational Culture*, pp.55-93.

[72]Burnell & Morgan, *Paradigms*, p.26; Alvesson, *Cultural Perspectives*, pp.1, 6, 24.

[73]It has been suggested that education and training may play a key role in managing and changing culture. Indeed, the personnel function has been dubbed 'the guardian of culture', A. Baron, "Winning Ways with Culture", *Personnel Management*, vol.26, (Oct. 1994), p.66. See also Kornicles & Tokesky, "Strategic Human Resource Management", p.115.

dysfunctional effect, in particular, traditional core-values can often prevent or frustrate the implementation of a new strategy that "makes sense from a financial, product or marketing point of view."[74] Such arguments naturally lead us to the next question, of whether culture can be intentionally managed and changed. Again, there is a wide diversity of opinion. Some authors, such as Peters and Waterman, have simply assumed that organisations have cultures which can be manipulated, but others arguing from an interpretative perspective, consider that organisations do not have cultures, rather they are cultures, characterised by "ambiguity uncertainty and contradiction, which probably defy deliberate intervention."[75] For the majority of researchers, however, the management of culture is a contingent matter. For example, it has been claimed that, if the organisation is characterised by good communication between hierarchies and divisions, company culture, or at least parts of it, will be more easily managed. On the other hand, if communication is poor, there are likely to develop interlocking, sometimes conflicting, sub-cultures which resist managerial intervention. Similarly, it has been claimed that while a unique company culture will lend itself more readily to management, a company culture which reflects broader industrial and societal cultures, will be extremely difficult to alter.[76]

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[74]Smircich clearly takes the agnostic stance, Smircich, "Understanding Organisations", pp.55-57. The beneficial effects of a strong culture have been stressed by, among others, T. Deal & A. Kennedy, *Corporate Cultures: The Rites and Rituals of Corporate Life* (London, 1982); T. J. Peters & R. H. Waterman, *In Search of Excellence* (New York, 1983). Authors who have argued that a strategically appropriate culture will have a positive impact upon business performance include: H. Scwartz & S. M. Davis, "Matching Corporate Culture and Business Strategy", *Organisational Dynamics*, (Summer 1981), pp.30-48; M. E. Porter, *Competitive Strategy: Techniques for Analysing Industries and Competitors* (New York, 1980), Scholz, "Culture and Strategic Fit", pp.78-87.; J. Kotter and L. Heskett, *Corporate Culture and Performance* (New York, 1992). Schein has particularly stressed how culture can have a detrimental effect upon business performance by acting as a barrier to, or retardant on, change, Schein, *Organisational Culture*, see esp. pp.30-32. For a more detailed discussion of the divisions in the literature see Alvesson, *Cultural Perspectives*, pp.74-80.

[75]Those authors who are confident that culture is something an organisation has and can therefore be managed include: Deal and Kennedy, *Corporate Cultures;* Peters & Waterman, *Excellence;* E. L. Baker, "Managing Organisational Culture", *Management Review*, (June 1980), pp.8-13. J. Griffiths believes that his work demonstrates that, "culture is something an organisation has, rather than is. Beliefs, values and symbols can be manipulated to managed ends in order to achieve a degree of shared beliefs." Griffith, "Uncle Billy", pp.42. Those who consider culture to be characterised by ambiguity and therefore extremely difficult, if not impossible, to manage include: J. Feldman, "The Meaning of Ambiguity: Learning From Stories and Metaphors", in P. J. Frost et al (eds.), *Reframing Organisational Culture* (London, 1991), pp.53-61; K. L. Gregory, "Native View Paradigms: Multiple Cultures and Culture Conflicts in Organisations", *Administrative Science Quarterly*, vol.28, no.3, (1983), pp.359-376. L. Smircich, "Concepts of Culture and Organisational Analysis", *Administrative Science Quarterly*, vol.28, no.3, (1983), pp.339-358; L. Smircich, "Studying Organisations as Cultures", in G. Morgan, *Beyond Method: Strategies for Social Research* (London, 1983)

[76]The majority of authors appear to lie in between the "can manage", "cannot manage" poles of the debate, for example: Wilkins and Ouchi stress good communication between all parts of the organisation as a facilitator of managerial attempts to control culture, W. G. Ouchi and A. L Wilkins, "Organisational Culture", *American Review of Sociology*, vol.2, (1985), pp.457-483, see esp. p.471; Maanen and Barley and Schein see the founding Phase of an organisation as the period most conducive to cultural management, J. V. Maanen and S. R. Barley, "Cultural Organisation: Fragments of a Theory", in Frost et al (eds.), *Organisational Culture*, pp.31-38, see esp. pp.35-38; Schein *Organisational Culture*, pp.64-70; Martin argues that, rather than ask whether culture can be managed, we should ask "Are there conditions

Some authors have argued that it is unfortunate that such eclecticism continues to persist, and that no single view has become pre-eminent.[77] However, it will be argued here that rather than regard eclecticism as a problem, we should see it as an advantage. In particular, as Alvesson has argued, different approaches should be viewed as distinct lenses which can be used in turn to focus, defocus and refocus, capturing a fuller view of the cultural context.[78] Thus, the issue is not so much choosing one perspective, as developing a multiple perspective approach, which recognises what a single perspective hides and what it highlights.[79] As Alvesson points out, the adoption of a variety of perspectives is not easy, but it is certainly not impossible. Indeed, this thesis adopts a multiple perspective that takes into account uncertainty, contradiction, planned and unplanned change, organisational sub-cultures, and larger industrial, regional and national cultures.[80] In order to do this, it makes use of a number of metaphors for culture contained in table 1.1[81]

under which culture can be managed?",J. Martin, "Can Organisational Culture be Managed?", in Frost et al (eds.), *Organisational Culture*, pp.95-124, see esp. 96; Both Siehl and Schein have stressed times of crises as offering a window of opportunity for managing culture, C. Siehl, "After the Founder: An Opportunity to Manage Culture", in Frost et al (eds.), *Organisational Culture*, pp.125-140, see esp. p.126, 139; Schein, *Organisational Culture*, p.64; Alvesson has stressed that company cultures which are reflections of local or national culture will be particularly difficult to manage, Alvesson, *Cultural Perspectives*, p.78-79. See also G. Hofstede, "The Interaction Between National and Organisational Value Systems", *Management Studies*, vol.22, (1985), pp.347-357; others who straggle the divide include: M. R. Louis, "A Cultural Perspective on Organisations: The Need for and Consequences of Viewing Organisations as Culture bearing Mileux", *Human Systems Management*, vol.2, (1987), pp.246-258; J. Martin and C. Siehl, "Organisational Culture and Counter Culture: An Uneasy Symbiosis", *Organisational Dynamics*, vol. 12, (1983), pp.52-64.

[77]Brown & Starkey, "Organisational Culture and Information", pp.807-828.

[78]Alvesson, *Cultural Perspectives*, p.120; according to Louis, "current efforts to understand organisational culture are analogous to the Suffi story of the blind man's efforts to decipher the elephant. Many are interested, some pursue one end of the beast, others pursue another. Most proceed as if the single focus pursued were the sum total and the definitive focus. Almost no one has discussed the possibility that the beast is larger than one focus. As a result differing approaches are rejected rather than reconciled through appreciation of the differences among the issues they address", M. R. Louis, "An Investigators Guide To Work Place Culture", in Frost et al (eds.), *Organisational Culture*, pp. 73-93, see esp. p82.

[79]Alvesson, *Cultural Perspectives*, p.91.

[80]*Ibid.*, p.120.

[81]*Ibid.*, pp.9-18.

Table 1.1: Organisational Culture as Metaphor.

Metaphor	Organisational Description	Classification
'Social Glue'	Organisations are integrated and controlled through shared values, and norms. Culture is thus the 'glue' holding the organisation together. There are 2 major versions of the social glue metaphor - 1. Integrationist/Pragmatic - Consensus and harmony are natural; 2. Strategic - Top management use corporate culture, as a strategy for achieving glue like effects, in order to prevent disorder and conflict	Functionalist, but version 2 allows for the possibility of opposition and disorder
'Compass'	Culture as a guide to assist in the setting of organisational goals, policies and strategies. In this, metaphor culture is a crucial factor in organisational performance: in particular the wrong values, like a defective compass, will indicate the wrong direction and people will not go where they want to go, or perhaps, where management wants them to go.	Can be Functionalist or dysfunctionalist
'Clan'	Providing organisational members "with the intellectual tools and a long memory", which guarantees their perceptions and evaluation of fair reward in the long-run, and this discourages them from opportunistic behaviour.	Functionalist
'Sacred Cow'/'blinders'	Stresses the deeper levels of culture, and members internalisation of certain ideals and values. This internalisation occurs as an historical process, in which core-values come to be seen as almost impossible to change, because of their taken for granted character and the deep commitment to them of organisational members. Thus, culture limits the scope for strategic change. These values are considered to be more difficult to change if they are a reflection of broader industrial and societal cultures.	Dysfunctionalist. managers controlled/constrained by culture
'Manager-Controlled Rites'	Culture as organisational rites, which are, or can be controlled for instrumental purposes. Rites are organised and planned activities that have both practical and expressive consequences. The activities involved are usually relatively elaborate, dramatic and are carried out usually for the benefit of an audience.	Functionalist This metaphor presumes that managers are capable of standing above culture and controlling it.
'World Closure'/'Dramaturgical Domination'	Culture as a management strategy, which aims to manipulate symbols and rituals, implant management's favourable perceptions and definitions of social reality in the interpretative schemes of employees. If it is successful in this, these perceptions and definitions come to constitute a selective and biased world view that reproduces a particular social order.	Functional, Managers above culture
'Non-order'	Proceeds from the assumption that, modern societies and organisations are characterised by ambiguity, uncertainty, contradiction and confusion. Fragmentation and disharmony, sub cultures and counter cultures are the norm, and a cultural perspective on organisations must take this into account.	Agnostic. Management of cultures is extremely difficult.

(Source: M. Alvesson, *Cultural Perspectives on Organisations* (Cambridge, 1993), pp.18-21.)

For example, chapter 7 focuses upon the issue of whether culture can be managed. It explores how the directors at Thomas Firth and Sons, attempted to use policies of recruitment, training and promotion along with a whole range of industrial welfare measures, to steer the company culture in the context of a rapid increase in the scale of its business activities, and an adverse shift in the business environment. It is argued that the criteria used by management for recruitment, training, promotion and retirement were "powerful primary mechanisms for culture embedding"[82], and that stories, rituals and role-modelling, were also used by management as a tool to foster a company culture based upon product quality and loyalty. (Culture as managerial-rites) However, it will be argued that the directors could not prevent a conflicting sub-culture emerging in the company's sales offices, thus, the metaphor of culture as 'non-order' is also utilised and explored. Chapter 2, on the other hand, takes up the metaphor of 'sacred cow'. It is argued that, the cultural commitment of cutlery manufacturers to product quality and handicraft methods, placed severe constraints upon the pace of mechanisation and the introduction of new training initiatives, which were needed if Sheffield was to meet the growing demand for cheaper cutlery. Finally, a novel component of this thesis is the application of the concept of organisational culture to schools. Thus, chapters 3 and 6 argue that the secondary school, King Edward VII developed an extremely strong culture, which valued a classical education above all else. Of course, this reflected the national bias towards a liberal classical curriculum, which has been well documented, but, it will be argued that this school became more classicist in its orientation than even the Board of Education thought desirable, and this prevented it from making a significant contribution to the human resource needs of local industry. However, I now turn to Sheffield in the 1880s and explore how, and why, business demands for education and training changed in the quarter century before World War One.

[82]Schein lists a number of primary mechanisms for culture embedding, Schein, *Organisational Culture*, p.224.

Chapter 2: Business Needs and Business Demands, Technical and Commercial Education, c1860-1918.

According to Maurice Kirby, "British business adopted a dismissive, almost cavalier attitude towards technical education, with the result that, by 1914, Britain had lost technical superiority in almost every staple industry."[1] Such arguments have become something of an orthodoxy in British economic history, and are linked with an entrepreneurial failure to "respond to the challenge of changed conditions."[2] It is claimed that, during the second half of the nineteenth century, the conditions for innovation became very different to those which had prevailed during the industrial revolution, when innovations were developed by practical men who worked according to a 'rule-of-thumb'. In particular, it is alleged that there occurred a 'second industrial revolution', in which innovation came to depend more and more upon "the deliberate and systematic application of scientific knowledge to industrial technology."[3] This required the abandonment of rule-of-thumb methods and the adoption of formal technical education and scientific research. But, whilst businessmen in Germany and America recognised this and acted upon it, Aldcroft has claimed that the typical British businessman remained uninterested in technical education, and believed that graduates had spent too much time immersed in theory to be of use in the practical world of manufacturing.[4] Indeed, it is argued that British manufacturers were generally "complacent and unwilling to learn from abroad, having led the world at a time when industrial leadership...depended on practical tinkering...not realising that the skills, methods and knowledge which had served so well in the past were largely irrelevant to the new world of advanced technology."[5] This complacency and "imperturbable

[1]Kirby does note the use of Professor Arnold as an industrial consultant in Sheffield but reiterates the traditional view that businessmen were opposed to technical education and attached to the "cult of the practical man", M. Kirby, *The Decline of British Economic Power Since 1870* (London, 1981), p.7.

[2]See D. S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge, 1969), esp. pp.344-348; D. H. Aldcroft "Introduction: British Industry and Foreign Competition 1875-1914", in D. H. Aldcroft (eds.), *The Development of British Industry and Foreign Competition, 1875-1914* (London, 1968), esp. pp.28-34; D. H. Aldcroft & H. W. Richardson, *The British Economy 1870-1939* (London, 1969), pp.147-148; G. C. Allen, *The British Disease* (Hertfordshire, 1976), p.44-45; A. L. Levine, *Industrial Retardation in Britain, 1880-1914* (London, 1967); A. E. Musson, *The Growth of British Industry* (London, 1981); R. R. Locke, *The End of the Practical Man: Entrepreneurship and Higher Education in Germany, France and Britain, 1880-1914* (London, 1984), esp. pp.72-73; J. Wrigley, "Technical Education and Industry in the Nineteenth Century", in B. Elbaum & W. Lazonick (eds.), *The Decline of the British Economy an Institutional Perspective* (Oxford, 1986), p.174; C. Barnett, "Long-Term Industrial Performance in the U. K.: The Role of Education and Research, 1850-1939", in D. Morris (eds.), *Economic System in the U. K.* (Oxford, 3rd. Edition 1987), pp.673-675; F. Crouzet, *The Victorian Economy* (London, 1982.), esp. pp.408-422.

[3]Crouzet, *Victorian Economy*, p.414.

[4]Aldcroft & Richardson, *British Economy*, p.148.

[5]This is how Pollard sums up the orthodox view, which he to some extent challenges, S. Pollard, *Britain's Prime and Britain's Decline: The British Economy 1870-1914* (London, 1989), p.115.

confidence in their superiority over foreigners" is also alleged to have manifested itself in inefficient marketing techniques: "since British manufacturers were convinced that their products were the best and always would be, they could see no need for aggressive marketing."[6] Thus, manufacturers have been criticised for an anachronistic attachment to the agency system, for failing to take small orders, to study customer wishes, to adopt the metric system and to learn foreign languages. These failings have in turn been linked with conservative attitudes towards commercial education, in particular, it is argued that British manufacturers were sceptical of any education that purported to prepare the student for a career in commerce, preferring him to learn his trade on the job.[7]

Ultimately the current orthodoxy is based upon two assertions; first, that there was a need for technical and commercial education; second that the vast majority of businessmen failed to recognise this need and this contributed to Britain's relative decline as a manufacturing nation. However, some historians have begun to chip away at these assertions. S. J. Nicholas, for example, has questioned whether British marketing techniques were as antiquated as the received wisdom suggests, and a few researchers have argued that the reliance upon rule-of-thumb methods may have been economically rational at least prior to 1914.[8] Moreover, Pollard has claimed that the concept of a 'second industrial revolution' is problematic, since the appropriate time at which to abandon rule-of-thumb would have varied from industry to industry.[9] The implication of Pollard's argument is clear, there is a need for detailed sectorial analyses of human resource requirements and business demands. However, aside from Robertson's examination of the shipbuilding industry, few studies of this kind exist, and Robertson only deals with the question of technical instruction, whilst commercial education is ignored.[10] This chapter therefore examines business demands for technical and commercial education, through a case-study based upon Sheffield. Sheffield provides an ideal location for such a case-study because of the variegated nature of its industrial base, as discussed in chapter one. A key finding is that Aldcroft's 'typical' businessman was not representative of all Sheffield manufacturers, let alone British industrialists as a whole. However, before we can examine business demands for

[6]Crouzet, *Victorian Economy*, p.408; Aldcroft & Richardson, *The British Economy*, p.156.
[7]*Ibid.*, pp.157-159; Allen, *British Disease*, pp.45-46; Landes, *Unbound Prometheus*, p.337.
[8]S. J. Nicholas, "The Overseas Marketing Performance of British Industry, 1870-1914", *Economic History Review*, vol.37, no.4, (1984), pp.506; R. Floud, "Technical Education and Economic Performance: Britain 1850-1914", *Albion,* vol.14, (1982), pp.153-171.
[9]Pollard, *Prime and Decline*, p.202.
[10]P. L. Robertson, "Technical Education in the British Shipbuilding and Marine Engineering Industries, 1863-1914", *Economic History Review*, vol.27, no.7, (1974). The British Shipbuilding industry remained a world leader throughout the period 1860-1918 and is, therefore, perhaps not the most appropriate sector of study for those concerned with the question of industrial decline. The steel industry, on the other hand, has acquired a central role in the debate over Britain's long-run industrial decline.

technical and commercial education, we must explore what contemporaries understood by these terms.[11]

Definitions of Technical Education.

In the 1860s, according to *The Economist*, "the notion of technical education was almost entirely new to the country."[12] However, between 1860 and 1914, debates on this type of education became increasingly common. Analysis of these debates reveals that definitions of technical education not only varied, but were often extremely vague.[13] One of the earliest debates on technical education took place in the House of Commons in 1867. A. J. Mundella, the Liberal M.P. for Sheffield Brightside, commented upon the confusion as to what this education entailed. He claimed that, "The impression on many people's minds is that those who advocate technical education want to instruct apprentices in their trades instead of teaching them in their workshops, but what we want is simply to teach them the technical principles of chemistry, mechanics and geometry, in order that when they get into the workshop they may...apply them to practice in their business."[14] The question of whether technical education should be based upon theory or practice was a vexed one and some 17 years later it was clear that businessmen and educationalists were still as confused as ever as to what technical education involved. James. W. Dixon, the President of the Sheffield Chamber of Commerce, for example, defined technical education as instruction in the theory of manufacturing and natural laws, mirroring the definition provided by Mundella in 1867. But George Barnsley, a local steel manufacturer, contended that while he was in favour of technical education, he was unable to see how they could establish a technical school in the city as Sheffield's trades were so diverse. Implicit in Barnsley's argument was a definition of technical education based upon practical trade instruction, rather than the teaching of scientific theory. Between these two poles of opinion, Dr. Roscoe, a local educationalist, articulated the view that technical education meant "the inculcation of (scientific) principles and the application of knowledge in accurate construction and skilful manipulation", or in other words, a blend of theory and practice.[15] Meanwhile, the State did little to allay the confusion. The Samuel

[11]Clearly contemporary understandings of technical and commercial education would have played a key role in shaping business attitudes and business demands. I therefore believe that we should avoid the temptation to foist a late twentieth century definition of technical education on to the late nineteenth century.

[12]Cited in P. W. Musgrave, "The Definition of Technical Education, 1860-1910", *The Vocational Aspect*, (May 1964), p.105.

[13]A point emphasised by Lord Armstrong in his nineteenth century critique of technical instruction, Lord Armstong, "The Vague Cry for Technical Education.", *Quarterly Review*, (October 1888).

[14]*P.P., 1868, Report from the Select Committee on the Provisions for Giving Instruction in Theoretical and Applied Science to the Industrial Classes, 1867-68*, p.281.

[15]The views of George Barnsley and Dr. Roscoe are to be found on pages 561 and 567 of P. P., 1884, *The Second Report of the Royal Commission on Technical Instruction, 1884.* Dixon's opinions can be

Commission of 1884 conceptualised technical instruction as "everything which prepares a man or woman for the walk of life he or she intends to pursue."[16] Such a loose definition was open to a wide variety of interpretations and harped back to the equally nebulous aim of the mechanics institutes, which had been founded earlier in the nineteenth century in order to "disseminate useful knowledge."[17] Between 1884 and 1889, the debate continued to reverberate, and the tension between practical instruction in a specific trade, versus the teaching of scientific principles, remained. However, it was increasingly argued that theoretical instruction should be supplemented by basic training in the use of tools, in order to promote the co-ordination of hand and eye.[18] And, despite Huxley's conclusion in 1887 that "...it passes the wit of man...to provide a legal definition of technical education...", the Technical Instruction Act of 1889 finally defined technical education as: "Instruction in the principles of science...applicable to industries and the application of specific branches of science...to specific employments." This definition did not permit the teaching of any particular trade, but it did allow for "instruction in the use of tools", in order to develop manipulation skills.[19]

As Musgrave, Summerfield and Evans point out, the most significant aspect of the act was the admission that practical instruction would be tolerated, and the failure to specify the optimum balance between theory and practice. According to Musgrave, one consequence of this was that by 1895 technical instruction had in *some places* been carried into "technological instruction", that is, the teaching of the trade itself, which was supposed to have been forbidden.[20] This emphasis on "some places" is important because the terms of the act were implemented locally, allowing a local consensus to emerge as to what technical education was. In Sheffield this came to revolve around "the happy combination of theory and practice."[21] Technical instruction at the elementary level was based upon the inculcation of general scientific principles which informed all industries, but businessmen were particularly concerned with scientific knowledge specifically relevant to the city's steel and engineering trades; in other words, to metallurgy and engineering. Moreover, businessmen took the utmost advantage of the State's failure to specify the relative importance of theory and practice,

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found on page 268 of P. P., 1886 *The First Report of the Royal Commission on the Depression in Trade and industry, 1884-1886.*

[16]Cited in P. Summerfield & E. J. Evans, "Introduction: Technical Education, the State and the Labour Market", P. Summerfield and E. J. Evans (eds.), *Technical Education and the State since 1850* (Manchester, 1990), p.2.

[17]See E. Royle, "Mechanics Institutes and the Working Classes, 1840-1860", Historical Journal, vol.XIV, no.2 (1971).

[18]Summerfield & Evans, "Introduction", p.3; Musgrave, "Definition Technical Education", p.106-108.

[19]See Musgrave, "Definition Technical Education", pp.107-108.

[20]*Ibid.*, pp.108-109; Summerfield & Evans "Intro.", pp.3-4.

[21]R. A. Hadfield, "A Plea For practical Education", given at the Prize Distribution Ceremony of the Technical Department of Sheffield University College, on November 20th 1899, in SUA VIII/1/2, Sheffield Technical School Minute Book, no.2, pp.109-111.

and they came to regard practical instruction in the manufacture and analysis of steel as a key aspect of any technical education.[22] But what of commercial education? Both in Sheffield and elsewhere, commercial instruction was regarded as a distinct sub-branch of technical education. It required instruction in such subjects as book-keeping, accounts, commercial geography and modern languages. Whilst the State's distribution of funds signalled its lower regard for such studies, vis-'a-vis more technical subjects, it will be argued later in this chapter that many Sheffield businessmen were vociferous in their demands for commercial education, and untiring in their attempts to influence local provision and overcome the obstacles presented by an unsympathetic State. However, for now I will focus on business demands for technical education.

Businessmen and Technical Education, c1860-1918.

Coleman and Macleod have argued that, "it is not easy to discover the historical attitudes of businessmen towards the introduction of new techniques", for "unlike social reformers, or politicians, businessmen have left few explicit historical records of their views on such matters."[23] Rather, "They have normally had to be jolted into comment by some outside agency."[24] This means that "historians have to assemble their material from the opinions of informed contemporaries or from the evidence given by businessmen to periodic enquiries usually set in motion by the government of the day."[25] Much the same applies to the reconstruction of business attitudes towards technical education.[26] Whilst Coleman and Macleod's path-breaking study revealed that the traditional picture of widespread hostility to new techniques was too crude a representation of a more complex historical reality, they nevertheless aligned themselves with the orthodox view of business antipathy towards technical education, without exploring this issue to any great extent. In what follows it is argued that, in the

[22]Such instruction was not intended to supplant the managerial prerogative of training one's own workforce, but rather to supplement workshop training and ensure that the student did not spiral off into an orbit of pure science, divorced from the needs of industry, SUA VIII/1/1, Sheffield Technical School Minute Book, no.1, p.51. In an adroit political manoeuvre, A. J. Mundella was able to reinvent himself as a champion of the emerging local consensus when he dropped his 1867 definition and pronounced that "practice without theory is rule-of-thumb and theory without practice is the absence of useful and practical knowledge", SUA VIII/1/1, December 13th 1883, pp.2-8; M. E. Sadler, arguably Britain's leading educationalist at this time, summed up the Sheffield consensus during a visit to the city in 1903, when he proclaimed that "the close union of scientific knowledge with practical experience can alone meet the needs of the situation. We do not want pendant or bookish theorists but what the Americans call live-men, who value practical experience but at the same time value a sound theoretical knowledge", M. E. Sadler, *Report on Secondary and Higher Education in Sheffield* (London, 1903), p.14.

[23]D. C. Coleman & C. Macleod, "Attitudes to New Techniques: British Businessmen, 1800-1950", *Economic History Review,* vol. 34, no.4, (1986), p.588.

[24]*Ibid.*, p.588.

[25]*Ibid.*, p.588.

[26]Having said this, the Sheffield Chamber of Commerce and Manufactures' minute books proved a veritable mine of business demands for commercial instruction. Stored at SCA, LD 1986/1-LD 1986/29.

case of Sheffield, not only is the traditional picture crude, but it is also static, in that, it does not take account of changes in attitudes during the period, and is, ultimately, historically inaccurate.

The Sheffield School of Practical Science was established in 1861. This institution was the brainchild of Sir John Brown, a leading steel manufacturer, and C. R. Atkinson, the Principal of Sheffield's Collegiate College. The school aimed to provide "preliminary instruction for students...destined to...work in manufacturing.". And Atkinson claimed that students passing through the grades would enter industry with a thorough knowledge of the scientific principles which informed their work.[27] This school was the first attempt within the city to move away from a singular reliance upon rule-of-thumb methods, and we may ask: did it receive significant support from the local business community? The school had a very short life; indeed, it closed in 1864, when Atkinson was forced to admit that it had proved "a failure."[28] The main reason for this failure was the overwhelming lack of business support. This self-same indifference also undermined attempts by 3 large-scale manufacturers to establish a similar school, some 9 years later.[29] Here, then, is evidence to support the orthodoxy that the vast majority of businessmen believed in the 'practical man' and treated theory with disdain. However, can such attitudes be explained merely by reference to conservatism and complacency, or were there good reasons for business indifference; in other words, was the attachment to rule-of-thumb rational from a business perspective?

At the opening of the Sheffield University Metallurgy Laboratories in 1905, it was claimed that, prior to the 1880s "the time was not ripe for technical education."[30] A point which I consider to have been well made. The technological, educational and economic context of the 1860s and 1870s largely justified business neglect of technical education and attachment to the 'rule-of-thumb.' Firstly, the art of metallurgy was at this time far in advance of the science; indeed, Henry Seebohm could claim that "the candid chemist must admit that there are many things in best crucible cast steel than are dreamt of in his philosophy."[31] It is therefore difficult to understand how the school

[27] SUA 5/1/2 (i), Chapman Collection, papers relating to the history of the Sheffield Technical School, vol.1, pp.8-10.
[28] *Ibid.*, p.13.
[29] These manufacturers were John Brown, Mark Firth and Frederick Thorpe Mappin, *University of Sheffield Souvenir of the Openings of the New Engineering and Metallurgy Laboratories, 1905* (Sheffield, 1905),p.7.
[30] *Ibid.*, p.7.
[31] Seebohm expressed his views on page 349 of *Engineering,* vol.38, (July-December 1884). This point was reinforced by the local businessman, Robert Hadfield, who claimed that, about the time of the School of Practical Science, there was no science of metallurgy worth talking of, SLSL, BBSTQ, R. A. Hadfield, Personal Collection, article in the *Sheffield Independent* (Nov. 21 1899); Geoffrey Tweedale has claimed, there was "an absence of any scientific basis for the industry for much of the nineteenth

could have provided the workers, as it claimed it could, with a thorough knowledge of the theories which informed their work. Secondly, it was not until 1870, some 6 years after the closure of the School of Practical Science, that Forster's elementary education act came into force. In 1864 the vast majority of Sheffield's workers possessed limited literacy and they were, therefore, in no position to benefit from technical education, which not only required a thorough grounding in the 3 "R"'s, but also presupposed some elementary scientific knowledge and basic numeracy.[32] And, thirdly, prior to the 1880s, Sheffield steel remained predominant in world markets and, even had technical education been a viable option, there would have been little pressure to change as foreign competition, though increasing, was not yet a threat to Sheffield's pre-eminence.

During the 1880s, however, circumstances began to change, and around the turn of the century reliance upon rule-of-thumb methods could no longer be regarded as a rational strategy for any firm which aimed to maintain a position at the forefront of the international steel industry. Indeed, during the two decades prior to World War One the technological context of the industry was transformed. The new science of metallography was developed in 1886 by H. C. Sorby, and during the 1880s researches into alloy steels, particularly those undertaken by Robert Hadfield, significantly increased metallurgical knowledge of the properties of steel. G. P. Jones has gone as far as to argue that "the foundation of modern ferrous metallurgy was laid by the work of these two Sheffield pioneers."[33] The importance of their work to this thesis is that "advancing knowledge meant that science could increasingly be applied to illumine problems not to be solved by traditional skill and judgement...", in other words, the experiments of Hadfield and Sorby sounded a clear death-knell for rule-of-thumb methods.[34]

Not only was the technological context altering, but the educational context was becoming very different to that of 1864: Sheffield was the first city in the country to respond to the requirements of Forster's Education Act, and as chapter 3 will show, a number of elementary schools were established during the 1870s. These schools

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century", G. Tweedale, "Sheffield Steel and America: Aspects of Atlantic Migration of Special Steel Making Technology, 1850-1930", *Business History,* vol. 25, no.3, (1983), p.227.

[32]Thus, as the local educationalist Henry Stephenson declared in 1884, "I hardly think the movement...(for technical education) could have been pushed forward with advantage at any earlier period than now for, it appears to me that, the foundation of all technical education is getting the workmen to think and use their minds. Till elementary education had become diffused and complete, it is vain to suppose they could have understood mechanical engineering...or the various branches of technical knowledge...technical education without previous elementary education is an impossibility", P. P., (1884), *The 2nd Report of the Royal Commission on Technical Instruction, 1882-1884*, p.553.

[33]See M. Walton, *Sheffield its Story and its Achievements* (Sheffield, 1968), p.234; G. P. Jones, "Industrial Evolution", in D. L. Linton (eds.), *Sheffield and its Region: A Scientific and Historical Survey* (Sheffield, 1956), p.159.

[34]Jones, "Industrial Evolution", p.159.

produced a new generation of workers who possessed the educational prerequisites necessary to benefit from technical instruction. Moreover, there was now not only scope for more formal technical education but also overwhelming pressure to change: during the 1880s the city's manufacturers were subjected to increasing competition from large and technically-efficient U.S. and German producers.[35] A key question to address, therefore, is: did the city's manufacturers recognise the changes in their business environment and demand appropriate shifts in the technical attributes of their workforce, and what, if anything, did they expect technical education to achieve?[36]

A number of Sheffield manufacturers gave evidence to the Royal Commission on Technical Instruction in 1884, and their testimony provides the business historian with valuable insights into their attitudes towards technical education.[37] It is clear that post-1880, there was a gradual awakening to the importance of technical education within the business community, and the key reason for this was the unprecedented increase in foreign competition. For example, when the commissioners asked Albert. A. Jowitt (Master Cutler and local steel manufacturer) if he had "felt the want of technical instruction in his managers, foremen or workmen", he replied "Yes to some extent. We feel it more...now on account of the keen competition we experience from abroad."[38] Jowitt added that "we feel (technical education) to be a necessity. We must now educate the men to know more about what they are doing. We feel that a man will be all the better if he has a knowledge of metals...."[39] He expressed the opinion that technical education was appropriate for all the workers and not just the foremen, emphasising that it was common practice to select the foremen from the "cleverest workmen".[40] He considered, therefore, that technical education, would if nothing else, widen the pool of talent available for promotion.[41]

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[35]For a discussion of the increase in foreign competition in the 1880s, see M. J. Lewis, "The Growth and Development of Sheffield's Industrial Structure, 1880-1930" (Unpublished PhD, Sheffield City Polytechnic, 1989); R. Lloyd-Jones and M. J. Lewis, "Business Structure and Political Economy in Sheffield: The Metal trades 1880-1920s", in C. Binfield et al (eds.), *The History of the City of Sheffield: vol.2, Society* (Sheffield, 1993); G. Timmins, "Concentration and Integration in the Sheffield Crucible Steel Industry", *Business History*, vol.24, no.1, (1982).

[36]In other words, did changes in the technological, educational and economic context create 'inducement effects' which convinced businessmen that technical education had become a necessity? For a discussion of 'inducement effects', see chapter 1 of this thesis, and S. Moss, *An Economic Theory of Business Strategy* (Oxford, 1981), pp.53-58.

[37]As Coleman and Macleod argued Royal Commissions are a key source for the reconstruction of business attitudes and business demands, Coleman & Macleod, "Attitudes to New Techniques", p.588.

[38]P. P., 1884, *The Second Report of the Royal Commission on Technical Instruction, 1882-1884*, p.541.

[39]Jowitt's testimony suggests that businessmen were indeed being 'induced' to accept the need for technical education as a consequence of changes in their business environment, *Ibid.*, p.541.

[40]*Ibid.*, p.541.

[41]As chapter 4 will argue, the acquisition of technical education became a prerequisite for promotion to the position of foreman at specialist steel firms such as Firth's and Samuel Osborn's.

Jowitt's opinions were highly progressive and appear to have surprised the commissioners, who were clearly expecting a more conservative response. In a classic nineteenth century condemnation of technical education, Dr. Percy had concluded that file-cutting was a matter of practical manipulation and that no amount of technical education would make a workman a better file-cutter.[42] Jowitt's attitude, however, was entirely different; taking the same example, he emphasised that "Occasionally the steel from which the file is made, works in an irregular manner and (the file-cutter) cannot put the workmanship upon it which he would otherwise do if he knew the cause of the defect."[43] Jowitt thus assigned a major role to technical education in promoting cognitive capabilities, as opposed to motor skills that were fostered by the traditional apprenticeship system. But, were his opinions shared by the wider business community? Jowitt clearly believed that they were. Whilst he acknowledged that "They still heard disparaging remarks about technical education" and admitted that "scientific training was sometimes pooh-poohed by men who boasted of their practical experience...", he informed the commissioners that such attitudes were largely confined to the older manufacturers, whilst the younger generation believed that "we cannot educate...(the workers)...too much ...."[44] It is possible that Jowitt may have understated the extent of the opposition to technical education at this time in order to project the city in a favourable light, but it will be argued that his views were not atypical; rather, Jowitt's opinions were shared by a number of steel and engineering manufacturers.

The commissioners were clearly aware of the division within Sheffield between the light and heavy trades, they recognised that file-cutting lay in the former category, and asked whether businessmen felt technical instruction to be a necessity for workers engaged in the heavier armour plate and rail trades, where the division of labour was much greater. Jowitt's response to this question was unequivocal, he argued that such manufacturers were "decidedly of the opinion that the men should have technical knowledge...", and he added that "even the labourer ought to receive some technical instruction because with that knowledge there would not be the same liability to risk and loss of life...", as many accidents "are due to the workmen's ignorance of weights and want of knowledge of that description."[45] The owners of the large armour plate and rail firms, such as John Brown, were, as we have seen, amongst the earliest advocates

[42]Dr. Percy appears to have been both businessman and educationalist. His views were published on page 385 of *The Engineer*, vol.59, (May 15th 1885).

[43]Jowitt claimed that "If the file-cutter had technical knowledge, he could say if this were such and such I could do so much better", P. P., 1884, *Second Report of the Royal Commission on Technical Instruction, 1882-1884*, p.541.

[44]*Ibid.*, p.542. See also Jowitt's address to the Sheffield Mechanics' Institute, SCA, MD 231, Sheffield Mechanics' Institute Minute Book, no.5, 29th March 1883

[45]P. P., 1884, *2nd Report of the Royal Commission on Technical Instruction, 1882-1884*, p.542.

of technical education and, during the 1880s, they received increasing support from less prominent manufacturers, such as Thomas Eadon, who informed the commissioners that "One great reason why technical schools should be encouraged is because of the very great division of labour that takes place in some...engineering establishments. There is a tendency to put a boy at a machine and he understands but little beyond that machine."[46] Thus, Eadon considered that the growing use of machinery and the increasing division of labour, provided a rationale for more formal technical instruction. A view that was echoed by C. H. Greasey, one of the nation's leading educationalists, who emphasised that "the operations of the workshop and the factory have become more complicated, and, in a number of cases, more dangerous. They require supervision by men who understand them...Theoretical and practical training are complementary, and it is men who have received both forms of training that are needed in industry."[47]

Whilst technical education in some of the city's heaviest trades was viewed as a response mechanism to the increasing sub-division of labour, Jowitt identified a different role for this education in the lighter cutlery trades. He argued that if artisans were provided with technical knowledge of machinery, this would undermine their traditional resistance to mechanisation, and allow Sheffield manufacturers to introduce new methods which would enable them to compete more effectively with larger, and more efficient, German producers.[48] Professor. J. Viramau Jones, Principal of Sheffield's Firth College, pushed Jowitt's argument even further, expressing the opinion that "A scientific knowledge of the processes used in the various manufactures would in fact stimulate its possessor to invention and original effort."[49] In Jones's scenario, therefore, not only would technical education render the workers more receptive to mechanisation, but also make them better able to invent machines and introduce them into the work process.[50] However, the growth and concentration of the cutlery industry in Sheffield during the eighteenth and nineteenth centuries had been based upon product quality which in consequence had become established as a core-value of the industry's culture. Thus, manufacturers regarded product quality as a 'sacred cow'; that is, as an almost unquestionable aspect of their business activities, and since machine methods were considered to be synonymous with low-quality cutlery, they were

[46]*Ibid.*, p.566.
[47]C. H. Greasey, *Technical Education in Evening Schools* (London, 1905), p.8.
[48]Complaints of labour's active and passive resistance to mechanisation were rife. For example, they were accused of acts of industrial vandalism and of working machinery so slowly that no improvements in productivity were realised, P. P., 1884, *The Second report of the Royal Commission on Technical Instruction , 1882-1884,* p.543; see also Tweedale, *Steel City*; S. Taylor, "Tradition and Change: The Sheffield Cutlery Trades, 1870-1914" (Unpublished PhD, Sheffield University, 1988)
[49]*Second Report on Technical Instruction*, p.544.
[50]The tone of Jone's argument was reminiscent of the early nineteenth-century debates on the "innovating artisan" which dominated the mechanics institute movement, See Royle, "Mechanics Institutes and the Working Classes"; J. Salt, "The Creation of the Sheffield Mechanics Institute", *The Vocational Aspect*, vol.18, (1966).

reluctant to damage their good-name by mechanising the production process. Instead, the majority of manufacturers looked to the craft skills of their workers to support the batch production of high-quality articles such as pocket knives, and they therefore had little interest in technical education.[51] Nevertheless, a large number of steel and tool manufacturers were in support of the technical education movement. They demanded technical education for a variety of reasons, and looked to such education to fulfil a variety of aims. However, the common denominator in the growing support for technical education, was a recognition that the technical context and market configuration facing Sheffield steel firms was changing, and that in consequence, the days of rule-of-thumb were numbered. Thus Jowitt declared that, "In our works...we are making crucible cast steel as our grandfathers made it. We know that by mixing certain brands of iron with certain preparations of carbon we can and do produce a certain effect...but we do not know why it is. We do it but it is really by rule-of-thumb...with further knowledge and more instruction we should arrive at more certain results."[52] An argument that was reinforced by J. W. Dixon, the President of the Sheffield Chamber of Commerce and Manufactures, who confessed that, "We have been going too much upon rule-of-thumb...and the Germans are ahead of us in that their workmen have a better technical training."[53] Dixon believed that technical education would, in the very near future, become essential to the city's industrial performance, and he identified one of the institutional barriers that stood in the way of the successful introduction of more formal technical instruction. He pointed out that, particularly in the cutlery trades, apprentices were often bound to an individual workman, rather than indentured to a firm, and, as a result, it was extremely difficult to introduce policies of technical education into the apprenticeship programme as the workers simply refused to accept it. Indeed, as Pollard has argued, "organised labour consciously attempted to restrict the teaching of their trades in the city's schools as they considered this an outflanking of apprentice rules."[54] Thus the small minority of cutlery manufacturers who were in favour of technical education, found that worker control over the labour process consistently frustrated their attempts to develop a more technically-educated manpower. However, I now turn to examine the local debates which informed the founding of the Sheffield Technical School in 1884.

A number of historians have emphasised that Sheffield's position in world steel markets had been achieved by virtue of the city's reputation for quality, and that this reputation

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[51]For a discussion of culture as 'sacred cow', see chapter one of this thesis and M, Alvesson, *Cultural Perspectives on Organisations* (Cambridge, 1993), p.20; see also Taylor, "Tradition and Change", p.33; Tweedale, *Steel City*, pp.170-171.
[52]*Second Report on Technical Instruction,* p.544.
[53]P. P., 1886, *First Report of the Royal Commission on the Depression in Trade and Industry, 1884-1886*, p.268.
[54]See Pollard, *History of Labour*, pp.68-72.

rested upon the supply of skilled labour.[55] In the 1880s, however, there was a growing recognition amongst the city's businessmen that, in order to remain competitive, they must enhance the technical attributes of this labour. The tool steel manufacturer, W. H. Brittain, for example, claimed that "with regard to technical education...they could not close their eyes to the fact that it was of the utmost importance to a town like Sheffield...and that although their workmen were undoubtedly the best in the world...they had it in their power to improve the workmen by following in the steps already marked out for them by...Germany."[56] Sheffield manufacturers, such as Brittain and Dixon, do not fit with the complacent, self-satisfied, almost smug businessman of the standard economic history texts, who placed blind faith in traditional methods and was unwilling to learn from abroad. Rather, many Sheffield manufacturers were clearly abreast of the changes that were occurring in their business environment. Indeed, a statement prepared by Sheffield businessmen acknowledged that increasing foreign competition "has brought out forcibly the want of technical education in England...The chief defect in continental training has been the want of large centres of particular industries, where practical experience could be gained and traditions formed...(whereas)... the theoretical knowledge, without which it is difficult to make advances either in...improved machines or in the introduction of new industries, has been almost neglected amongst ourselves."[57]

This statement was clearly based upon an astute recognition of Sheffield's comparative advantages and disadvantages. The reference to large centres of particular industries, and the formation of traditions, suggests that Sheffield manufacturers were acutely aware of the importance of the industrial district in transmitting practical skills and empirical knowledge from one generation of workers to another, often directly from father to son.[58] They were, however, beginning to recognise that empirical knowledge was no longer adequate under modern conditions, and that the theoretical knowledge, with which the Germans appeared to be better-equipped, was rapidly becoming a precondition for product and process innovations. Indeed, A. J. Balfour (a director of several leading steel and engineering firms) explicitly stated that, although it was "quite possible in times past for men who received no scientific training to invent or even discover, it was no longer possible for them to do anything of the kind", and he

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[55] See, for example, G. Tweedale, *Steel City: Entrepreneurship, Strategy and Technology in Sheffield, 1743-1993* (Oxford, 1995); Lewis, "Sheffield's Industrial Structure".
[56] See details of a public meeting on technical education held in Sheffield on December 13th 1883 in SUA VIII/1/1/, p.2.
[57] *Ibid.*, p.51.
[58] For a detailed discussion of Sheffield as a Marshallian industrial district, see R. Lloyd-Jones & M. J. Lewis, "Personal Capitalism and British Industrial Decline: The Personally Managed Firm and Business Strategy in Sheffield, 1880-1920", *Business History Review*, vol.68, no.3, (Autumn 1994).

therefore demanded technical education as an "imperative necessity".[59] There is little here to suggest that steel manufacturers were unwilling to respond to the challenge of changed conditions; indeed, one is struck by the similarities between Balfour's argument, and those propounded by economic historians over a century later.[60]

In the debate over local technical education, Sheffield businessmen made it clear that they "did not want a little Oxford or a little London University"; rather, they wanted "an institution especially adapted to the city's requirements", that is, a technical school which would provide instruction in metallurgy, engineering and mining.[61] Businessmen demanded that the school should cater for the needs of all classes of producers, including manufacturers, managers, foremen and workmen, and they considered that the students could be expected to group themselves into two classes: day students and evening students. Evening students being composed of foremen and workmen, and day classes largely of manufacturers sons, who would be trained for managerial succession. They demanded a technical education based upon general scientific principles, and technical knowledge useful to the city's metal and engineering trades. In particular, they argued that students should learn by active experimentation in laboratories, and that they should receive intensive practical instruction in the processes used in local industry.[62] Manufacturers, such as George Wilson and Charles Henry Firth, considered that such technical education would enable Sheffield "to go with the times and keep its ancient reputation for quality."[63] Indeed, Samuel Osborn concluded that technical education would enable Sheffield "to manufacture goods both better and cheaper and so secure to the town the markets of the world."[64] Here then, was a dual role for technical education; it was not only intended to improve product quality, but to ensure that products were manufactured more efficiently. As chapter 4 will argue, this became a key consideration for manufacturers, whose value-added goods were beginning to suffer intense price competition.

The foremost advocate of the Sheffield Technical School was Sir Frederick Thorpe Mappin, a local tool steel specialist. Mappin claimed, in no uncertain terms, that unless Sheffield adopted technical education, the city would be unable to maintain the position

[59]The salient points of Balfour's speech presented at the Manchester Municipal Technical School are contained on page 561 of *The Engineer*, vol.74, (1892).
[60]See the introduction to this chapter: economic historians have argued that during the second half of the nineteenth-century there was a 'second industrial revolution' where innovation came to depend more and more upon the deliberate and systematic application of scientific knowledge to industrial technology, see for example, J. P. Hull, "From Rostow to Chandler to You: How Revolutionary was the Second Industrial Revolution", *Journal of European Economic History*, vol.25, no.1, (Spring 1996)
[61]SUA VIII/1/1/, p.2.
[62]For a detailed discussion of the technical education that was demanded by businessmen in 1883 see *Ibid.*, pp.51-53.
[63]*Ibid.*, p.2.
[64]*Ibid.*, p.44.

it had hitherto held, and, in particular, he emphasised that the requirements of the armaments industry were so exacting that "It was useless for any steel houses in Sheffield to attempt to take contracts from the Government unless they employed the very highest scientific knowledge."[65] Mappin was an undoubted believer in technical education, and he considered it his mission to convert the whole of the business community to the new gospel. As a result, it is difficult to disentangle what he believed technical education could achieve from the propaganda. For example, in 1886, he made the extraordinary claim that "If students took advantage of the technical school, the city's manufacturers would not suffer from trade depressions".[66] Such ludicrous comments may have hardened attitudes against technical education, rather than the reverse. The technical journal *The Engineer*, for example, criticised businessmen such as Mappin, arguing that they claimed too much for technical education.[67] However, this did not deter manufacturers, such as Robert Hadfield, from supporting the cause, for although he was quick to point out that education was "no Aladdin's lamp or panacea", he considered it an effective weapon in the fight against foreign competition.[68] An argument that was shared by Sheffield's most prominent politicians: the Liberal A. J. Mundella and the Conservative Colonel Howard Vincent, who, though bitterly divided over tariff reform, agreed on the importance of technical and commercial education to the city's prosperity.[69]

It appears, therefore, that by the mid 1880s local educationalists, politicians, and many steel and engineering manufacturers, were rallying in support of technical education. On the first of February 1886, the *Sheffield Telegraph* concluded that the opening of the Sheffield Technical School revealed "The old order yielding to the new", and that "the

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[65]*Ibid.*, p.8; *The Engineer*, vol.59, (January 30th 1885), p.92. Chapter 4 of this thesis explores how Thomas Firth & Sons attempted to support the manufacture of specialist steels and armour-piercing projectiles through graduate recruitment and the development of technical training programmes.

[66]SUA VIII/1/1, p.154.

[67]*The Engineer*, vol.74, (1892), p.561; vol. 67, (1889), p.11; vol.59, (1885), p.92; vol.66, (1888), p.119 & p.331; *The Engineer* claimed that "When once an idea has taken root in popular opinion, it is impossible to arrest its growth. Someone found out a few years ago that the technical schools of Germany were better than the technical schools of Britain. At the same time he saw that Germany was making great industrial strides and, without stopping to inquire, he assumed that the two facts were correlated. Then he wrote and talked. Thus technical education became a catchword...the one and only panacea for all the complaints from which British trade was or was supposed to be suffering", *The Engineer*, vol. XCIV, (Sept. 1902), p.287; *The Engineer* remained a staunch supporter of the 'practical man' down to 1918 and claimed that those who supported technical education did not take account of the hostile tariffs that were raised against Britain. However, rival journals, such as *Engineering* and *Nature,* crusaded for technical education from the late nineteenth-century onwards.

[68]Hadfield "A Plea for Practical Education", 1899 in SUA VIII/1/2, p.111.

[69]See P. P., 1887, *Hansaard Commons Parliamentary Debates, Third Series*, vol.318, 9th August 1887; Cain has argued that "There were free-traders who did agree with the tariff reformers that British industry was ailing and needed regeneration. Like many of the tariff reformers, they looked to vigorous state action in...technical education...to help the regeneration forward", P. Cain, "Political Economy in Edwardian England: The Tariff Reform Controversy", in A. O' Day (eds.), The Edwardian Age: Conflict and Stability (London, 1979), p.45.

era of rule-of-thumb" had finally been "succeeded by scientific knowledge...of the qualities of metals."[70] Although one can understand how the *Sheffield Telegraph* arrived at this conclusion, given the comments that have been examined thus far, I consider that this interpretation glossed over real divisions that still existed within the business community. The science of metallurgy had not been clearly articulated by 1886, and, although support for technical education was increasing, the movement did not have the backing of all the city's steel manufacturers, rather, as the less sanguine *Sheffield Independent* phrased it, the school represented "a contribution from the more thoughtful school of Sheffield Commercial life towards solving the problem presented by foreign competition."[71] This is not to suggest that the supporters of technical education were a small minority; rather, as Samuel Osborne pointed out, "Some manufacturers gave subscriptions to the school that were in keeping with their position, others responded not at all, and others in a very nominal way."[72] There were, then, active supporters, or zealots, who were prepared to invest heavily in education in anticipation of significant returns; for example, Robert Hadfield, Edgar Allen and Joseph Jonas.[73] There were also many passive supporters who believed that technical education was a good thing but wanted "to get as much out of the school as possible whilst putting little in" (perhaps an understandable attitude at a time of severe trade depression) and, finally, there were those steel manufacturers who, in Hadfield's words, were "jealous of the school" and "opposed to it", fearing that it would reveal trade secrets and thereby increase, rather than reduce, foreign competition.[74]

During the late 1880s, however, as the science of metallurgy became more refined and foreign competition continued to intensify, support for technical education became more widespread and, by 1890, J. O. Arnold, Professor of Metallurgy at the Sheffield Technical School and President of the local Metallurgical Society, could conclude that "the spirit of the age is such that many steel manufacturers will welcome anything which like technical education reduces production costs but at the same time maintains product quality."[75] Thus, although *The Engineer* remained sceptical of the idea that technical education would enable Britain to produce better goods, more and more Sheffield businessmen were looking to technical education to improve product design, tighten quality control and deliver economies in production.[76]

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[70] SUA VIII/1/1/, p.144.
[71] SLSL, Newspaper Cuttings Relating to Sheffield, vol. 2, (Feb. 2nd 1886), p.46.
[72] SUA VIII/1/1/, pp.101, 103, 107.
[73] During the First World War the university received £10,000 from Edgar Allen and Jonas, and £2,000 from Hadfield to finance the establishment of new research laboratories, SUA VIII/1/3, pp. 59, 104.
[74] SLSL, BBSTQ, R. A. Hadfield, Personal Collection, speech printed in the *Sheffield Independent* on November 21st 1899.
[75] *Sheffield Technical School Metallurgical Society Journal, 1891-92*, pp.9 & 71.
[76] *The Engineer*, vol.67, (1889), p.11. The local tube manufacturer S. E. Howell regarded technical education as vital to product quality and business success, *Sheffield Technical School Metallurgical*

By the turn of the century, the majority of steel and engineering manufacturers were in support of technical education, and as table one in Appendix B shows many of them made a significant financial contribution to the foundation of the University of Sheffield.[77] Such strong support was probably related to the discovery that the Taylor-White process, developed in the United States in 1900, was producing high-speed steels of infinitely superior quality to anything manufactured in Britain. Thus, Sheffield's manufacturers had always felt able to view cheap American and German goods with a degree of equanimity, as they believed that the quality of their products would enable them to retain the most lucrative markets; but they regarded the Taylor-White product as a mortal threat to the city's industrial future. It was recognised that, if Sheffield was to maintain its position as a leading supplier of high-quality steel, it must develop high-speed alloys which would supersede the American product, and this awakened even the most conservative steel manufacturers to the importance of technical education.[78] Indeed, the development of specialist and high-speed steels whose properties, as chapter 4 will argue, were no longer solely determined by their carbon content, was a major factor behind increased business demands for scientific graduates and technically-educated workers. Thus, businessmen such as A. J. Balfour recognised that, "in view of the great advance in chemical knowledge of specialist alloys", such as manganese steel, it would be "impossible for Sheffield to maintain its position" in the global steel industry "unless its manufacturers recruited the highest scientific knowledge."[79] In particular, manufacturers generally acknowledged that, because of the development of specialist alloys, their strategy of bespoke production (which will be discussed in chapter 4), now demanded a high level of technical education. Indeed, it was claimed that workers, who had to manufacture steel to closely defined properties, would require a detailed scientific training.[80] Not surprisingly therefore, in 1903 Hadfield was able to proclaim that, whilst there had been opposition to the Sheffield Technical School in its early days, he was "happy to say this was now entirely changed and they now found not opposition but thousands of friends everywhere."[81] In particular, as research into

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Society Journal, 1891-92, p.50; A. J. Balfour argued in no uncertain terms that if Britain wanted to maintain and extend her supremacy she must adopt and extend the principle of technical education, *The Engineer*, vol.74, (December 23rd 1892), p.561.

[77]See contributions listed in SUA VIII/1/2.

[78]For a full discussion of the Taylor-White process and Sheffield's response to it, see Tweedale, *Steel City*, pp.114-118.

[79]A. J. Balfour, "Sheffield Industries Cradle of the Modern Steel Trade: Highest Qualities in the World.", SLSL, Newspaper Cuttings Relating to Sheffield, vol.9, p.345; See also C. H. Desch, *The Steel Industry of South Yorkshire: A Regional Study*, a paper read before the Sociological Society on 24th January 1922.

[80]W. Ripper, "Training of Apprentices", in LD 1986/9, Sheffield Chamber of Commerce Minute Book, no.9, 22nd Feb. 1917, p.212.

[81]SLSL, BBSTQ, R. A. Hadfield, Personal Collection, speech printed in the *Sheffield Independent* on November 21st 1899; this argument was reinforced by M. E Sadler, one of the nation's leading educationalists who, during a visit to Sheffield in 1903, proclaimed that "During recent years there has

specialist steels became more widespread, businessmen became more vociferous in their demands for scientific graduates.[82] Analysis of my database reveals that many Sheffield steel and engineering firms recruited metallurgy and engineering graduates from the local university. As early as 1904, 30 Sheffield firms had recruited at least one such graduate; by 1913, this figure had almost doubled, and by the end of the First World War, approximately 70 steel, tool and engineering firms had recruited one such graduate or more (see table two in Appendix B). Leading firms, such as Vickers, recruited many graduates, but graduate recruitment was not solely confined to the largest firms; rather, small and medium scale family-managed steel businesses, such as William Peace and Sons, were amongst the earliest recipients of graduates. By the turn of the century a number of family firms had begun to use the Sheffield University Applied Science Department as an integral component of education and training for managerial succession, a phenomenon that is explored in chapter 4. My database suggests, therefore, that there are problems with Kirby's assumption that "rule-of-thumb...went hand in hand with outdated forms of industrial organisation based upon small-scale family-firms."[83] Having said this, Kirby's argument does have more applicability to the city's cutlery trades. Although many steel and engineering firms recruited graduates, only four of the city's cutlery firms did so prior to 1919.[84] The majority of manufacturers in this sector could either see no need for graduates or could not afford to employ them. In particular, the structure of the industry - the prevalence of outwork and labour resistance - acted as a constraint on mechanisation, graduate recruitment and technical education more generally. Thus the cutlery industry grew very slowly at the end of the nineteenth century, and despite the failing demand for quality cutlery which stimulated some mechanisation particularly in forging with the introduction of fly presses, the rate of technical change was far behind that of the steel sector. Indeed, the industry remained heavily reliant upon traditional handicraft-methods. Since Lloyd has examined the training required for these handicraft-methods, there is no need to devote a separate chapter to them in this thesis.[85] Rather, chapter 8

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been a remarkable change of attitude on the part of the practical men of business...towards the problem of technical education. At one time the movement in favour of technical education was treated rather coldly...It was regarded as a fad, rather than as a practical necessity. Here and there this point of view still prevails. But every year strengthens the general conviction that more technical education...is indispensable to success under modern conditions and in the present phase of industrial development", Sadler, *Report on Education in Sheffield*, p.15.

[82]SLSL, BBSTQ, R. A. Hadfield, Personal Collection, speech at the Annual Meeting of the Iron and Steel Institute, May 12th 1905.

[83]Kirby, *British Economic Power*, p.7.

[84]Two of these firms were cutlery and tool firms and perhaps belong more properly to the tool and engineering sector rather than cutlery.

[85]Cutlery production involved 3 key stages, forging, grinding and hafting or assembly. Apprentices were trained in one of these stages. This training usually lasted from 7 to 10 years. The apprentices developed a range of practical skills and detailed empirical knowledge which has been well documented by Lloyd and Pollard, Lloyd, *Cutlery Trades*; Pollard, *History of Labour*. For a typical cutlery apprentice

will focus upon the new training initiatives which were introduced during the depressed conditions of the inter-war years to support new machine-methods and new products such as the stainless-steel knife which facilitated moves down-market, as the demand for quality cutlery collapsed. However, for now I will focus upon developments in the steel and engineering sector prior to World War One.

The greater rate of innovation within the steel industry proved a constant source of business demands for enhanced educational provision. For example, in 1909 the local steel manufacturer, Sir Joseph Jonas, emphasised that "the time would come when the electrical process of steel manufacture would rank amongst the methods of steel making in Sheffield", and that he, and other businessmen would have "to look to the Applied Science Department of the city's university to train men properly qualified to manage and work the furnaces."[86] Thus, owing to a series of product innovations, such as high-speed steel, and process innovations, such as the electric arc furnace, the debate amongst Sheffield steel and engineering manufacturers in the first decade of the twentieth century was no longer focused upon whether technical education was necessary or useful. This was now generally accepted by the vast majority of manufacturers and the debate revolved around the age at which a student should specialise in technical subjects. The leaders of the Sheffield Metallurgical Society were of the opinion that, specialisation in technical subjects should "commence immediately after a sound elementary education in the world renowned 3 "R"'s"[87]; an argument which received strong support from a large number of businessmen such as, Robert. A. Hadfield, who advised students to specialise as early as possible.[88] However, such arguments were strongly opposed by other businessmen: Sir Trevor Dawson, a director of the multi-national armaments firm Vickers Ltd, for example, supported M. E. Sadler's claim that "A well planned course of liberal secondary education lasting up to 16 years of age was the best preparation for technical training and for the practical tasks of business life...." Indeed, Dawson considered that "Early specialisation in scientific and technical subjects...stunted the growth of the mind and checked its full

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indenture, see SCA, records of Burgon & Ball, B & B 126 (A), Indenture of Apprenticeship, William Sykes to James Ball, May 2nd 1871.

[86]Speech by Jonas dated 5th April 1909, in SUA VIII/1/2, p.424. Earlier in the nineteenth century the development of the Siemens furnace, which possessed a "greater need for control and instrumentation" and therefore "scientific knowledge and the ability to read dials" had encouraged businessmen to demand more technical education.", P. W. Musgrave, *Technical Change, The Labour Force and Education: A Study of the British and German Iron and Steel Industries, 1860-1964* (London, 1967), pp.134-136.

[87]*Sheffield Technical School Metallurgical Society Journal*, 1891-92, p.4.

[88]Hadfield claimed that "A man had better be a master of one line rather than knowing a smattering of many" since "Each particular branch nowadays had so many sub-branches that it seemed hopeless to try and cover more than a small portion of the field", R. A. Hadfield, "A Plea For Practical Education", November 20th 1899, in SUA VIII/1/2, p.111.

development."[89] Nevertheless, Dawson was a major advocate of the sandwich-system, where the student would spend part of his time at work and part of his time at school. He argued that businessmen should double the number of pupils in their works, and run them in two shifts; one being in class, and the other at the bench or the machine. Initially, such arguments received little support from businessmen, who preferred their workers to acquire technical education in their own time, but, during World War One, the steel and engineering section of the Sheffield business community gave increasing support to the idea of part-time continuation classes, for all male employees under the age of 18. In particular, they emphasised that day continuation classes were becoming desirable because the boys were too tired after a days work in the shops to derive much benefit from evening instruction. Thus, on the eleventh of November 1916, the Sheffield Chamber of Commerce and Manufactures passed a resolution in support of the principle of day continuation classes and, a year later, *Engineering* proclaimed that: "We are glad to note an increasing consensus of opinion in favour of some scheme whereby apprentices will be able to attend part day classes on 2 or more days per week while serving their time provided they prove worthy of the privilege."[90] The change in business attitudes towards technical education over our period, in the steel and engineering section, was thus clearly pronounced: but what of commercial education?

Businessmen and Commercial Education, 1880-1918.

The majority of cutlery manufacturers believed that quality products would sell themselves, and they therefore had little interest in commercial education. Industry leaders such as Christopher Johnson and Company informed their German customers that "as your English is very good we hope that you will write to us in that language because we do not understand German and we know very little French."[91] Nevertheless, from the late 1880s onwards, the city's steel manufacturers began to become more and more interested in commercial education. During the three decades prior to World War One, the Sheffield Chamber of Commerce held numerous debates on the subject, and these reveal an almost neurotic obsession with foreign, and particularly German, education. Businessmen were clearly worried by the intensification of foreign competition, and they believed that superior commercial

[89]Dawson claimed that "Unfortunately" much technical instruction was "intensely narrow...(and)...The student contracts intellectual myopia and comes to despise anything which is not capable of definite statement either by figure or formula", Dawson presented his views on technical education to *Engineering*, vol.102, (October 27th 1916), p.115; Sadler, *Report on Education in Sheffield,* p.5.
[90]*Engineering,* vol.103, (January 26th 1917), p.84.
[91]In addition, Australian customers complained that "You can only purchase Sheffield scissors through London merchants but the Germans come directly to us." Cutlery firms were very conservative in their response to new conditions, placing a premium upon empire markets, Christopher Johnson's, for example, viewed colonial markets as "important for the protection of our interests, indeed very existence" and by 1910 five-eighths of all British cutlery exports were going to the colonies, see SCA, MD 2374, Records of Christopher Johnson, Australian Letter Book, Letter to Holmshaw (New Zealand agent), June 5th 1885, p.66; Taylor, "Tradition and Change", pp.106-107; Tweedale, *Steel City*, p.179.

education was enabling nations, such as Germany, to erode Sheffield's position in world markets. In 1887, for example, W. H. Brittain, emphasised that "The trade of this country has gone through a period of depression which has brought prominently before us the fact that we are no longer the sole commercial nation in the world and that if we are to retain commercial equality with other nations, it is necessary to look the facts in the face and not think that everything will be put right by our ancient prestige."[92] He considered that in view of this he was "glad" to note the burgeoning interest in commercial education, and particularly the growing recognition of the importance of foreign languages.[93] He understood that none of the city's steel firms could rest upon their reputation for quality, and emphasised that no matter how good their products were, they needed to be well-marketed and pushed by vigorous and intelligent salesmen.

It was thus, a recognition of the adverse shifts in the economic environment that induced business interest in commercial education.[94] Sheffield steel manufacturers were, in fact, acutely aware of the challenge of changed conditions, and during the final decades of the nineteenth century they began to respond to them. Although the much maligned agency system remained a feature of Sheffield's marketing apparatus long after World War One, it was, as S. J. Nicholas has argued, only one of many institutional arrangements used by firms to push their products.[95] Many firms had appointed their own salesmen long before 1914 and, in addition (as chapter 4 will argue) it was common practice for businessmen and their sons, who were being groomed for managerial succession, to visit overseas customers, in order to identify their needs and establish personal relations with them. Indeed, this was a distinguishing feature of the city's family capitalism, and as foreign competition increased during the inter-war years, firms such as Edgar Allen's attached even greater importance to the quantity and quality of their sales representatives and commercial staff.

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[92]LD 1986/3, Sheffield Chamber of Commerce and Manufactures Minute Book no.3, 2nd September 1887, W. H. Brittain was at this time the head of the family-managed steel firm S. S. Brittain and Sons and the chairman of the Sheffield Chamber. Sheffield businessmen generally had no quarrel with The National Association for Secondary Technical Education. Indeed, this association, which was founded in 1887, articulated similar views to those advanced by W. H. Brittain. The association claimed that whilst the neglect of foreign languages had not been a problem in the past, because customers had been more or less forced to buy from England, the recent expansion of foreign competition meant that world markets were less secure, and since foreigners could speak several languages they were able to take business away from English firms whose salesmen and commercial correspondents were unable to use any language but their own. For a detailed discussion of the National Association for the Promotion of Technical Education see M. A. Dalvi, "Commercial Education in England During 1851-1902: An Institutional Perspective" (Unpublished thesis, London University, 1957), pp.390-397

[93]LD 1986/3, 2nd September 1887.
[94]For a discussion of 'inducement effects', see chapter 1 of this thesis
[95]Nicholas, "Overseas Marketing", p.496.

In order to improve the system of commercial education, businessmen encouraged local politicians to communicate their demands for the teaching of subjects, such as modern languages and book-keeping, to Parliament. At a meeting in 1887, for example, Howard Vincent (Conservative M.P. for Sheffield Central) informed the Sheffield Chamber of Commerce that he had petitioned Parliament, on the behalf of local business, for the inclusion of commercial subjects in the technical instruction bill. In fact, both Vincent and Mundella (Liberal M.P. for Sheffield Brightside), clearly believed that there was a need for commercial education, and particularly education in modern languages, a need which the local industrialist Frederick Thorpe Mappin considered to be "a most pressing " given the fact that "clerks who could speak 2 or 3 languages were a most valuable acquisition" but were in very short supply."[96]

Such was the level of business concern that, whilst Mundella and Vincent fought the case for commercial education in Parliament, businessmen focused their attention upon influencing local provisions, through the aegis of the Sheffield Chamber of Commerce. In 1888, for example, the chamber decided to establish Sheffield as a centre for the Cambridge University commercial examinations, and accepted responsibility for the management and financing of the scheme. In order to secure suitable candidates, it requested that the Royal Grammar School and Wesley College integrate commercial studies, such as book-keeping into their curricula.[97] This represented the first attempt by local businessmen to respond to the perceived need for commercial education, and they soon recognised that the scheme would not solve the magnitude of the problem that faced them. Between 1890 and 1892 a number of reports on commercial education were submitted to the Sheffield Chamber, one of which was produced by the local steel manufacturer, Sir Joseph Jonas. Jonas, like Mappin, argued that "The great want in Sheffield was a better acquaintance with modern languages." He considered that modern languages ought to be taught for their "conversational or business use", rather than undertaken as a "grammatical study", and stressed the importance of acquiring a

[96]Mappin's views expressed in 1883 are contained in: SUA VIII/1/1, p.8; LD 1986/3, 2nd September 1887. According to Vincent, "no one could fail to be greatly struck with the extraordinary facilities offered in nearly every large continental town for commercial education, facilities which up to the present were entirely unobtainable and entirely unknown here", LD 1986 /3, 2nd September 1887, *The Sheffield and Rotherham Independent*, Saturday 3rd, September 1887. A. J. Mundella sought to "secure greater encouragement for foreign languages and commercial subjects generally. " He claimed that England "must place such teaching on a much more popular basis than heretofore in order that it may reach the class attending the nation's elementary schools who entered the warehouse, the counting house and the workshop deficient in the necessary training", Mundella's speech was printed in *The Sheffield and Rotherham Independent*, Saturday 3rd September 1887.

[97]LD 1986/3, 19th April 1888.

"business vocabulary."[98] Such arguments received strong support from Charles Ducommun, a former teacher in the Osnabruck School of Commerce, whose report emphasised that the Cambridge examination had brought very little improvement in the teaching of foreign languages, as it was designed to test knowledge that was "theoretical, bookish and ultimately useless." He added that, the state of commercial education generally was little better and that "the majority of young Englishmen who...came to the office at 16 had learned little that would be of value to them in a commercial career."[99]

In 1892 the chamber sat to consider these reports and came to the conclusion that, if industrial performance was to improve, they must devise a more effective system of commercial instruction within the city. Businessmen recognised that their attempt to influence the curricula of the Royal Grammar School and Wesley College had failed, and that the Cambridge examinations were too theoretical in their orientation. They therefore abandoned their support for the Cambridge scheme, and began to provide financial assistance for students sitting the Royal Society of Arts examinations, which were considered to be more practical, and therefore more appropriate to business needs.[100] In addition, the chamber demanded that the Sheffield School Board provide commercial instruction in the Central Higher Elementary School. In particular, it requested that adequate provision be made for the teaching of German, French commercial arithmetic, shorthand, book-keeping, commercial correspondence and accounting.

As chapter 3 will argue, the school board readily agreed with local business as to the urgent necessity for such instruction and accepted the chamber's demands. Indeed, the chamber was so pleased with the response of the Central Higher, that in 1900 it looked to this school to provide additional instruction in the decimal system, the measures and coinage of Russia and other European states, and instruction in Spanish, the history of South America, and the weights and coinage of the various South American republics. The demand for Spanish and South American studies was informed by the spread of protectionism in Europe and America, which, as chapter 4 will argue, placed a premium upon the development of empire markets, both formal and informal.[101] Indeed, A. J.

[98]Jonas' report was printed in the *Sheffield Daily Telegraph*, Friday 29th April 1892, a copy is contained in LD 1986/3.
[99]C. Ducommun, "Considerations and Suggestions on Commercial Education.", contained in LD 1986/3.
[100]Later, in 1911, Sheffield adopted the London Chamber of Commerce examinations which were even more practical in their orientation, LD 1986/3, 28th April 1892; LD 1986/8, Sheffield Chamber of Commerce Minute Book, no.8, Monday 13th November 1911, pp.5-6.
[101]The chamber emphasised that the additional subjects were required because "the South American republics are such large customers of our manufacturers today and active commercial correspondence goes on with them to a large extent." The chamber considered that if the Central Higher added the desired

Hobson and Daniel Doncaster demanded that special attention be given to the teaching of Spanish in order to support the development of the South American market.[102] They, and other businessmen, such as Colonel Hughes, recognised that the city's connection with South America was already significant, but that the resources of this continent were "but untouched at the present time", and that South American customers could be persuaded to purchase more and more of Sheffield's high-quality steel, so long as firms acquired personnel who could deal with the Latin Americans in their own tongue.[103] In particular, they were concerned that a formidable German effort was being made to capture the South American market, and that if they did not acquire salesmen and correspondents with a sound working knowledge of the Spanish language, history and culture, they would lose out to German competition.[104]

The Sheffield School Board strongly agreed with local business as to the importance of students studying these subjects, and decided to integrate them into the commercial curriculum of the Central Higher. However, for reasons discussed in chapter 3, the State forced the Sheffield Central, and other such schools throughout the country, to abandon the commercial components of their curriculum.[105] This brought forth a venomous response from the Sheffield Chamber who argued that, the Board of Education was stopping the "vigorous attempts of local school authorities to provide for the wants of the people in the matter of commercial and industrial education,"[106] and from 1900, local businessmen became increasingly vociferous in their demands for a national system of vocational secondary education. In 1904 for example, the Sheffield Chamber gave its unequivocal support to an Associated Chambers of Commerce circular, which expressed the opinion that: "In order to retain our industrial position and introduce into this country such further industries as may be profitably developed, this association is of the opinion that it is absolutely necessary to establish secondary schools of the highest standard with fees low enough to make them accessible to all ...."[107]. Indeed, such was the strength of business support for this circular that the local M.P., Stuart Wortley, was induced to represent the city on a deputation for secondary commercial education, to be presented before the president of the Board of Education.[108]

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subjects to its curriculum it would become "a truly efficient commercial school", LD 1986/5, Sheffield Chamber of Commerce Minute Book, no.5, 15th June 1900 and 12th July 1900.
[102]LD 1986/9, Sheffield Chamber of Commerce Minute Book, no.9, 7th November 1916, pp.127-128.
[103]*Ibid.*, 20th December 1916.
[104]*Ibid.*, 20th December 1916, 25th February 1917, p.144.
[105]*Ibid.*, 22nd November 1900; See also for a general discussion of the effects of the 1900 decision, J. Murphy, *Church, State and Schools in Britain 1800-1970* (London, 1971), p.156.
[106]LD 1986/5, 30th January 1901.
[107]LD 1986/6, Sheffield Chamber of Commerce Minute Book, no.6, 5th December 1904.
[108]*Ibid.*, 5th December 1904.

Nevertheless, as chapter 3 will demonstrate, the system of secondary education that the State finally pushed through was heavily influenced by the civil servant, Mr. Robert Morant, who established the day secondary school system in a classicist grammar school tradition.[109] This disappointed many Sheffield businessmen, such as Robert Hadfield, who had "strongly recommended" the teaching of shorthand and modern languages.[110] Thus, business demands for such subjects continued to increase down to 1914, as the emergence of large vertically-integrated companies, such as John Brown's, created unprecedented difficulties in administration, and brought forth an acute need for commercially-educated personnel.[111] In particular, the business community sought to influence the curricula of evening schools and institutions such as Sheffield University, that were freer from state intervention. In 1902, for example, the Sheffield Chamber of Commerce offered financial assistance for the establishment of chairs in French and German at the local university.[112] Later, in 1917, it requested that the Central Secondary Evening School provide additional classes in Spanish, Italian and Russian, and, in the same year, Douglas Vickers promised a grant of £300 per annum, tenable for a 7-year period, in order to support a chair in the Russian language at Sheffield University.[113] During the War the demand for commercial education continued to escalate, and by 1918 the Principal of the Central Evening School could claim that "...owing to the more scientific organisation of the works there is a great demand for commercial subjects."[114] Indeed, Hal Fisher, the educationalist responsible for the 1918 Education Act, concluded that "If the great business houses in the great business centres co-operated as they are co-operating in Sheffield with the local universities and schools, they could give a great stimulus to English education the effect of which it is difficult to estimate."[115]

What conclusions can we draw from this survey? The case-study of Sheffield has exposed the limitations of the black and white generalisations of the standard economic

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[109]Murphy, *Church, State and Schools*, p.156.
[110]Hadfield, "A Plea for Practical education", November 20th 1899, in SUA VIII/1/2, p.112.
[111]It was recognised that "...a social class, not hitherto largely represented in Sheffield, is growing through commercial development amongst the large firms of Sheffield", and that "commercial education is becoming more and more important as outside competition makes more scientific methods of distribution and administration a necessity", Principal's Report on the Central Secondary Evening School, November 3rd 1913, in CA 319, Governors' of the Central Secondary School Minute Book, no.3, p.1922.
[112]LD 1986/6, 31st January 1902.
[113]SUA 5/1/20, Chapman Collection, papers relating to the teaching of modern languages; CA 320, Governors of Central Secondary School Minute Book, no.4, 7th April 1917.
[114]Principal's report on the Central Secondary Evening School, 3rd October 1918, CA 320, p.288; Even some of the larger cutlery houses such as Wostenholm's recognised the need for more scientific methods of administration and looked to enhanced commercial education to up-date old fashioned methods of book-keeping and introduce a good system of office routine, SCA records of Wostenholm's, Wos R6, Memorandum on office efficiency, 18th November 1915.
[115]LD 1986/9, Sheffield Chamber of Commerce and Manufactures Minute Book, no.9, 20th December 1916, p.144.

history texts. Although many cutlery manufacturers fit with the received wisdom of limited graduate recruitment and general neglect of technical and commercial education, many steel and engineering manufacturers clearly do not. Indeed, technical and commercial education were demanded for a variety of reasons, and specialist steel and armaments manufacturers, in particular, showed alacrity in responding to the challenge of changed conditions. They clearly understood that a 'second industrial revolution' was taking place, and that this had important ramifications for their human resource requirements. Indeed, they lived through it, and, via the development of specialist steels, contributed to it. However, in the next chapter I will examine the key question: did Sheffield's education system satisfy business needs for graduates and for technical and commercial education generally, both in a quantitative and qualitative sense?

Chapter 3: Technical and Commercial Education in Sheffield, c1880-1918.

This chapter explores whether Sheffield's education system responded to the needs of local business identified in chapter 2: whether it provided the quantity and quality of technical and commercial personnel which Sheffield's industries required during the period 1880 to 1918. The English education system has been subjected to intense criticism by economic historians. Although recent research has suggested a close nexus between some provincial universities and their local industries, the overriding consensus is that the English education system has consistently failed to deliver business requirements.[1] Indeed, Aldcroft has claimed that the education system has *never* been geared towards industrial needs.[2]

The provision of education prior to World War One has been criticised on both quantitative and qualitative grounds. Although there are dissenting voices, the vast majority of historians appear to support Burgess' conclusion that "the rate at which Britain was improving its human capital was inadequate to the new phase of industrialisation", and that this contributed to her relative decline as a manufacturing nation.[3] In particular, it is held that in a context of competitive capitalism the education system developed with poor communication between its constituent parts and with little connection to the human resource requirements of industry.[4] A more extreme school of thought has even suggested that the system was deliberately biased against manufacturing: it aspired to a 'gentlemanly ideal' and placed a premium upon classical subjects as a prerequisite for entry into the professions, the concomitant of which was the devaluation of technical studies.[5] Moreover, historians such as Vlaeminke have argued that this system was positively encouraged by the State, which established the secondary school syllabus within a public school classicist tradition, "destroying local efforts to provide a more industrially oriented curriculum."[6] Whilst it will be

[1]See for example the work of F. Crouzet, C. Barnett, J. Wrigley, S. F. Cotgove and D. H. Aldcroft; Sanderson has emphasised the links between British industry and some of the civic universities, M. Sanderson, *The Universities and British Industry* (London, 1972).
[2]My italics, see D. H. Aldcroft, "Education and Britain's Growth Failure", in G. Tortella, (eds.), *Education and Economic Development Since the Industrial Revolution* (Valencia, 1990), p.226.
[3]For the consensus view see: K. Burgess, "Did the Late Victorian Economy Fail?", in T. R. Gourvish & A. O' Day (eds.), *Later Victorian Britain, 1867-1900* (London, 1988), p.267; according to Dintenfass, "The enduring failure of the British educational system to supply an adequate number of trained people...produced and then sustained a vicious circle of uncompetitive products, processes and personnel", M. Dintenfass, *The Decline of Industrial Britain, 1870-1980* (London, 1992), p.36. For a dissenting view see M. Sanderson, "Technical Education and Economic Decline: 1890-1980", *Oxford Review of Economic Policy*, vol.4, no.1, (Spring 1988), esp. p.38.
[4]J. Wrigley, "Technical education and Industry in the Nineteenth Century", in B. Elbaum & W. Lazonick (eds.), *The Decline of the British Economy: An Institutional Perspective* (Oxford, 1986), p.182.
[5]See for example, M. J. Weiner, *The Decline of the Industrial Spirit* (Cambridge, 1981).
[6]M. Vlaeminke, "The Subordination of Technical Education in Secondary Schooling, 1870-1914", in P. Summerfield & E. J. Evans (eds.), *Technical Education and the State since 1850* (Manchester, 1990), pp.55-76.

acknowledged that there is great deal of merit in Vlaeminke's thesis, it will be argued that there are, nevertheless, dangers in arguments of this kind, given that much of the legislation which emanated from Whitehall was permissive. Although the State set the parameters of the education system, localities retained some autonomy in formulating the actual content of provision.[7] Thus, local education systems can be viewed as the product of negotiations between local business and local educationists on the one hand, and between these two groups and the State on the other. These negotiations would have produced variations in provision across the length and breadth of the country, but here I will focus upon a case-study of Sheffield, a key industrial centre of strategic importance to the British economy. In what follows, it will be argued that although Sheffield's education system was not ideal from a business perspective, it was not nearly as bad as the received wisdom would lead us to believe. Sheffield's forte was the quality of its higher technical education but this was undermined by quantitative and qualitative inadequacies in secondary education. These were not solved by State intervention and were, in some respects, even exacerbated, but not to the degree that Vlaeminke's thesis would suggest. This survey of the city's educational apparatus begins with a detailed examination of the Sheffield Technical School, which, in 1905, became the Applied Science Department of the new Sheffield University.[8] This institution warrants our close attention because, as chapter 2 argued, it grew out of business concern with foreign competition, and was deliberately established in order to meet industrial needs for more technically-educated personnel.

The Sheffield Technical School 1886 -1889.

From the outset, the Sheffield Technical School was divided into 2 departments: Engineering and Metallurgy. These were under the control of Professor W. H. Greenwood (Member of the Institute of Mechanical Engineers) and his assistant William Ripper (Associate of the Institute of Mechanical Engineers), both of whom had acquired industrial experience prior to embarking upon their teaching careers.[9] This experience enabled them to develop an engineering course which was eminently practical and tailored to the needs of local industry. However, neither Greenwood nor Ripper were metallurgical experts, and under Greenwood's administration the Engineering Department functioned far more effectively than its Metallurgical counterpart, which experienced acute difficulties in recruiting students. The greater importance attached to engineering was, in fact, manifested in the very design of the school. The metallurgical laboratory was consigned to the basement of a three-storey

[7]As will be argued later in this chapter, even after the Secondary Education Act of 1902, localities were still permitted to develop courses of secondary education that were especially tailored to their needs.
[8]Firth College, the Technical School and the Medical School were amalgamated in 1897 to form the University College of Sheffield, the Sheffield University was founded in 1905, SUA 5/1/33, Chapman Collection, papers relating to the history of the Department and Faculty of Metallurgy, p.1.
[9]Sheffield Technical School Prospectus, 1885-1886, p.300.

building, a location which scarcely lent itself to the effective dispersal of noxious chemical fumes.[10] Its equipment was typical of the period: miniature wind and muffle furnaces, benches and stench cupboards.[11] There were no Siemens, Bessemer or crucible furnaces which could be operated on a manufacturing scale, and the Metallurgy Department was, therefore, simply unable to meet the demands of business for a practical training in steel production (discussed in chapter 2).

The school's engineering equipment, on the other hand, was far more impressive. The large mechanics shop contained sliding, surfacing and screw-cutting lathes, a shaping machine and a vertical drilling machine; whilst the pattern shop contained a circular saw and a 6-inch treadle lathe.[12] Moreover, the whole of the school's upper storey was devoted to engineering-drawing, providing accommodation for 80 students and making it one of the largest drawing offices in the country at this time.[13] This equipment allowed manual instruction to be established as an integral component of the school's engineering education. Qualification for the full diploma could only be achieved by following an intensive 3-year syllabus, which incorporated a theoretical, testing and manufacturing dimension, and which is described in table 1.1.

Table 1.1: Sheffield Technical School's Engineering Syllabus

Year One	Focused upon: lectures in maths, plane geometry, elementary algebra, trigonometry, physics, chemistry and geometrical drawing, and provided for thirteen hours of laboratory and workshop instruction.
Year Two	Provided: further instruction in maths, advanced algebra, geometry, physics, metallurgy, and engineering drawing. In addition, students continued to receive 13 hours of laboratory and workshop instruction
Year Three	Focused upon: manual training and laboratory work, however, students were required to follow advanced courses in differential and integral calculus.

(Source: *Sheffield Technical School Prospectus, 1885-1886*, p.300.)

The syllabus for the diploma in metallurgy, which is described in table 1.2, was of 2-years duration and far less comprehensive.

[10]Formal Opening of the Sheffield Technical School, 1st February 1886, in SUA VIII/1/1, Sheffield Technical School Minute Book, no.1, p.144.
[11]*Ibid.*, p.144.
[12]*Ibid.*, p.144.
[13]*Ibid.*, p.144.

Table 1.2: Sheffield Technical School's Metallurgy Syllabus

Year One	Focused upon: chemistry, engineering drawing, maths, algebra, plane geometry and laboratory work; that is, the physical testing of materials.
Year Two	Focused upon: lectures on iron and steel, and devoted more than 5 hours per week to the testing of the physical properties of steel.

(Source: *Sheffield Technical School Prospectus, 1885-1886*, pp.300-301.)

As with the engineering syllabus, students could attend any of the lectures, but a certificate was only awarded to those students who followed the whole course and passed the necessary exams.[14] The brevity of the metallurgy course can be explained, in part, by the qualifications of the masters whose strengths and interests lay in engineering; however, other factors were also important. Firstly, in the 1880s, as chapter two emphasised, the theory of metallurgy was still very much in its infancy; indeed, metallurgy could only be regarded as an emerging sub-branch of chemistry and physics, rather than as a subject in its own right. Secondly, the metallurgical department was organised under South Kensington grant regulations, which forced it to remain at an elementary level and to concentrate upon theory rather than practice. A combination of insufficient experience, inadequate equipment, and restrictive external regulations therefore ensured that, prior to 1889, the metallurgical students' manufacturing activities were confined to the production of small metal buttons in miniature crucibles.[15] Thus, whilst the Engineering Department was closely in line with business needs, the Metallurgy Section was far from satisfying the hopes of businessmen who had provided financial support for the school.[16]

The Sheffield Technical School 1880-1914.

The year 1889, however, marked a watershed in the history of the school. In this year W. H. Greenwood resigned his post as Professor of Mechanical Engineering and was succeeded by William Ripper. J. O. Arnold, a metallurgical consultant with extensive

[14] *Sheffield Technical School Prospectus*, 1885-1886, p.300.

[15] *University of Sheffield Souvenir of the Opening of the New Engineering and Metallurgy Laboratories, September 1905* (Sheffield, 1905), p.15.

[16] By 1889 the Technical School had absorbed a total capital expenditure of £13,000, which was garnered from three key sources: private subscriptions totalling more than £6,000 (most of which came from local businessmen), grants from the Science and Art Department of South Kensington and student fees. As far as the Metallurgy Department was concerned businessmen were far from satisfied with the return on their investment, A. W. Chapman, *The Story of a Modern University*, (Oxford, 1955), p.69.

industrial experience, obtained the newly-created post of Professor in Metallurgy.[17] Under the control of Professors Ripper and Arnold, the Sheffield Technical School became much more closely geared towards industrial needs.[18] Indeed, there developed a very tight relationship between the school and the local business community.

The passing of the Technical Instruction Act of 1889 was a major boon for Ripper and Arnold, as it freed them from their reliance upon the science and art grants of South Kensington, the regulations for which had "resulted in the Department of Metallurgy having utterly broken down in efficiency" to the extent that Arnold's first lecture in 1889 was given to only "a single student."[19] In particular, the act allowed the Sheffield council to provide the school with a block grant. This grant was made upon the condition that the fees for evening classes were set low enough to allow artisans to attend, and the consequent reduction in fees led to a dramatic increase in the number of students in attendance.[20] The quantity of day and evening students and the qualifications they received will be considered later in this chapter, but for now I will focus upon the improvements that were made in the school's courses and equipment, beginning with a detailed examination of the developments in the Department of Metallurgy.

In 1890 the Sheffield Technical School pioneered a new form of metallurgical education "with a view to more thoroughly meeting the requirements of local industries"[21] This required important additions to the equipment of the school, in particular the erection of an experimental steel works. These works contained a 25-cwt open-hearth steel furnace, a 50-ton testing machine and numerous crucible steel furnaces. Together with pyrometers and other instruments of furnace control, this new plant finally enabled the school to provide a practical training in steel production, and

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[17]SUA VIII/1/1, p.245; Obituary Notice of J. O. Arnold, 1858-1930, in SUA 5/1/120, Chapman Collection, p.1; see also Chapman, *Modern University*, pp.74-78.

[18]Their success can be partly explained through reference to their abilities as teachers and their commitment to their subjects. However, the key reason for the success of the Ripper-Arnold partnership was its appreciation of industrial needs. Although Ripper's "early training in industry had not been long...he brought from it a...understanding of industrial attitudes of mind which enabled him to make easy and friendly contacts with manufacturers and workmen alike." Both Ripper and Arnold enjoyed working with industrialists and their contact with the city's manufacturers ensured that the education provided by the School after 1889 responded more readily to business requirements. Chapman, *Modern University*, p.75.

[19]Letter from Prof. Arnold to Sir William Clegg (Acting Chairman of the Sheffield University Applied Science Committee) 30th August 1916, in SUA 5/1/2 (ii), Chapman Collection, papers relating to the history of the Sheffield Technical School, vol.2, p.189.

[20]For the increase in student numbers, see table two in Appendix C; Chapman emphasises the importance of the funds provided under the Technical Instruction Act of 1889 and the Customs and Excise Act of 1890, Chapman, *Modern University*, pp.68-69, 73-74.

[21]*Sheffield Technical School Prospectus, 1891-1892*, p.34.

placed the Department of Metallurgy directly in line with business needs.[22] Significant improvements were also made in the metallurgical laboratory where new equipment allowed students to undertake "chemical examinations of both...steel...and refractory materials".[23] The Sheffield Technical School prospectus for 1890 proclaimed that this new equipment made the school "the most complete of its kind for teaching the practical manufacture, the chemical constitution and the physical properties of steel."[24] This, as we shall see, was no idle boast.

From 1890 down to World War One the "Sheffield System" of metallurgical education was praised as a model of effective technical instruction by informed opinion, both at home and abroad. For example, one of the nation's leading educationalists, Mr B. H Thwaite, claimed that the school possessed a "unique plant...for the manufacture of steel...for the moulding of iron and steel in the forms of industry...(and)...for the physical, thermic and chemical analysis of the raw materials and the finished product."[25] He argued that this marked a significant advance on, what he referred to as, the "old-style metallurgical education" which simply consisted of attendance at "a series of lectures and laboratory work" based upon "analytic procedures".[26] The Sheffield system was, Thwaite considered, far superior, because although "the reactions and...chemical phenomena that occur in the treatment of small proportions ...on a laboratory scale are undoubtedly indices of those that occur in...actual industrial practice; they are only indices (and) everyone knows full well that actual practice includes a knowledge of conditions and events never dreamed of nor allowed for in the laboratory".[27] It followed therefore, that training on equipment which was "an actual copy of the appliances and practical modus operandi of the best systems of steel manufacture" would prepare the students more effectively for the world of work.[28] Thwaite's report concluded that "after falling behind the continent in terms of educational provision, Britain had in recent years...equalled and in some branches of industrial education eclipsed the Continental 'Ecoles techniques" and the Sheffield Technical School was "one of the most pre-eminent examples" of this convergence.[29]

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[22]*Ibid.*, pp.34-35; W. Ripper and J. O. Arnold, "The Application of Science to the Steel Industry", in W. Porter (eds.), *Sheffield 1910, British Association Handbook and Guide* (Sheffield, 1910), p.256.
[23]*Ibid.*, p.34; see also, *University of Sheffield Souvenir, 1905*, p.15.
[24]*Ibid.*, p.35; according to Ripper, Sheffield had "the most complete school of practical metallurgy in existence", SUA VIII/1/1, p.363.
[25]B. H. Thwaite examined the Sheffield Technical School on behalf of the Iron and Steel Institute, B. H. Thwaite, "The Metallurgic Department of the Sheffield Technical School", *Journal of the Iron and Steel Institute*, part 2, (1891), pp.93-112, see esp. p.93.
[26]*Ibid.*, p.93.
[27]*Ibid.*, pp.93-94.
[28]*Ibid.*, p.94.
[29]*Ibid.*, p.93.

The equipment introduced into the Metallurgy Department allowed students to "enter upon a course of scientific metallurgical training of immediate practical utility."[30] Students were permitted to take up any part of the syllabus, but the associateship in metallurgy, (the equivalent to a BSc honours degree from London University) was only awarded to those day or evening students who followed all of the syllabus, which is described in table 1.3, and passed the necessary exams.[31]

Table 1.3: Sheffield Technical School's Improved Metallurgy Syllabus

Year One	Focused upon: maths, physics, chemistry, geology, mineralogy, iron and steel lectures, mechanical drawing, and the manufacture, physical and chemical analysis of crucible steels. Students were required to make a correct analysis of the materials to be melted, and once they had manufactured the steel they tested it in order to ascertain which kind of tool or task it would be most appropriate for.
Year Two	Focused upon: fuel and refractory materials, maths, physics, chemistry, mechanical drawing and the manufacture and analysis of open-hearth steels.
Year Three	Focused upon: advanced courses in geology, mineralogy, maths, applied mechanics, and mechanical drawing. Students gained further experience in the manufacture and testing of crucible and open-hearth steels. However, the key focus was upon the manufacture and analysis of specialist alloys, such as manganese steel, and research under the supervision of Professor Arnold.

(Sources: *Sheffield Technical School Prospectus, 1891-92*, pp.34.-36; *Sheffield Technical School Metallurgical Society Journal, 1891-92*, pp.8-9.)

The training provided in the manufacture and uses of different steels was vitally important to Sheffield's bespoke manufacturers, who tailored their production to closely-defined customer requirements. Moreover, as chapter 4 will argue, in the 3 decades prior to World War One Sheffield suffered from an unprecedented expansion of foreign competition, and the development of specialist alloys became essential to its survival as a steel-making centre. The focus upon the manufacture and analysis of specialist steels in the metallurgy programme meant that the school was in close synchronisation with business needs and provided "those who went faithfully through

[30]*Sheffield Technical School Prospectus, 1891-1892*, p.35.
[31]*Ibid.*, p.35; see also a letter written by Prof. Arnold, 15th November 1918, in SUA VIII/127/2, Prof. Arnold Letter Book, vol.2, p.30; see also Chapman, *Modern University*, pp.79-80.

the complete course" with "a training which allowed them to become thoroughly scientific makers and manipulators of steel."[32]

In their practical training the students were supervised by workers from local firms who oversaw the running of the furnaces. The students theoretical studies were therefore accompanied by an in-depth process of learning by doing under the expert tuition of Sheffield's skilled melters.[33] In the operation of the Siemens furnace, for example, the students worked in gangs alternating between charging, pit work and analysis.[34] The benefits of this system were two-fold. Firstly, it prepared students for the strong emphasis which local firms placed upon team-work and enabled them to develop the interpersonal skills required for effective co-operation. Secondly, it allowed the academic staff and skilled workers to observe the students at work and ascertain where their strengths and weaknesses lay: in particular, whether a student would be better placed in industry as a furnaceman, analyst or researcher.[35] The Metallurgy Department focused upon research: Professor Arnold allowed final year students to assist him in his experiments, taught them research methods and raised them above the level of the routine analyst.[36] Through his research Arnold was able to make significant contributions to metallurgical knowledge, particularly in the important field of specialist alloys, and students must have benefited enormously from working under him.[37] Local businessmen argued that the research and manufacturing experience gained by Arnold's students was worth all the books on the subject.[38]

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[32]*Sheffield Technical School Metallurgical Society Journal, 1891-92*, pp.7-8. It is frequently argued that "Britain tried to live through the 'second industrial revolution' with the tools of the first", but the syllabus of the Sheffield Technical School was clearly geared towards providing the science-based skills required by specialist steels, which were key products of the 'second industrial revolution', for a review of the thesis that Britain lagged behind her competitors in developing new skills, see J. P. Hull, "From Rostow to Chandler to You: How Revolutionary was the 'Second Industrial Revolution'", *Journal of European Economic History*, vol.25, no.1, (Spring 1996), p.204.
[33]SUA 5/1/33, p.5, 8.
[34]*Ibid.*, p.94.
[35]*Ibid.*, p.94.
[36]Her Majesty's inspectors praised the teaching of research methods, Her Majesty's Inspectors Report on the Sheffield University Applied Science Department, July 1910, in SUA VIII/1/2, Sheffield Technical School Minute Book, no.2, p.478.
[37] Thwaite, "Sheffield Technical School", p.107; Chapman, *Modern University*, p.76. As a result of the researches of Arnold and other scientists the theory of metallurgy grew rapidly in the 1890s. In consequence, it became increasingly difficult to cover the whole syllabus for the associateship in 3 years of evening classes and, in 1900, the course was extended to 4 years. From 1897 onwards, students could sit for London University degrees and, in 1905, when the University College became the Sheffield University, the Department of Metallurgy was enabled to grant its own degrees. The degree course was to all intents and purposes identical to the associateship, a fact which pays tribute to the quality of the latter qualification which continued to be offered to students who, though capable of university work, had not matriculated and were therefore ineligible to qualify for degrees, SUA 5/1/33, p.1; SUA VIII/1/2, p.137; Letter from Prof. Arnold to Sir William Clegg (Acting Chairman of the Sheffield University Applied Science Department), August 30th 1916, in SUA 5/1/2 (ii), p.189.
[38]SUA 5/1/33, p.95.

A major factor in the success of the Metallurgy Department was Arnold's insistence that plant and equipment should be kept right up-to-date. In 1902, for example, the school's initial plant was extended by the purchase of a steel works in Charlotte Street.[39] This enabled the school to improve its technology through a process of electrification, and facilitated the installation of a Tropenas-blown Bessemer furnace, which was ideal for the manufacture of large steel castings in which local firms such as Edgar Allen's specialised.[40] By 1903 it was generally recognised that the Metallurgy Department had excellent, perhaps even unique, facilities.[41] Michael Sadler believed that its equipment and courses were the best in the world, a view shared by a group of German businessmen and educationists, who following a visit to the school in 1905, wrote in the Cologne Gazette that "we are always told by the English...that they are behind Germany in their educational advantages, but what we have seen in Sheffield, in the Technical Department of their university, leads us to believe that we Germans can learn a lot from them".[42]

The quality of the plant and equipment was not only maintained down to World War One, but was augmented. A notable improvement was made in 1909, with the installation of an electric arc furnace.[43] These furnaces had been widely used on the continent, but were conspicuous by their absence in Sheffield. Local businessmen were beginning to recognise that these furnaces produced steels of an equivalent quality to their lower-grade crucible varieties but at a much cheaper price. They therefore contributed to the cost of the furnace and worked closely with Arnold in his experiments with the result that, as chapter 4 will argue, Sheffield became a major producer of electric automobile steels.[44]

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[39]The local steel manufacturer, Sir Frederick Thorpe Mappin, paid £1,500 towards the cost of these works, SUA VIII/1/2, p.173.

[40]*Ibid.*, p.173. Ripper & Arnold, "The Steel Industry", p.256.

[41]In July 1910 Her Majesty's Inspectors concluded that "the equipment for metallurgical training and research is unique", Her Majesty's Inspector's Report on the Sheffield University Applied Science Department, July 1910, in SUA VIII/1/2, p.478; see also, *Sheffield University Souvenir, 1905*, p.19.

[42]M. E. Sadler, *Report on Secondary and Higher Education in Sheffield* (London, 1903), p.14; extracts taken from the article in the Cologne Gazette are contained in SUA 5/1/33, pp.6-7.

[43]SUA VIII/1/2, p.404.

[44] This achievement pays testimony to the tight relationship that emerged between the Metallurgy Department and the local business community. The Metallurgy Department not only provided industry with well-trained students but also provided a scientific advisory service for local manufacturers, and ran tests on their behalf (so long as the tests involved some question of fundamental scientific importance or were required for the purposes of law). The relationship between the university and its local industries was tempered by the university's activities during World War One, when it trained large numbers of women in the turning of shells. During the War, Arnold worked even harder than usual and it was perhaps inevitable that his "super-human efforts should eventually take their toll", thus in 1919 "following a complete nervous collapse", he resigned his post as Professor of Metallurgy. However, one of his final acts in 1917 had been to establish the Department of Metallurgy as a Faculty in its own right, SUA VIII/1/2, p.441; SUA VIII/1/3, Sheffield University Department of Applied Science Minute Book, no.3, pp.41, 64; SUA 5/1/33, pp.40-44.

After 1889 the equipment and syllabus of the Metallurgy Department was much more closely geared towards industrial requirements, but what of Engineering? During the 1890s, William Ripper endeavoured to ensure that the department remained responsive to business needs. In 1891 the course for the associateship was very similar to that of the 1880s. It extended over three years and continued to include lectures, experimental laboratory work, and practical training in the workshops and drawing offices.[45] In order to support this practical instruction the Engineering Department had acquired an impressive range of state-of-the-art equipment. The laboratory was fitted with a vertical tubular steel boiler, which worked to 100lbs pressure per square inch, a compound steam engine, a Stockport gas engine, dynamometers, draught gauges and a 50-ton Buckton testing machine designed to determine the strength of materials through tension, compressing and twisting tests. The Machine and Fitting workshop contained a comprehensive range of sliding, surfacing and screw-cutting lathes, whilst the drawing office remained one of the largest and best-equipped in the country.[46] It was these facilities which, as B. H. Thwaite argued, allowed the engineering students to construct a compound marine engine "from the graphic inception on the drawing board to the indicative and exhaustive test of the actual completion".[47]

However, the strategy of providing practical training on the latest equipment came under pressure as the rate of technical change within the industry hastened, and by 1900 the Engineering Department had clearly fallen behind best practice techniques. In particular, Ripper acknowledged that many of the tools in the workshop were " ...of...an antiquated type" and that if the technical school was "to hold a front rank position" it was "necessary that improved equipment should be provided."[48] He therefore requested a sum of £1,160 in order to purchase "a small selection of the best classes of machine tools" which were needed to support "a carefully planned and thorough course of instruction in their design and use."[49] Typically in the pre-war period Ripper got what he asked for, and a full list of the equipment, which included a 6-inch centre sliding, surfacing and screw-cutting lathe on the leading Model II Loewe pattern, is contained in table one, in Appendix C.[50] In requesting these machines, Ripper displayed an acute sensitivity to Sheffield's industrial needs. The key feature of the tools he ordered was "their adaptability to all kinds of special work and the great accuracy

[45]*Sheffield Technical School Prospectus, 1891-92*, p.22.
[46]*Ibid.*, pp.22-23; see also, Chapman, *Modern University*, p.70.
[47]Thwaite, "Sheffield Technical School", p.107.
[48]Statement by Professor Ripper, 12th February 1900, in SUA VIII/1/2, p.120.
[49]*Ibid.*, p.120.
[50]Ripper's request was approved on 14th March 1900, *Ibid.*, p.120, 128. In the depressed conditions of the inter-war years, however, as chapter 6 will argue, economies in educational expenditure resulted in the equipment in both the Metallurgy and Engineering Departments of the university falling behind best practice techniques.

and refinement of the work which may be done with them."[51] For Sheffield manufacturers, many of whom, as Chapter 4 will argue, were batch producers and flexible specialists operating in high-quality niche markets, the recruitment of an engineer who had been trained, not only to use, but also to design these tools, provided an obvious competitive advantage.[52]

The course of study in the Engineering Department remained much the same throughout our period. The associateship was improved by allowing third-year students the option of specialising in either mechanical, civil or electrical engineering, and in 1917 these disciplines were established as distinct departments within the new Faculty of Engineering.[53] As with metallurgy, students were required to pass the matriculation examination before they could sit for the degree, but the associateship continued to be available to students, who, though capable of degree work, had not matriculated.[54] The major course innovation of the period, however, was the introduction of the work's pupils' certificate. This qualification was open to engineering students who worked in local firms and who obtained their university education on a sandwich-system. Two companies in particular, made extensive use of this scheme, these were: Vickers (a leading armaments firm) and Davy Brothers (a producer of steam engines and hydraulic presses), and chapter 4 explores how these firms integrated the work's pupils course into their human resource strategies.[55] However, I will now examine the number of students that were coming through the Sheffield Technical School and the type of awards that they received.

As table two in Appendix C shows, by far the vast majority of students at the technical school acquired their education through evening study. Although such students were

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[51] *Ibid.*, p.120.

[52] Following this re-equipment in 1900, the Engineering Department remained more or less up-to-date, indeed a report for the Board of Education, written by Dr. J. A. Ewing (Director of Naval Education for the Admiralty) and an HMI Report published in July 1910, considered that the department was "well housed in rooms which" were "spacious and well arranged" and that "in nearly all divisions of engineering the equipment" was "remarkably good", Dr. J. A. Ewing, Report to the Board of Education on visits to the Engineering Department of Sheffield University, in SUA VIII/1/2, p.491; Her Majesty's Inspectors Report on the Sheffield University Department of Applied Science, July 1910, in SUA VIII/1/2, p.478.

[53] *Sheffield University Souvenir, 1905*, p.19.

[54] Degrees were awarded from 1897 onwards, SUA VIII/1/33, p.1.

[55] The number of work's pupils' certificates awarded before 1919 was small (see table three in Appendix C). Thus many students followed the course without qualifying for the certificate. However, this does not mean the education they received was of no value. The Work's pupils' certificate required students to spend 6 months in a local engineering firm and 6 months in the Applied Science Department for a period of 3 years and pass the necessary examinations, SUA VIII/1/2, p.529. It is clear that, after 1889, the Technical School was geared towards the needs of the specialist steel, armaments and heavy engineering firms. However, prior to World War One, it had little contact with the cutlery sector. Nevertheless, as chapter 8 will argue, this sector developed closer links with the University and the Technical School of Art during the inter-war years.

allowed to study for the associateship and degree courses, only a minority of them progressed beyond the intermediate stages of the City and Guilds.[56] Full-time day students were better placed to obtain the higher awards, but the number of day students increased only slowly during our period and remained a very small proportion of the whole; moreover, up until 1896, the figures for day students were swollen by the Junior Technical Department, which focused upon elementary physics and chemistry.[57] Not surprisingly, therefore, as table three in Appendix C illustrates, the number of metallurgy and engineering graduates/associates turned out by the Sheffield Technical School prior to 1919 was rather small. Indeed between 1897 to 1919 the university, on average, only made 18.27 awards each year. In this respect, Sheffield University was not atypical. It has been claimed that one feature which the civic colleges had in common was the slow rate of growth in the number of candidates taking degree courses.[58] Historians such as Roderick and Stephens, have linked this phenomenon to the absence of an effective system of primary and secondary education, which they argue forced the civic colleges to deliver the vast majority of their lectures at a sub-degree level.[59] It is, therefore, to an examination of these 2 sectors of Sheffield's education system that I now turn.

Elementary Education 1870-1914.

The Education Act of 1870 required the election of local school boards which were to fill the gaps in existing elementary school provision.[60] In 1870 there were approximately 40,000 children in Sheffield who required an elementary education, but the city's schools provided accommodation for only 28,000.[61] The Sheffield Board was therefore forced to embark upon a large-scale building programme. By 1873, it had built 12 additional schools, and by the 1880s sufficient places were available for all the

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[56]Less than a third of students went on to take the more advanced courses, SUA VIII/1/2, p.175.

[57]In 1890, Professor Ripper reported that provision had been made for a "2 year preparatory course of instruction for students between 14 and 16 years of age...The instruction given would be of a practical character consisting largely of work in the laboratories and workshops...giving the boys an interest in work requiring manipulative skill rather than a desire to become office boys", Opening Meeting of the Junior Day Department, 4th January 1890, in SUA VIII/1/1, p.264; see also Chapman, *Modern University*, pp.77-78.

[58]G. W. Roderick & M. D. Stephens, *Education and Industry in the Nineteenth Century: The English Disease* (London, 1978), p.97.

[59]G. W. Roderick & M. D. Stephens, Scientific and Technical Education in Nineteenth Century England: a Symposium, (Plymouth, 1972), p.44.

[60]H. K. Hawson, *Sheffield: The Growth of a City, 1893-1926* (Sheffield, 1968), pp.70-72.

[61]Initially applied to children between the age of 5 and 10, 350/E5/1, Sheffield School Board Minute Book, vol.1, p.55; see also, J. H. Bingham, *The Sheffield School Board, 1870-1903* (Sheffield, 1949), pp.7-9; W. H. G. Armytage, "Education in Sheffield", in D. L. Linton (eds.), *Sheffield and its Region: A Scientific and Historical Survey* (Sheffield, 1956), p.205; J. Derry & G. S. Baxter, "Elementary and Secondary Education", in Porter (eds.), *British Association Handbook*, p.160.

city's children.[62] The education provided in these schools was organised in accordance with the standards set by the state department for education. These standards ranged from one to seven. Each demanded an increased level of skill in the 3 "R"'s, and in addition the pupils were also required to study subjects such as science and technical drawing (see tables four A, four B and four C in Appendix C)

The quality of education provided in the city's schools was generally good. Informed contemporaries, such as M. E. Sadler, considered that the Sheffield School Board was one of the most successful, both in terms of the quantity and quality of its elementary school provision: a view which has been supported by historians such as David Fines, who have claimed that until World War One Sheffield's elementary school system was more than satisfactory.[63] Sheffield does not then fit with Roderick and Stephens' picture of poor elementary education. The city's schools were producing pupils who, not only had a sound understanding of the 3 "R"'s, but also some elementary scientific knowledge; that is, pupils with the educational prerequisites which chapter 2 identified as a necessity for further technical education.[64] However, in what follows it will be argued that Sheffield's day secondary education system was far from ideal. The development of the city's secondary school system is considered in 3 sections, divided chronologically viz.: 1880 to 1897, 1897 to 1904 and 1904 to 1914. It will be argued that provision prior to 1897 suffered from both quantitative and qualitative deficiencies, and that decisions taken by local and national government during the period 1897 to 1904 did little to solve these deficiencies; rather, by and large, they compounded them.

Secondary and Technical Education 1880-1900.

As Eaglesham has argued, some elementary school children were able to complete the 7 standards long before reaching the minimum school leaving age, which was raised from 10 to 11 in 1893 and to 12 in 1899.[65] Prior to 1880, therefore, all of Sheffield's elementary schools were forced to provide 'higher elementary tops' for their most intelligent pupils, who received more advanced instruction in subjects such as

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[62]M. Mercer, "Education in Sheffield: Early Provision, 1843-93", in C. Binfield et al (eds.), *The History of the City of Sheffield, 1843-93: vol.2, Society* (Sheffield, 1993), p.306; J. J. & A. J. Bagley, *The State of Education in England and Wales, 1833-1968* (New York, 1969), p.28.

[63]Sadler, *Secondary and Higher Education*, p.13; D. Fine, *Sheffield History and Guide* (Gloucestershire, 1997), p.81.

[64]National statistics suggest that by 1891 literacy rates were 94% for males and 93 % for females, given that Sheffield elementary schools were considered to be amongst the best in the country, we can assume that the essential prerequisite for technical education, identified in chapter 3, a literate population, had been more or less secured by the late 1880s, J. Lawson and H. Silver, *A Social History of Education in England* (London, 1973), p.324.

[65]E. J. R. Eaglesham, *The Foundations of Twentieth Century Education in England* (London, 1967), p.12; Bagley, *State Education*, p.28.

engineering science and mechanics.[66] However, the teaching of these subjects to a few pupils in numerous schools was not considered cost effective and, in 1880, the Sheffield Board established a Central Higher Grade School which was to provide intelligent pupils with a more technically-oriented curriculum. Although the school also provided elementary instruction in the 3 "R"'s, the majority of the timetable focused at a more advanced level, and pupils were encouraged to remain in attendance long after the minimum leaving age.[67] The Sheffield Central Higher Grade School was, therefore, essentially a secondary school of a distinctly technical and vocational type.[68] It will be argued that this school developed a curriculum which was closely in line with business needs, and that had it been allowed to develop free from State intervention, it may well have become an even more important source of technical and commercial personnel for the city's industries, and of students for the university's associateship and degree programmes.

The Sheffield Central Higher Grade School

Prior to joining the academic staff of the Sheffield Technical School, in 1884, William Ripper held the position of Science Master at the Sheffield Central.[69] He ensured that the school met business demands for a combination of theoretical and practical instruction. Indeed, he persuaded local businessmen to equip the school's workshop with the most up-to-date tools.[70] The Royal Commissions of both 1884 and 1895 considered that these tools enabled the school to provide a blend of theoretical and practical instruction that was "the finest thing of its kind in the country" and encouraged other boards to emulate the precedent set by Sheffield in establishing a higher grade school[71]. In particular, the commissioners considered that technical drawing was thoroughly taught and provided a good foundation for workshop instruction. In the workshops the pupils were taught how to use tools, in order to make correct geometric forms, and they acquired a detailed working knowledge of model making. This instruction was deliberately designed to enhance the pupils motor skills, and inculcate capabilities that "would be useful whatever trade they might follow" and it complimented the more theoretical studies in geometry, maths, chemistry, electricity and magnetism, thus ensuring that the pupils education was not too bookish.[72]

[66]Eaglesham, *Education in England*, pp.13-14.
[67]Bingham, *Sheffield School Board*, pp.174-175, 181-182; Eaglesham, *Education in England*, p.14.
[68]*P. P., 1884, The First Report of the Royal Commission on Technical Instruction, 1882-1884*, p.496.
[69]Bingham, *Sheffield School Board*, p.249.
[70]*P. P., 1884, The Second Report of the Royal Commission on Technical Instruction, 1882-1884*, p.561; Bingham, *Sheffield School Board*, pp.181-182.
[71]*1st Report of the Royal Commission on Technical Instruction 1882-1884, p.539; P. P., 1895, Royal Commission on Secondary Education 1895, vol.6, Assistant Commissioners Reports*, p.172.
[72]*2nd Report of the Royal Commission on Technical Instruction 1884*, p.559.

The quality of the practical training appears to have been of a very high standard. For example, in 1884 it was reported that "some of the pupils work...would as specimens of exactness and precision compare favourably with the productions of apprentices of many years standing."[73] In 1885, the school took steps to improve this practical instruction, by developing an additional laboratory and an up-to-date machine drawing room, and it became organised as a science school developing a 3-year syllabus, which allocated more than 15 hours per week to scientific studies.[74] Later in 1889, the school received additional funds through the Technical Instruction Act and this enabled it to develop even more laboratories and workshops.[75] This investment facilitated further improvements in both the quantity and quality of the manual instruction which the school provided, and allowed it to extend its evening classes, which were especially geared towards the needs of apprentices and artisans.[76] In addition, the Technical Instruction Act also provided funds for the development of commercial education and enabled the school to begin to meet business demands for subjects such as shorthand, which from the late 1880's onwards, as chapter 2 argued, became increasingly insistent.[77] For example, in 1892, in response to a petition from the Sheffield Chamber of Commerce, the school split its classes into two sections: technical and commercial. On the commercial side, it focused upon classes in modern languages, commercial arithmetic, shorthand, book-keeping, commercial geography and business methods. Such subjects were designed to provide the students with both "the general culture and the special knowledge requisite...for successful careers either at home or abroad."[78]

By 1892 the school was in tune with industrial needs and a close relationship was beginning to emerge between the institution and local business. Unfortunately, however, the Sheffield Central was the only day 'secondary' school within the city that was remotely concerned with the human resource requirements of manufacturing industry. As the Royal Commission of 1895 pointed out, prior to the establishment of this school, there was no institution of any kind with a laboratory in which practical work could be effectively taught.[79] Neither of Sheffield's other day secondary schools, the Sheffield Grammar School and Wesley College, had developed a significant scientific or commercial bias in their curricula.[80] As chapter 2 argued, the inability or

[73]*Ibid.*, p.563.
[74]Letter from Science and Art Department of South Kensington to the Sheffield School Board, 8th December 1885, in 350/E2/2, Sheffield School Board Minutes and Committee Reports, vol.2, p.25; Report of Sheffield School Board, May 20th 1886, in 350/E2/2, p.181; Bingham, *Sheffield School Board*, p.183; Eaglesham, *Education in England*, p.19.
[75]Mercer, "Education in Sheffield", p.309.
[76]*2nd Report of the Royal Commission on Technical Instruction 1884*, p.565.
[77]Bingham, *Sheffield School Board*, p.183.
[78]Report of School Board for month ending July 21st 1892, 350.E2/8, Sheffield School Board Minutes and Committee Reports, vol.8, pp.278-279.
[79]*P. P., 1895, Royal Commission on Secondary Education, vol. 3, 1895*, p.86-88.
[80]*Ibid.*, p.88.

unwillingness of these schools to develop a commercial curriculum proved a source of frustration for local businessmen, disappointed with their classical orientation. Local industry was therefore very much reliant upon the Sheffield Central to deliver its human resource needs, but it simply could not provide the quantity of recruits that it required, nor could it provide the Technical School with sufficient recruits for its associateship and degree courses.[81] The Technical School was therefore forced to provide a lot of the preparatory work itself, in evening classes, and in a Junior Day Department which was established in 1890.[82] Thus, from a business perspective, there were, in 1897, clear quantitative and qualitative deficiencies in the city's day secondary school provision. In the next section it will be argued that the decisions made by both local and national government over the next 7 years, exacerbated, rather than ameliorated, these deficiencies.

The Development of the Secondary Education System 1897-1904.

In 1897 the Sheffield Council urged the School Board to exercise economies in educational expenditure, through a reorganisation and rationalisation of the education system. In particular, it demanded that the 'unnecessary' duplication of classes at different institutions be avoided.[83] Under the scheme devised by the School Board, the Technical School was forced to pass its small classes in French, German and shorthand, over to the Central School, and to abandon its Junior Day Department, on the understanding that the Central Higher would provide a steady flow of recruits for its associateship and degree courses.[84] However, disbanding the Junior Day Department proved a mistake, as the Central Higher was not significantly extended after 1897 and, therefore, simply could not provide the Technical School with many more recruits than in the past.[85] In addition, it was soon recognised that the Central School alone could not meet the growing business need for linguistic education and, therefore, as chapter 2 argued, businessmen were forced to fund new chairs in French and German at the Sheffield University.[86]

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[81]On average about 1,000 pupils (approx. 500 boys and 500 girls) attended the Central Higher Grade School, CA 681/8/3, Sheffield School Board Annual Report, Nov. 1898 to Nov. 1899, p.8.
[82]Professor Ripper reported that "A large proportion of the time of the teaching staff...has been wasted in the teaching of subjects which should properly have been dealt with before commencing on an advanced course of technical study", SUA VIII/1/2, p.175.
[83]SUA VIII/1/2, meeting 7th Jan. 1897, p.4; see also CA 681/8/1, Sheffield School Board Annual Report, Nov. 1896 to Nov. 1897, pp.9-10.
[84]SUA VIII/1/2, p.4.
[85]*Ibid.*, p.234; see also Chapman, *Modern University*, p.78.
[86]SUA 5/1/20, Chapman Collection, papers relating to the teaching of Modern Languages, p.8.

Unfortunately, the problems created by this local reorganisation were compounded by the actions of the Minister of Education and his junior secretary, Robert Morant. He devised a plan to simplify the administration of education throughout the country by creating local education authorities which were to be given full control of both elementary and secondary education in their areas.[87] Morant recognised that the school boards and, in particular, the higher grade schools, such as the Sheffield Central, stood in the way of his goal and he therefore resolved to eliminate them.[88] One method used was the 'Higher Elementary School Minute', issued on the 4th of April 1900. Under this minute, higher grade schools were only allowed to continue if they converted to higher elementary Status. The conditions for the conversion were made so severe that very few schools could adapt. The minute stipulated that higher elementaries must not be commercial schools, must admit pupils only up to the age of 15, and that these pupils must be of sufficient ability to benefit from the education provided for them, but not so intelligent that the schools competed with traditional grammar schools.[89]

The Sheffield Central was one of a very few schools to convert, and this conversion had a severe impact upon its capacity to meet the needs of local industry. For example, the school was forced to eliminate commercial subjects from its curriculum. Although it endeavoured to provide some commercial instruction by integrating commercial correspondence into its classes in writing and composition, the school authorities were forced to admit that the Higher Elementary Minute had seriously impaired their ability to deliver business needs for commercial personnel. In addition, they acknowledged that since the Central School could not now admit pupils over 15 years of age, and the Technical School could not admit pupils under the age of 16, they were unable to meet their pledge to supply the university with well-trained recruits.[90]

Not only were these complaints ignored, but Morant exacerbated the school's problems. In order to destroy the evening work of the nation's higher elementary schools, he engineered affairs so that an auditor was given details of the London School Board's expenditure on higher education, together with a report which he had written explaining why such expenditure was illegal. The auditor concluded that by raising rates for funding education other than elementary, the London School Board had acted

[87]Prior to the 1902 Education Act, the administration of education was confusing, see Eaglesham, *Education in England*, pp.24-25, 28, 41.
[88]*Ibid.*, p.41.
[89]*Ibid.*, p.33.
[90]See letter from the Board of Education to the Sheffield School Board, 18th October 1900, and Report of the Central Higher School Sub-committee, 20th October 1900, both in 350/E2/16, Sheffield School Board Minutes and Committee Reports, vol.16, pp.2011, 2016; see also The Humble Petition of the Sheffield School Board, 14th Feb. 1901, in 350/E2/17, Sheffield School Board Minutes and Committee Reports, vol.17, pp.77-79.

unlawfully, and his decision was upheld in the Court of Appeal.[91] This, as Eaglesham claims, "dealt a mortal blow to school board ambitions throughout the nation", since it established, first, that school boards could not use the rates to finance education that was higher than elementary, and second, that they could only educate children, so that evening education was out of the question.[92] The Sheffield School Board regarded the decision as a "national calamity" and informed the Board of Education, "That in view of the judgement...there was a danger that the work of the...higher grade schools would be seriously interfered with if not absolutely prevented."[93] However, this was precisely what Morant wanted and it paved the way for the 1902 Education Act, which I will now discuss.

The 1902 Education Act abolished the school boards, and established counties and county boroughs as local education authorities responsible for all of the elementary and secondary schools in their areas.[94] Regulations issued two years later, required these secondary schools to provide a general education and not confine development to a particular channel, whether that of pure and applied science, or commerce. In order to secure a general liberal curriculum, the Board of Education required that not less than 4.5 hours per week be allotted to English and the humanities, and not less than 3.5 hours per week to a language other than English. These regulations stipulated further that, where two languages were taught and Latin was not one of them, the board would have to be convinced that the omission of Latin was to the advantage of the school.[95]

Historians of education have generally taken a dim view of these regulations. Curtis, for example, regards them as "a missed opportunity", in so far as "they envisaged only one form of secondary education that was academic in orientation."[96] Dent has argued that thanks to Robert Morant the idea that secondary education was inclusive of technical education was rejected, and Eaglesham considers that "the technical tradition of the old higher grade schools was eliminated from the curriculum of secondary schools as Morant banished pre 16 specialisation."[97] Economic historians have been even more scathing. Vlaeminke, for example, claims that "under Morant technical subjects were constantly under attack" and that "commercial and manual instruction were even more out of favour." Barnett claims that "technical education at a lower level was actually

[91] Eaglesham, *Education in England*, p.34.
[92] *Ibid.*, pp.34-35.
[93] 350/E2/17, pp.77-79.
[94] Eaglesham, *Education in England*, p.48.
[95] *Ibid.*, p.59.
[96] S. J. Curtis & M. E. A. Boultwood, *An Introductory History of English Education Since 1800* (London, 1960), p.172.
[97] H. C. Dent, *1870-1970: Century of Growth in English Education* (London, 1970), pp.72-73.

destroyed"[98], whilst Pollard argues that, "the act of 1902 throttled the promising developments foreshadowed by the central schools, and drove secondary education in an elite classicist direction."[99] Indeed, Pollard considers that it was "probably the last time" that "arrogant blinkered men of liberal education managed to damage so severely the contribution that education might make to the country's economic progress and well being."[100] The general consensus, therefore, is that after 1902 "technical education at all levels suffered a period of relative neglect, or at best, slow evolution and at the secondary level the picture was particularly bleak."[101]

There can be no doubt that Morant particularly disliked commercial education and sought to discourage its inclusion in the curriculum of day secondary schools. He even made the extraordinary claim that day classes, in subjects like shorthand and book-keeping, had been one of England's greatest educational misfortunes.[102] Equally, there can be no doubt that he preferred specialisation to occur after the age of 16, and that he considered a classical curriculum to be superior to all others, but, nevertheless, did Morant's regulations 'destroy' or 'reject' technical and manual instruction as has been frequently argued? That is, did they allow for only one type of education that was classical and academic in orientation? In what follows it will be argued that although the received view has very much to recommend it, in the case of Sheffield, at least, it requires some revision.

Secondary Education 1904-14'

There was, in Morant's regulations, a caveat which has been largely overlooked in the literature, but which ensured that the secondary education developed after 1904 was not of only one type. Secondary schools were allowed to devise a "special course of instruction in science", provided that the Board of Education was satisfied that the course was "specially suitable" to the needs of a particular locality.[103] Schools which offered these 'special courses' were required to provide education in two distinct branches of science. Indeed, science was to absorb no less than 13 hours of the weekly timetable. This caveat therefore "permitted those secondary schools which obtained the board's approval to provide a course of advanced science for some of their pupils, while

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[98]M. Vlaeminke, "Technical Education", pp.70-73; C. Barnett, "Long-Term Industrial Performance in the U. K.: The Role of Education and Research, 1850-1939", in D. Morris (eds.), *Economic System in the U. K.* (Oxford, 1985), p.679.
[99]S. Pollard, *Britain's Prime and Britain's Decline: The British Economy, 1870-1914* (London, 1989), p.168.
[100]*Ibid.*, p.168.
[101]Vlaeminke, "Technical Education", p.73.
[102]Quoted in Eaglesham, *Education in England*, p.63.
[103]E. W. Jenkins, *From Armstrong to Nuffield: Studies in Twentieth Century Science Education in England and Wales* (London, 1979), pp.9-10.

retaining a more general curriculum for the remainder."[104] In effect then, the schools were allowed to develop a science side and could claim additional grants to support this.[105] It will be argued that by exploiting this caveat, the Sheffield Central Secondary School was able to offer some students a scientific curriculum that was not dissimilar to that provided by its nineteenth-century antecedent, the Sheffield Central Higher Grade School. Nevertheless, day commercial instruction was not so well provided for, and it was here that the negative effects of the 1904 regulations were most keenly felt.[106] Fortunately however, regulations for evening schools issued in 1903 permitted the study of commercial subjects, and it will be argued that the Central Secondary Evening School was able to develop a flourishing commercial section, which compensated for inadequacies in the day curriculum.[107] However, whilst the account presented here is slightly more optimistic than the bleak picture of the received wisdom, it will be emphasised that the 1904 regulations did create a number of problems. In particular, they built two pernicious assumptions into the secondary system. The first was that the vast majority of the working class could not benefit from secondary education, and the second, that a classicist curriculum was far superior to a technical one, which was accorded a lower status. It will be argued that the institutionalisation of these assumptions ensured that only a small percentage of youths acquired a day secondary school education prior to World War One, and only the weaker students tended to follow the scientific courses at the Sheffield Central, which are considered below.

From 1900 to 1904, the Sheffield Central operated as a higher elementary school, but thereafter it was recognised as a day secondary school. The fees were set at £2 per annum, a figure which was prohibitive for many working class families, but the school offered 100 free places per year, available by competition.[108] Moreover, in 1907 the school met article 20 of the revised secondary school regulations issued by the new Liberal government, which provided a higher rate of grant to those schools that offered 25% of their places free of charge.[109] Thus, the school became more egalitarian in terms of the make-up of its student body. Moreover, the Board of Education enabled the school to develop special courses that were explicitly designed to meet the needs of local business. The school in fact offered 4 courses: classical, modern, scientific and engineering, the latter two of which were to feed local industry. Pupils who followed

[104] *Ibid.*, p.10.
[105] My italics, *Ibid.*, p.12.
[106] As Dalvi has argued, after 1902 "the provision of day commercial education was meagre", M. A. Dalvi, "Commercial Education in England During 1851-1907: An Institutional Perspective", (Unpublished PhD, London University, 1957), p.534.
[107] Curtis & Boultwood, *English Education Since 1800*, p.173.
[108] CA 681/9/1, City of Sheffield Education Committee Annual Report March 31st 1904, p.8; CA 622 (4), Sheffield Higher Education Sub-Committee Minute Book, no.1, p.43; .J. W. Derry, *The Story of Sheffield* (London, 1915), p.307; Derry & Baxter, "Secondary and Elementary Education", p.173.
[109] CA 318, Governors of the Central Secondary School Minute Book, no.2, p.19.

the engineering course spent a large proportion of their time in manual instruction and took extra classes in machine drawing and maths. Whilst the pupils who took the scientific course focused upon physics and chemistry, and spent many hours working in the laboratories.[110] The quality of the education provided in both these courses appears to have been extremely high. Her Majesty's Inspectors, for example, considered that the engineering course provided a sound foundation for careers in local industry.[111] In particular, engineering pupils were provided with a thorough working knowledge of machine drawing and solid geometry. They were taught to measure up models of the working parts of various machines, and from such measurements to prepare scale drawings, before recreating the machine parts using workshop tools, such as lathes and files.[112] The engineering section therefore provided a technical education which continued to meet business demands for an integrated study of theory and practice. Students in the science section were also given a sound practical training in the use of tools and were encouraged to write up their own experiments and draw their own conclusions. Significantly, Her Majesty's Inspectors considered that such heuristics improved the pupils independent observation and thought skills, which, as chapter 4 will argue, were vitally important to Sheffield steel firms.[113] The available evidence, therefore, leaves little doubt that the courses were highly relevant to local industry.

Unfortunately, however, due to the assumptions that were built into the Sheffield education system, the Central's engineering course was invariably reserved for the less intelligent pupils, who were considered "incapable of studying foreign languages."[114] Indeed, the courses at the Sheffield Central were arranged in a strict order of ability: the most able pupils were encouraged to focus upon Latin and the classics, the lesser able on modern languages, and the least able on science and especially engineering. Moreover, the Sheffield Education Committee encouraged and supervised the transfer of the Central's most intelligent pupils to King Edward VII grammar school, where they were prepared for the classical tripos at Oxbridge.[115] It is, therefore, to a consideration of this school that I now turn.

[110]Report of Inspection of the Central Secondary School 1914, in CA 319, Governors of Central Secondary School Minute Book, no.3, p.280.
[111]*Ibid.*
[112]*Ibid.*
[113] HMI's praised the high standard of work achieved in both chemistry and physics which along with the engineering course provided a "valuable training for positions in local industry.", *Ibid.*
[114]CA 318, p.74.
[115] CA 318, p.252. A process encouraged by Her Majesty's inspectors who emphasised that if the Central discovered that it possessed boys who were 'good enough' to do classical work for open scholarships at Oxbridge they should be sent to King Edward VII, CA 319, p.30.

The mission of King Edward VII School, which was formed in 1906 through the amalgamation of the Sheffield Grammar School and Wesley College, was outlined in 1905: "to establish a first grade day school for boys...equal to...public schools of the highest type."[116] The school was divided into 2 sections, Preparatory (for pupils aged 9 to 12), and Senior (for pupils aged 12 to 19.)[117] The fees were exceptionally expensive. Set at £16 per annum, they were far in excess of the £2 minimum demanded by Morant, and the school only offered 5 scholarships by competition each year. As a result, the composition of the student population was predominantly middle class.[118]

The Senior Department was sub-divided into a classical and a modern side. The staff was largely made up of Oxbridge honours graduates: in 1910, 8 of the staff were Masters of Art, a further 8 were Bachelors of Art, and only one held honours in science. The headmaster J. H. Hickens (MA (Hons.), LLD, Headmaster 1905-26) surrounded himself by people with similar backgrounds and ideas and the homogeneity of the staff and student body spawned a particularly strong culture which valued a classical education above all else and which regarded secondary education as a privilege to be reserved for the upper and middle classes. In consequence, the curriculum became increasingly skewed towards scholarship work for Oxbridge, particularly to the classical tripos.[119] In fact, the school became more elitist and classical in orientation than even the Board of Education thought desirable. In December 1910, therefore the board opposed the school's plan to augment its income by increasing its already high fees, when there was another source of money available, if the school would accept article 20 of the 1907 regulations.[120] But, the governors of King Edward's expressed the opinion that the Central Secondary school, which charged very low fees, met the needs of "the *industrial portion* of the population"; whilst their school catered for the upper and middle classes, and "parents would not pay a fee of £16 to King Edward's, if the school complied with article 20 and became similar in character to the Central Secondary School."[121] The Board of Education was not impressed by this argument and attempted to force the governors hands by refusing to allow the increase in fees unless the school agreed to meet article 20.[122] Nevertheless, such was the commitment to elitist classical education that the governors refused and concluded that under the circumstances it was

[116]Outline of Scheme for King Edward VII, 1905, in CA 622 (4), p.146.
[117]*Tha'll Never Gerr in Theer: A Living History of King Edward VII School, 1905-95* (Sheffield, 1995), pp.3-4; H. K. Hawson, *Sheffield: The Growth of A City, 1893-1926* (Sheffield, 1968), p.75.
[118]Report of the First Inspection of King Edward VII Secondary School Feb. 1910, in CA 328, Governors of King Edward VII School Minute Book, no.2.
[119]Gerr in Theer, p.4,8.
[120]From 1907 the Board had offered to accept 10% instead of the usual 25% of free places as sufficient to meet article 20, in deference to the character of King Edward's, but the headmaster and governors refused to accept this and, in consequence, the school received a lower rate of grant. CA 328, p.98
[121]*Ibid.*, p.98.
[122]Letter from Board of Education to King Edward VII, 10th March 1911, CA 328, p.110.

desirable that the school should be withdrawn from the list of institutions receiving grants from the Board of Education.[123] This decision freed the school from state interference and secured its middle and upper class origins, however it cost the school an annual income of £713, and the local economy was therefore forced to pay more for an institution which creamed off the most able students from the Central Secondary School, and which was designed to channel Sheffield's brains out of the city to Oxbridge and London.[124] Thus, in terms of cost-benefit analysis, the school cost the city dearly but offered little in return. The Board of Education condemned the school for failing to serve the needs of local industry. In particular, it criticised the school on the grounds that its modern side was "poorly developed", the proportion of time given over to the sciences was "too small" and there were "no facilities for practical instruction in mechanics."[125] As late as 1915, the Board of Education was still lambasting the school for its "failure to develop a course preparatory to engineering" which would focus on manual instruction, workshop mechanics, hand sketching and machine-drawing.[126] Nevertheless, this held little sway with the staff who regarded the exceptional performance of their students in the Oxbridge Higher Certificate examinations as the acid test of the quality of the school, and their elitist classicist culture may have blinded them to the need to develop more vocational and technical

[123]Letter from Headmaster to Board of Education, 7th April 1911, CA 328, p.113.
[124] Hawson, *Growth of A City*, p.76.
[125]Report of the First Inspection of King Edward VII Secondary School, Feb. 1910, in CA 328
[126]The Inspectors also considered that the school neglected commercial education. Report of Inspection of King Edward VII School, March 1915, CA 328, p.322. King Edward VII only provided short classes in book-keeping and shorthand, and in 1910 only 4 boys took these subjects.(Ca 328) None of this, of course, is to detract from the outstanding academic success of the school. The scholastic record of the school was the subject of much admiration. H. A. L. Fisher (the architect of the 1918 education Act and the Vice-Chancellor of Sheffield University) claimed in 1914 that "I do not believe there is a school in England with a history at once so short and distinguished." King Edward VII received many distinctions in the Oxford and Cambridge Higher Certificate examinations, indeed in 1916 it received twice as many as any other school and was a strong competitor with the old public schools particularly for the highest honours in the Oxbridge classical tripos. A recent oral history of King Edward's, *Tha'll Never Gerr In Theer* informs us that "it was easy then (and it is even easier today) to criticise the headmaster's emphasis on examination results in general and on scholarship work at Oxford and Cambridge in particular" but "one must judge his work against the background of the social structure of the community that the school served and the educational ideas then current." This plea to place the school in context is well-made, but we have seen that the Board of Education was more enlightened than a school which bought the classicist tradition wholesale and failed to consider the needs of local industry. Indeed, the school claimed public school status on the grounds that the headmaster was a member of the headmaster's conference, the membership of which was confined to the headmasters of public schools. See Fisher's remarks in CA 681/9/12, p.5; CA 681/9/14, p.7; Her Majesty's Inspector's Report on the Central Secondary School Oct. 1914, in CA 319, p.256; Derry & Baxter, "Elementary and Secondary Education", pp.171-172; W. H. G. Armytage, "Sheffield Schools, 1893-1918", in Binfield (eds.), *History of Sheffield*, pp.315-316; *Gerr in Theer*, pp.4-21; recently Edgerton has argued that the arguments of a cultural bias in education against manufacturing may have been overdone, or at least that more detailed evidence is needed to substantiate this. More case-studies of individual schools, such as that provided here would be useful, D. E. H. Edgerton, *Science, Technology and the British Industrial 'Decline', 1870-1970* (Cambridge, 1996).

courses.[127] Given that the Central and King Edward's were the only 2 secondary schools established in Sheffield prior to World War One, we may ask to what extent were business needs for technical and commercial personnel met?

The key deficiency in Sheffield's, and England's, day secondary education system after 1902, remained a quantitative one. As Tawney pointed out in 1922:

> the free place system initiated in 1907, though useful as making a break, if a small one, in the walls of educational exclusiveness, was really the product of an age in which secondary education was regarded as an exceptional privilege to be strained through a sieve and reserved so far as the mass of people were concerned for children of exceptional ability.[128]

It did not deliver the TUC's demand for secondary education for all, and a number of schools, such as King Edward VII, simply refused to accept it. The result was that by 1913, there were in the whole of England only 188,000 pupils in day secondary schools, and, on the eve of the First World War, the great majority of children never proceeded beyond the elementary stage, at least not in day classes.[129] Moreover, the situation in Sheffield was far worse than that in other cities. In 1911, only 13 out of every thousand children in Sheffield's public elementary schools progressed to day secondary schools, compared to an average of 29 per thousand for the cities listed in table 1.4 below.

Table 1.4: Number of pupils of 12 and over in secondary schools on the grant list in the large towns in England expressed per 1,000 of population and of the number of children in public elementary schools.

City	Population 1911	No of Public Elementary School Children	Number of Full time pupils 12 and over in Grant Supported Secondary Schools	No in Column 4 per 1,000 of the No in Column 2	No in column 4 per 1,000 of the No in column 3
Hull	277,991	49,241	1,453	5.2	30
Bradford	288,458	44,054	2,384	8.3	54
Bristol	357,114	58,884	2,296	6.4	39
Leeds	454,155	76,113	2,620	5.8	34
Sheffield	460,183	82,277	1,043	2.3	13
Manchester	714,385	121,193	2,587	3.6	21
Liverpool	753,353	132,282	3,265	4.3	25
Birmingham	840,202	149,345	3,006	3.6	20
London	4,521,685	722,199	17,561	3.9	24

(Source: CA 321, Secondary School Sectional Sub-Committee Minute Book, no.2, p.27.)

[127]For a discussion of culture as 'blinders', see chapter one of this thesis and M. Alvesson, *Cultural Perspectives* (Cambridge, 1993), p.20.
[128]Cited in Bagley, *State Education*, p.56.
[129]Armytage, "Sheffield Schools", p.316; M. Seaborne, *Recent Education From Local Sources* (London, 1967), p.62.

These statistics add considerable support to Her Majesty's Inspector's conclusion that there was a severe lack of accommodation for secondary education in Sheffield, and that new schools were urgently required. The inspectors considered that, there was "no reason to doubt that many boys in Sheffield anxious for secondary education and fit to profit by it" were "debarred by lack of accommodation."[130] Many pupils, for example, who passed the city's entrance examinations were denied a day secondary education due to the acute shortage of places available.[131] More significantly, the inspectors argued that, since approximately 65,000 people were employed in Sheffield's metal and engineering trades, there must be "grave doubts as to whether the supply of secondary pupils is adequate to enable the town to maintain its supremacy in industry and commerce."[132]

It is easy to understand how the inspectors arrived at this conclusion. The number of day secondary school places was extremely small and the majority of the education provided in King Edward VII school was largely irrelevant to industrial needs. Had local industry been solely reliant upon day secondary schools for their human resource requirements there would have been major problems. However, the situation was not as bad as the table, or the inspectors comments suggests. It will be argued that inadequacies in day secondary education were largely ameliorated by the re-emergence of "higher elementary tops", by Sheffield's unusually extensive network of evening schools, and, as chapter 4 will emphasise, by the quality of the traditional apprenticeship training system.[133]

From 1906 onwards a number of the city's elementary schools began to redevelop 'higher elementary tops.' Parents who were unable to keep their children at school until the age of 16, were encouraged to send them to these schools, where they could remain until the age of 14 following a more vocational curriculum.[134] By 1910, there were 31 such schools in Sheffield, 10 of which were recognised as centres for the teaching of practical science. These schools focused upon technical and commercial studies, and a considerable proportion of the timetable was given over to manual instruction.[135] They

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[130]Her Majesty's Inspectors comments made in 1914 can be found in CA 319, p.280.
[131]Thus a building programme would not have led to an over-investment in secondary education, in terms of an alleged inability of pupils to profit by it, *Ibid.*, p.280.
[132]*Ibid.*, p.280.
[133]Although the increasing sub-division of labour was beginning to undermine the apprenticeship training system, many firms continued to provide their workers with an excellent craft training. Indeed, as Pollard has argued the quality of apprenticeship training prior to World War One should not be underrated, Pollard, *Prime and Decline*, p.127.
[134]CA 681/9/3, City of Sheffield Education Committee Report, 31st October 1906,p.6.
[135]Derry & Baxter, "Elementary and Secondary Education", p.163-164; J. W. Derry, Story of Sheffield, p.304.

therefore provided industry with a rich source of recruits for lower level posts such as clerks and artisans.[136] Such posts were also supported by a dense network of evening schools. In the late nineteenth century it was recognised that England's system of evening education was better than that of any of her major competitors and during the twentieth century the nation continued to be distinguished by the quantity and quality of its evening classes.[137] However, Sheffield's provision was more extensive than that of other English county boroughs and generally considered to be more than usually good.[138] Sheffield's evening schools therefore deserve further examination.

In 1904 the city's district evening schools were given a two-fold function. They provided education in the 3 "R"'s, and elementary classes in scientific and commercial subjects, such as chemistry and shorthand. These schools, which catered for over 10,000 pupils each year, aimed, firstly , to provide industry with technically- and commercially-educated personnel, and secondly to prepare more able students for advanced courses at the university and the Central Secondary Evening School.[139] The Central Secondary Evening School was a strange hybrid, its commercial classes formed the crown of Sheffield's organised system of commercial instruction, but its technical and science classes merely built upon the instruction given at district evening schools, preparing students for the more advanced classes at the university.[140] The Central therefore offered three distinct courses: a matriculation course, a science and technology course, subdivided into four sections (mechanics, electricity, chemistry and nature study), and a commercial and literary course, designed to meet the needs of clerks, correspondents and salesmen.[141] In an average year, over 1,500 pupils attended the Central Evening School, studying vocational subjects such as accountancy, applied mechanics, book-keeping, business methods, magnetism, electricity, metal work, commercial geography, shorthand, French and German.[142]

HMI reports on the teaching of these subjects were generally favourable. In 1909, for example, it was reported that the progress of the students was good, and that the

[136] *The Report of the Minister for Education For the Year 1950* (London, 1950), p.37; I. Morrish, *Education Since 1800* (London, 1970), p.52; P. W. Musgrave, *Society and Education in England since 1800* (London, 1968), p.82.

[137] According to Levine, "The Commission on Technical Instruction of 1882 found 'to their surprise' that the facilities available for evening instruction in science were unmatched elsewhere in Europe", A. L. Levine, *Industrial Retardation in Britain, 1880-1914*, (London, 1967), p.25; C. More, *Skill and the English Working Class*, p.216; R. Floud, "Technical Education and Economic Performance: Britain, 1850-1914", *Albion*, vol.14, (1982), pp.153-171.

[138] General Report of Her Majesty's Inspectors on the Technical Schools, Schools of Art and Evening Schools in the County Borough of Sheffield June, 1910, in SUA 5/1/2 (ii), p.151.

[139] CA 681/9/1, p.14-15; CA 681/9/5, p.15; Derry, *Sheffield*, p.307; Derry & Baxter, "Elementary and Secondary Education", p.176.

[140] CA 681/9/4, pp.15-18.

[141] CA 681/9/3, pp.24-25; CA 681/9/5, p.10.

[142] Derry, Sheffield, p.306.

teaching was competent, especially that in commercial subjects such as company accounts.[143] Not surprisingly, therefore, during the 1900s the Central Secondary School came to focus more and more upon commercial subjects, particularly as the scientific instruction provided by the district schools became more advanced. By 1913, approximately 80 per cent of the student body were enrolled for commercial classes, and during the war the school further demonstrated its responsiveness to business needs by inaugurating classes in typing, Spanish, Italian and Russian.[144] These commercial classes combined with the technical classes provided by the university and the district evening schools largely compensated for inadequacies in day secondary education, providing an opportunity for young workers to supplement their practical training in the firm with courses which would allow them to fit themselves for promotion to positions as foremen, draughtsman, clerks, commercial correspondents, travellers and even departmental managers.[145] Indeed, chapter 4 will provide a detailed case-study of how Thomas Firth and Sons, a leading steel and engineering firm, integrated evening technical study into its apprenticeship training schemes, in order to support the development of high-tech. products such as specialist steels. However, evening and higher elementary schools could not supply a rich source of recruits for the university's degree and associateship courses, and it was here that inadequacies in day secondary education were most keenly felt.

As Dintenfass points out, with secondary provision so meagre, the number who attained college and university places was necessarily small.[146] Moreover, as William Ripper emphasised, the problem in Sheffield was also qualitative, for "grave difficulties attended the university's attempts to recruit the more intelligent pupils who could be trained to become metallurgical and engineering experts."[147] Indeed, "the most able boys from the city's secondary schools were creamed off for classical studies at Oxbridge, and many of the city's most intelligent pupils turned their faces away from the city's trades and industries." Ripper recognised that this was partly due to the ideas of the boys and their parents, but he considered that the key factor lay in the organisation of the city's secondary education system, which accorded science a low status and encouraged the more able boys to take a classicist route.[148] He pointed out that, of the pupils who left the Central Secondary School in 1911 to take up degree

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[143]Her Majesty's Inspectors Report on the Central Secondary Evening School, in CA 318, p.74-76.
[144]CA 681/9/12, p.16; CA 681/9/16, p11; CA 319, p.192; CA 320, p.48, 128.
[145]In August 1907, Sir William Clegg (Chairman of the Sheffield University Applied Science Committee) argued that "the majority of the evening students are working men...and they come to our evening schools in order to qualify themselves for positions as foremen and mangers", SUA 5/1/33, p.8; See also Sanderson, *The Universities and British Industry*, pp.95-97.
[146]Dintenfass, *Decline of Industrial Britain*, p.34.
[147]W. Ripper, "Report on the Present Position of the Supply of Properly Trained Students to the Sheffield, Trades and Industries", 7th October 1911, in SUA VIII/1/2, p.496.
[148]*Ibid.*, p.496.

courses, only 7 per cent were studying applied science, whilst 93 per cent were following courses in the arts and the pure sciences. He considered therefore that the science section of the Central School had not fulfilled its obligation to the Applied Science Department of the Sheffield University, and that nothing had taken the place of the Junior Day Department of the Technical School which had been discontinued under the reorganisation of 1897.[149] In particular, however, Ripper's report reserved especial criticism for King Edward VII School. Whilst he acknowledged the "splendid work" done at this school and the honour which was due to it for the great successes it had gained in the examinations of the older universities, he concluded that "there is a danger of our losing the sense of true proportion in these matters and of our failing to recognise the positive claim of the city itself upon at least some proportion of the ability trained in its own schools at its own expense", a clear reference to the added burden which the city had to shoulder because of King Edward's decision to forego the Board of Education grant.[150] Significantly, Ripper was not alone in his opinions, indeed John Derry emphasised that "it is a thousand pities that so many of the studious and clever boys of Sheffield...are led away to feed on the dry husks of bookish learning instead of turning to practical science and seeking to push the bounds of knowledge further and further."[151]

As chapter 2 argued, business demands for graduates increased throughout our period, particularly following the development of specialist steels, which raises the question of whether industrial demand outstripped the supply of graduates from the city's university. The answer to this question is a categoric "no"! I may explain this apparent paradox by reference to tables five to fifteen in Appendix C, which show that, prior to World War One, Sheffield firms were able to procure a good proportion of the university's graduates.[152] Indeed, on average, from 1900 to 1910, as table fifteen demonstrates, Sheffield firms usually employed approximately 60 per cent of the university's cumulative total of metallurgy and engineering graduates / associates, whilst manufacturing firms outside of Sheffield invariably accounted for a further 14 per cent. Therefore, although the number of graduates produced prior to World War One was small, manufacturers appear to have been able to secure the full extent of their

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[149]*Ibid.*, p496. As early as 1903, Ripper had reported that "So long ago as 1890 in order to...supply the Technical Department with...students, the Technical School opened a Preparatory or Junior department...The work done in this department was very fruitful in results as can be shown by the subsequent careers of many of those youths who afterwards passed through the Senior department with distinction. In 1897 the Junior Department was closed with the expectation that steps would be taken to provide the Technical Department with similarly well prepared students through the ordinary educational channels but these hopes have not yet been realised, SUA VIII/1/2, p.234.

[150]SUA VIII/1/2, p.496.

[151]Derry, *Sheffield*, p.172.

[152]This contrasts with the work of Roderick and Stephens who have argued that the majority of science graduates from the Liverpool and Manchester civic universities either went abroad or entered the teaching profession, Roderick & Stephens, *The English Disease*, pp.106-107.

human resource requirements.[153] This challenges the received view that the majority of science graduates followed careers in education or went abroad and only a minority entered domestic manufacturing industry.[154] Moreover, in addition to its metallurgy and engineering graduates, the university also turned out 300 to 400 trained chemists who were sufficiently educated to supervise quality control, and who were absorbed into local firms whose business strategy, as chapter 4 will emphasise, was based upon quality production.[155] Nevertheless, as chapters 5 and 6 will demonstrate, during the inter-war years as the business need for well-trained graduates continued to increase, industrial demands consistently exceeded the university's ability to supply, in spite of a significant increase in the number of graduates who were produced each year, because more and more graduates turned to a careers outside of Sheffield industries and outside of British manufacturing in general.

To conclude this survey, it may be argued that, prior to World War One, the Sheffield education system was generally adequate to meet business needs. Although day secondary education was far from ideal, the quality and quantity of higher elementary and evening education ensured that business needs for technical and commercial personnel were largely met. Thus, the case-study of Sheffield suggests that the received view which links inadequacies in technical and commercial education with Britain's relative decline as a manufacturing nation may have been overstated.[156] Indeed, as the next chapter will argue, the quality of Sheffield's evening and university education, enabled firms such as Thomas Firth and Sons to acquire a substantial lead over foreign competitors in the manufacture of specialist alloy steels, which were key products of the 'second industrial revolution.'

[153]The high-quality of the training provided for graduates also ensured that, despite qualitative inadequacies in the student intake, the university was able to provide industry with sound metallurgists and engineers. Indeed, graduates such as Dr. W. H. Hatfield not only performed well for their firms but also published certain of their research findings in leading technical journals.
[154] See, for example, G. W. Roderick & M. D. Stephens, *Education and Industry in the Nineteenth Century: The English Disease* (London, 1978)
[155]Letter from Prof. Arnold to the Editor of the Times, 1st April 1916, SUA VIII/127/1, Professor Arnold Letter Book, vol.1, p.571.
[156]I would agree with Pollard, "The contribution of education and science to the British slowing down before 1914 was moderate at most....", Pollard, *Prime and Decline*, p.213.

Chapter 4: Education, Training and Business Performance: A Case-Study of Thomas Firth & Sons, circa 1880-1918.

Thomas Firth and Sons became one of Sheffield's leading producers of high-speed and specialist steels, which, as chapter two argued, were key products of the 'second industrial revolution.'[1] The company therefore provides an ideal example of a highly innovative and progressive firm, and this chapter will explore how it managed its human resources in line with the needs of the workplace during a period of rapid technical change. To explore the firm's training policies, this chapter will utilise the theory of business strategy which was introduced in chapter 1. In particular, it will be argued that during the 1890s technical education became integral to the firm's business strategy and the management regarded it as vital for long-run business performance. However, in order to set the case-study in a broader context, it will be tested against evidence garnered from a cluster of steel and engineering firms, and from a database which charts the career profiles of applied science graduates from Sheffield University. The chapter is divided into four parts. Part one provides a short account of Firth's early history and its development of a strong organisational culture which clearly influenced the firm's business strategy and its education and training programme which are discussed in parts two and three. Finally, part four explores the relationship between education, training and business performance. Here it is argued that technical education became crucial to the improvement of product quality, and the superior quality of Firth's steels was a major factor in the firm's business success prior to World War One.

I

Early History & Company Culture.

This section briefly examines Firth's early history and in particular its company culture which came to be based upon the core-values of product quality and reciprocal loyalty. Recent research in business history has stressed the impact of culture upon business practices, and it is important to explore Firth's company culture because it will be argued that it influenced its business strategy and shaped the particular form which its education and training programme took

Thomas Firth and Sons was founded in 1842 by Mark Firth and his brother Thomas, both of whom had just completed an apprenticeship at Sanderson's, a local steel firm

[1] "....the second industrial revolution is synonymous with...the rise of science-based industry", J. P. Hull, "From Rostow to Chandler to You: How Revolutionary was the Second Industrial Revolution", *Journal of European Economic History,* vol.25, no.1, (Spring 1996); A. L. Levine, *Industrial Retardation in Britain 1880-1914* (London, 1967), p.7; A. D. Chandler Jnr., *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass. 1990), pp.236, 261, 286.

renowned for the quality of its products. Shortly after establishing their business, the brothers were joined by their father, Thomas Senior, and by other melters poached from Sanderson's. Firth's initial works, which were located at Saville Street, occupied just one third of an acre and consisted of a 6-hole crucible furnace.[2] During the 1840s, steel was the sole product and the majority of sales were domestic. However, following the opening of the new Norfolk Works in 1852 , the firm also manufactured edge tools, saws and gun forgings, and its sales became increasingly global with a focus upon the American and Russian markets.[3] As table 1.1 shows, its business operations continued to grow throughout the nineteenth-century, and by 1914 the firm had more than 3,000 employees.[4]

Table 1.1: Firth's Plant and Workforce, 1842-1918

Year	No. Employed	Year	Plant size (acres)
1842	6	1842	0.33
1857	200	1852	13
1860	500	1890	20
1870	1,000	1900	20
1891	1,800	1914	44
1900	2,000		
1914	3,100		
1918	8,000		

(source: constructed from A. C. Marshall & H. Newbould, *The History of Firth's* (Sheffield, 1924); *One Hundred Years in Steel: Firth Brown Centenary, 1837-1937* (Sheffield, 1937))

Although Thomas Senior was nominally the chairman of the firm, Mark was the real driving force behind the business. The authors of Firth's official history claimed that he was "so bound up with the development of the firm", that "we are sure to appear to be writing his biography."[5] On his father's death in 1850, Mark officially acquired personal responsibility for strategic decision-making, but he received advice and assistance from several brothers who held positions as departmental managers. From the outset, therefore, Firth's was a personally-managed family firm, the type of organisation which Payne has revealed to be typical of British business. In what follows, it will be argued that the Firth brothers fostered a strong company culture

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[2]*A Souvenir of a visit to Firth - Brown Ltd, Sheffield March 14th 1957* (Sheffield, 1957), pp.25-6; P. Nunn, "Firth, Mark (1819-80): Steel Manufacturer", in D. J. Jeremy (eds.), *Dictionary of Business Biography*, vol.2 (London, 1984), pp.363-365; A. C. Marshall & H. Newbould, *The History of Firth's* (Sheffield, 1924), p.9.
[3] Nunn, "Firth, Mark", p.364; *Firth Brown Souvenir*, 1957, pp.25-28; Marshall & Newbould, *History of Firth's*, pp.16-20.

[4]The firm was a part of the expansion of heavy industry in Sheffield from the mid-nineteenth-century. Firth's like Vickers, Cammell's and Hadfield's grew on the back of its steel and armaments business, G. Tweedale, "The Business and Technology of Sheffield Steel-making", C. Binfield et al (eds.), *The History of the City of Sheffield: vol.2, Society* (Sheffield, 1993).
[5] Marshall & Newbould, *History of Firth's*, p.14.

based upon the core-values of product quality and reciprocal loyalty.[6] Indeed, reciprocal loyalty enabled the firm to retain the workmen whose skills, as part three of this chapter will argue, were integral to the manufacture of high-quality steels. However, how did product quality arise as a core-value of the company's culture?

Culture arises as an historical process and, according to Schein, the most powerful mechanisms for embedding culture are what leaders measure, control and reward.[7] The Firth brothers paid particular attention to quality control, working with their employees to maintain and improve product quality (which may be defined in terms of reliability, durability and the complete satisfaction of customer needs).[8] In 1924, it was claimed that the growth of the business was "a record of the triumph of a family that worked in close contact with their employees."[9] This close supervision of the production process, or as Schein has phrased it "visible management", was designed to instil in the workforce an appreciation of the importance of product quality. Management's success in propagating this core-value will be explored in part four of this chapter, which claims that Firth's reputation for product quality provided the firm with a significant competitive advantage in world markets.[10]

That the Firth brothers played some part in culture creation and reinforcement cannot be denied, but as Alvesson has argued "the interesting cultural aspects of organisations are not necessarily idiosyncratic values and norms, but deeper and broader patterns that belong to more general societal and industrial cultures."[11] Thus, product quality was a core-value of the industrial district. Manufacturers regarded product quality as the

[6]Personally-managed firms may be defined as those "administered without...an extensive administrative hierarchy and those whose founding entrepreneurs or families assembled smaller managerial teams but retained a personal style", A. D. Chandler Jnr, cited in R. Lloyd-Jones & M. J. Lewis, "Personal Capitalism & British Industrial Decline: The Personally Managed Firm and Business Strategy in Sheffield, 1880-1920", *Business History*, vol.68, no.3, (Autumn 1994), p.370.
[7]E. Schein, *Organisational Culture and Leadership* (Oxford, 1989) pp.224-225.
[8]Marshall & Newbould, History of Firth's, pp.9, 10, 22, 57, 63, 64.
[9]*Ibid.*, p.1
[10] According to Schein products are artefacts of the culture, that is its surface manifestation, see chapter one of this thesis on levels of culture, Schein, *Organisational Culture*, p.13. For a discussion of visible management, see p.211. of Schein opcit. As Alvesson has argued, most people would agree that, during the early years of an organisation, the founder may have a far reaching influence upon company culture, Alvesson, *Cultural perspectives on Organisations* (Cambridge, 1993), p.86; Schein claims "founders assumptions become shared by their employees", Schein, *Organisational Culture*, p.100; J. V. Maanen & S. R. Barley have argued that "The founding phase of organisations...seem to produce social systems marked by little internal or external sub-cultural differentiation." However, as the organisation grows, developing specific functions and divisions, sub-cultural differentiation increases. Thus, chapter 7 of this thesis uses the metaphor of culture as non-order in order to analyse how the rapid growth of Firth's business activities, during World War One, led to sub-cultural differentiation during the inter-war years, J. V. Maanen & S. R. Barley, "Cultural Organisation: Fragments of a Theory", in P. J. Frost et al (eds.), *Organisational Culture* (London, 1985) pp.37-38.
[11]Alvesson, *Cultural Perspectives*, p.78; as Schein himself admits, founders and group members always have prior experience, Schein, *Organisational Culture*, p.221. Thus, the Firth brothers and their first employees came from Sanderson's, a company which valued product quality.

lynch-pin upon which their business empires had been built. The owners of many local firms devoted "their personal attention to the business" in order to maintain quality control.[12] As Scranton has observed, "Within the cultural Boundaries of personal capitalism manufacturers placed a high value on direct participation and supervision of the production process."[13] The owners of Edgar Allen's, for example, considered that their "personal attendance at the works" had created "consciously and unconsciously" values or as they phrased it "traditions which were handed down and which gradually become fixed rules for the guidance of each succeeding persons concerned with the business...."[14] In particular, they believed that their "close and effective control over all operations, over a number of years" had created employees who "*took pride in their work, and who...scorned to turn out scamped or shoddy goods.*"[15] Over time therefore product quality became established as a 'sacred cow', that is, a taken for granted and unquestionable aspect of the business activities of firms such as Firth's and Edgar Allen's.[16]

Central to product quality, as part three of this chapter will argue, was the development of a skilled and loyal workforce. The Firth brothers therefore acted to establish reciprocal loyalty as a core-value of the company culture.[17] And, in order to ensure worker loyalty, they paid particular attention to recruitment, personally interviewing each and every employee, and they adopted a highly paternalistic approach to labour relations.[18] Mark Firth, alone, spent over £200,000 on paternalistic activities. In 1850, for example, he established a sick and funeral fund for the benefit of his workmen, and in 1879 he donated £20,000 to the foundation of Firth College: an institution which he hoped would promote "the intellectual, moral and social elevation of the inhabitants of the town."[19] His major triumph, however, was the provision of employer-tied housing. It was claimed that all the adult men who lived within two miles of the Norfolk works

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[12]S. Pollard, *Three Centuries of Sheffield Steel: The Story of a Family Business, Marsh Bros. & Co. Ltd.* (Sheffield, 1954), p.73; *John Bedford & Sons Ltd., 150th Anniversary, 1792-1942* (Sheffield, 1942), pp.3-5, 35; H. Stansfield, *Samuel Fox & Co. Ltd, 1842-1967* (Sheffield, 1967), p.4; G. Tweedale, *Steel City: Entrepreneurship, Strategy and Technology: Sheffield 1743-1993* (Oxford, 1995), p.1-12, 143.
[13]P. Scranton, "Learning Manufacturing: Education and Shop Floor Schooling in the Family Firm", *Technology and Culture*, vol.27, no.1, (Jan. 1986), p.43.
[14]*Edgar Allen News*, vol.3, no.32, (September 1924), p.527.
[15]*Ibid.*, vol.5, no.49, (June 1926), p.800.
[16]For a discussion of culture as 'sacred cow', see ch.1 of this thesis and Alvesson *Cultural Perspectives*, p.20.
[17]At the most basic level loyalty to an organisation implies not only a belief in its ethical code of conduct but also an emphatic identification with at least some of its major objectives, J. Brown & M. B. Rose, "Intro." in Brown & Rose, *Entrepreneurship, Networks and Modern Business*, (Manchester, 1993) p.5.
[18] Again this may have been a reflection of the culture of the Sheffield district, according to Tweedale the city was a centre of paternalism, Tweedale, *Steel City*, p.143; Gospel has claimed that "paternalism provided an ideological dimension to the employment relationship based on notions of protection, reciprocal obligation and harmony", H. F. Gospel, *Markets, Firms and the Management of Labour in Modern Britain* (Cambridge, 1992), p.25.
[19] Marshall & Newbould, *History of Firth's*, p.45-49; Nunn, "Firth, Mark", p.365; SUA VIII/1/1, Sheffield Technical School Minute Book, no.1, p.15.

were employees of the firm and it was Mark Firth's habit to ride to work on horse back and have a word with them and their families.[20] These personal relations enabled "one to one verbal communication", which Siehl has identified as a key mechanism for culture embedding and the development of trust.[21] Thus, in terms of the metaphor of culture as 'clan', the importance of establishing trust was recognised and valued at Firth's, and as Casson has argued, the most important aspect of business culture is the extent to which it promotes trust.[22]

The Firth brothers also used key events in firm or family history as a mechanism for reinforcing this trust and consolidating worker loyalty. In 1857, for example, Mark Firth invited every one of his employees to his wedding, where he made an important speech, which can be analysed in terms of business culture as 'manager-controlled rites'.[23] That is, Mark Firth used the wedding for instrumental purposes, informing the workforce that

> In all my dealings with you I have always endeavoured to act with fairness, knowing that I was as much indebted to you for your service as you are to me for your employment...With your continued aid to do your part in a workman like manner as heretofore, united with our own attention, we hope to be able to maintain the position we have reached among the manufacturers of this town.[24]

Clearly, what Mark Firth was promoting here was the notion of a unitary enterprise, a community of interdependent interests, by involving workers in such events, he hoped to elicit the loyalty and co-operation of a willing workforce behind his leadership. Underpinning the core-value of reciprocal loyalty therefore, was a particular assumption about the nature of human relationships; that is, Firth's considered that the right way for people to relate to each other was through co-operation, indeed, part three will argue that team-work was a central feature of the firm's steel-making operations.[25]

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[20] Marshall & Newbould, History of Firth's, p.15; Samuel Fox also provided houses for his workers, Stansfield, *Samuel Fox*, p.30.
[21] C. Siehl, "After the Founder: An Opportunity to Manage Culture?", in Frost et al (eds.), Organisational Culture, p.129.
[22] For a discussion of culture as 'clan', see ch.1 of this thesis and Alvesson, *Cultural Perspectives*, p18; M. Casson, "Entrepreneurship and Business Culture", in Brown & Rose (eds.), *Entrepreneurship*, p.30.
[23] See ch. 1 of this thesis and Alvesson, *Cultural Perspectives*, p.20.
[24] Marshall & Newbould, *History of Firth's*, p.2; other manufacturers such as Marsh Bros. may have also used events in this way: they invited all their employees to the firm's 250th Anniversary celebrations in 1904, and to a meal to celebrate Henry Parker Marsh's election as Lord Mayor in 1907, Pollard, *Three Centuries of Sheffield Steel*, p.49; see also B. Morris & J. Smyth, "Paternalism as an Employer Strategy, 1800-1960", in J. Rubery & F. Wilkinson (eds.), *Employer Strategy and the Labour Market* (Cambridge, 1994), p.198; According to Deal and Kennedy, "savvy corporate leaders spend a lot of time on rituals, not just devising them but taking an active part in them", T. Deal & A. Kennedy, *Corporate Cultures: The Rites and Rituals of Corporate Life* (London, 1982), p.75.
[25] According to Schein, assumptions about the nature of human relationships, human activity and the firm's relationship to its environment lay at the deepest level of culture, Schein, *Organisational Culture*, pp.18, 47, 86.

Whilst co-operation was stressed, there was, nevertheless, a clear leader to whom the workers were required to defer. Until his death in 1880, this leader was Mark Firth and it was claimed that "by his broad human sympathies and interests in all movements for uplifting those around him" he "bound his workmen to him with hoops of steel."[26]. It may be argued therefore that the 'social glue' which held the company together was the reciprocal relationship between management and workers, based upon notions of loyalty and obligation.[27] There was an ingrained respect for the authority of top management, who, through paternalism, acted to inspire the loyalty they demanded. The regard which the workmen had for Mark Firth, for example, is revealed by the fact that his funeral procession stretched for more than 2 miles. This funeral can be analysed as a 'social drama', which clearly reveals a company culture based upon the notion of loyalty and respect.[28]

Following the death of Mark Firth, in 1880, the 'glue' holding the company together did not immediately dissolve.[29] The remaining brothers who became directors of the new private limited company in 1881 continued to manage the firm personally, and they used a variety of techniques to reinforce culture.[30] In particular, at the heart of the company culture and underpinning the core-values of product quality and reciprocal loyalty, was a twin assumption regarding the firm's relationship to the market and the nature of human activity. The commitment to meeting diverse customer needs encouraged the management to regard the firm as a responder to the market, rather than as a shaper of it. Its mission was to operate in high-quality niche markets and respond quickly to changes in demand. In turn, this meant that human activity was interesting, varied and above all constantly changing, and this demanded broad and flexible skills. As part 3 of this chapter will argue, the management therefore focused upon education and training for broad skills, changing the precise make-up of the training programme in response to a variety of product and process innovations.[31] Thus, whilst changes in the ET programme were ostensibly responses to changes in technology, the company culture nevertheless mediated the form and pace of change. What is more, in order to

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[26] Marshall & Newbould, *History of Firth's*, p.14.

[27]For a discussion of the metaphor of culture as 'social glue' see ch.1 of this thesis and Alvesson, *Cultural Perspectives*, p.19.

[28]Griffiths has developed A. Pettigrew's concept of 'social dramas', which can be deconstructed and which reveal company culture. The funeral of Billy Lever is analysed in much the same way as that of Mark Firth, J. Griffiths, "Give My Regards To Uncle Billy: The Rites and Rituals of Company Life at Lever Brothers, c.1900 to 1990", *Business History*, vol.37, no.4, (Oct. 1995), pp.28-32.

[29]Again, chapter 7 of this thesis will argue that the rapid expansion of the business during World War One made face to face relations and one to one verbal communication extremely difficult with the result that reciprocal loyalty began to break down.

[30] Firth family members took up all the ordinary shares, A. Grant, *Steel and Ships, The History of John Brown's* (London, 1950), pp.48-50, Marshall & Newbould, *History of Firth's*, p.51.

[31]For a discussion of 'Company Man' see texts by Schein, Deal & Kennedy. Company men often join as trainees and remain with the company until retirement, they are deeply attached to its goals.

reinforce trust and loyalty, rather than appoint outsiders to positions of responsibility, the Firth brothers adopted the policy of promoting skilled and loyal employees, thereby creating 'company men' who were firmly attached to the goals of the firm[32] The company culture therefore acted as a 'compass', that is, as a guide to setting organisational goals and policies. Indeed, the core-values of the company culture and the assumptions underpinning them clearly influenced the business strategy which is discussed below.[33]

II

Business Strategy

During the late nineteenth century the business strategy became three-pronged. Firstly, Firth's developed its armaments business in order to acquire a broad product mix which would allow for flexible specialisation between military and civilian work according to the state of the economic and military cycles.[34] Thus, as Davenport has argued, "the demand for armaments is volatile and unpredictable not following any economic cycle, but rising and falling in the thrall of international tension."[35] The decision to expand the armaments business was therefore clearly informed by the assumption that the firm was a responder to, rather than, a shaper of the market. Secondly, the firm accentuated its focus upon product quality. As price-competition became more intense during the late nineteenth century one option may have been to go down-market, but going down-market would have reduced the firm's products in the eyes of its customers and since product quality was firmly established as a sacred cow of the company culture, such a move was virtually un-discussable. Even in the depressed conditions of the inter-war years (as chapter 7 will argue) the management remained convinced that, since product quality was central to their culture, there could

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[32]*The Bombshell*, vol.6, no.9, (September 1922), p.366; for a discussion of promotion and role-modelling, see Schein, *Organisational culture*, p225-226; many Sheffield firms used internal promotion in this way, for example, Hadfield's, SLSL, Hadfield's Ltd., AGM and Chairman's Speech, March 28th 1919, p.26.

[33]For a discussion of the metaphor of culture as 'compass', see ch.1 of this thesis and Alvesson, Cultural Perspectives, p.18.

[34]The concept of 'flexible specialisation' has been developed by economic historians such as Philip Scranton. He claims that the flexible specialist operates in niche markets responding rapidly to changes in customer demands by employing multi-purpose technology and multi-skilled workers, P. Scranton, "Diversity in Diversity: Flexible Production and American Industry, 1880-1930", *Business History Review*, vol.65, no.1 (Spring 1991), pp.38-42; M. J. Piore & C.F. Sabel, *The Second Industrial Divide: Possibilities for Prosperity* (New York, 1984). Thus, flexible specialists pursue a 'prospector' type business strategy which was described in chapter one of this thesis, they "continually search for new product and market opportunities, and regularly experiment with emerging environmental trends." Many Sheffield firms were prospectors or flexible specialists, the management at John Bedford and Sons, for example, claimed that "The firm survives only by...its ceaseless adaptation to changing circumstances.", *Bedford and Sons*, p.7.

[35]R. P. T. Davenport-Hines, "The British Marketing of Armaments, 1885-1935", in R. P. T. Davenport-Hines (eds.), *Markets and Bagmen: Studies in the History of Marketing and Industrial Performance, 1830-1939* (Aldershot, 1986), p.146.

be no question of going down-market. During the late nineteenth century, therefore, the firm focused upon the manufacture of only the very best steels, the demand for which was less influenced by price. In particular, it began to manufacture specialist alloys whose properties could be tailored to closely-defined customer requirements and continually adapted to meet new needs. It will be argued that these steels won the firm some important orders but as protectionism spread Firth's began to experience severe market constraints. A third component of the business strategy, therefore, was an aggressive policy of direct investment; in particular, Firth's established manufacturing subsidiaries in both the American and Russian markets. The evolution of this three-pronged strategy will now be explored in greater detail in order to set the context in which policies of education and training were introduced. For, as the theory of business strategy claims, firms should pursue staffing and training practices which are most appropriate to their business strategy.

The decision to manufacture armaments was informed by two factors. Firstly, since the military would accept nothing less than the best products, a switch to armaments appeared to be a logical strategy for a firm whose production was skewed towards the quality end of the steel market. Indeed, Mark Firth anticipated that they would receive very large orders from the Woolwich Arsenal if they maintained their high standard quality control.[36] Secondly, the development of armaments was viewed, from the outset, as a counter cyclical device: because the economic and military cycles did not necessarily rise and fall in tandem, Firth's hoped that when the demand for their commercial products was poor, they would be able to place more resources behind the armaments trade and vice-versa. For example, in 1856, in order to compensate for the decline in demand for cold-rolled steel following the end of the fashion for crinoline skirts, Firth's placed additional resources behind the manufacture of gun forgings . This was a classic example of the firm's ability to act as a flexible specialist, using its skilled human resources to move into related product areas in response to changes in its environment.[37]

In order to develop its armaments business further and maintain its competitive advantage, Firth's installed two Nasmyth hammers which enabled it to increase output and manufacture a more uniform product.[38] This investment ensured that, by 1870, the firm had become the world's leading gun forgings manufacturer.[39] However, during the early 1880s, Firth's began to suffer from physical resource constraints; in particular, the

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[36]See letter from Mark Firth to his brothers, 13th March 1860, in *One Hundred Years in Steel: Firth - Brown Centenary, 1837-1937* (Sheffield, 1937),p.24.
[37]Nunn, "Firth, Mark", p.364; Marshall & Newbould, *History of Firth's*, p.22.
[38] *Firth - Brown Souvenir, 1957*, p.28-9.
[39]Marshall & Newbould, *History of Firth's*, p.22.

military demand was for larger-size ingots, but the small-scale of the crucible process restricted capacity output.[40] This focused managerial attention upon the need to introduce established bulk steel-making technology. One option was the Bessemer Converter, but a Bessemer melt was completed in only half an hour and this militated against the necessary quality control. In 1884, therefore, Firth's installed a Siemens open-hearth furnace. The Siemens furnace was particularly appropriate to Firth's needs because during a Siemens melt, which lasted from 4 to 12 hours, the steel could be analysed and, if necessary, modified This furnace, therefore, combined the advantage of a large capacity with tight quality control. [41]

During the trade depressions of the mid 1880s, top management particularly valued the Siemens process as a vehicle for the expansion of their armaments business.[42] In particular, they recognised that the development of highly-resistant compound-armour had created considerable scope for improvements in projectiles.[43] They therefore embarked upon a research programme, using their Siemens furnace to develop new and better projectiles. The firm's initial innovation, the forged-steel projectile, introduced in 1885, proved only a minor improvement upon existing products, but the development of a chrome-alloyed projectile the following year, was a major technological breakthrough. It was able to penetrate compound-armour very easily, and it won the firm important orders from the British, Spanish and Japanese governments.[44] This forced specialist plate producers to respond and resulted in a battle for technological superiority, which spawned further innovatory activity. In response to the development of all steel armour, for example, Firth's attached a cap of mild steel onto the point of their projectiles. This enabled them to remain more or less intact upon impact and significantly enhanced their penetrative power.[45] Firth's capped-projectile was held in high esteem by the navies of the world, and the orders for these projectiles were considerable, especially after 1908, when experiments with the mass of the cap

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[40] *Ibid.*, p.15. For a discussion of 'physical resource constraints', see ch.1. of this thesis and S. Moss, An Economic Theory of Business Strategy (Oxford, 1981).
[41] *A Souvenir of a visit to the Atlas and Norfolk Works of Thomas Firth and John Brown Ltd., Sheffield, April 8th 1954* (Sheffield, 1954), p.36; Firth Brown Publication, no.224, (Sheffield, 1947), pp.8-10; Tweedale, *Steel City*, pp.68, 91; for a discussion of 'focusing effects' see ch.1. of this thesis and Moss, *Business Strategy.*
[42] 1884-86 was a period of severe trade depression, armaments manufacture may have offered a way to counteract this. Details of the trade depression can be found in, P. P., 1886, *The First and second Reports of the Royal Commission on the Depression in Trade and Industry, 1884-86.*
[43] Cammell's was a major producer of compound-armour, *The Evolution of the Modern Armour-Piercing Projectile* (Sheffield, 1924), p.4.
[44] These product innovations were related to the use of the Siemens furnace, a process innovation. It appears that, in the history of technical change, both types of innovation are inter-linked, N. Rosenberg, *Exploring The Black Box, Technology, Economics and History* (Cambridge, 1994), pp.15-21; *The Modern Projectile Factories of Thomas Firth and Sons Ltd* (London, 1912), pp.3-6.
[45] *Modern Armour Piercing Projectile*, pp.4-5.

facilitated longer-range attack.[46] Nevertheless, although the armaments trade was a profitable one, the management were never tempted to make a wholesale switch into military work. There were periods of relative stability in international affairs, when armaments orders were extremely difficult to procure, and during these periods they looked to their civilian trade, which I now turn to discuss, to absorb their manufacturing capacity.

The management focused upon the manufacture of high-quality steel and, during the late nineteenth century, advances in metallurgical knowledge provided the opportunity for Firth's to develop specialist alloys. The firm began to manufacture these alloys in 1886, but they only began to achieve prominence in the product range during the last decade of the nineteenth century.[47] Firth's was not alone in the development of such alloys, other early producers included Samuel Osborn's, Edgar Allen's and Hadfield's, and by 1920, the city was home to over 150 specialist steel firms.[48] Firth's alloy steel business developed on two fronts. Firstly, the most special alloys, such as high-speed tool steels which were marketed under the brand name 'speedicut', were manufactured in the firm's many crucible furnaces. Secondly, large forgings for the automobile and armaments trades were initially manufactured by the Siemens method, but, from 1911 onwards, many of the more special forgings were manufactured in electric arc furnaces, which provided even more flexibility with regard to the addition of alloying materials, facilitating even closer quality control.[49] The flexibility of these furnaces induced numerous local firms to install them and, by 1918, Sheffield was the most concentrated centre of electric steel production in the world.[50]

The development of specialist steels was only made possible by the city's growing commitment to research and development. Firth's, recognised that the development of specialist steels required the "application of scientific investigation to problems arising,

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[46] This projectile was known as the hollow-capped projectile, it was pioneered by Firth's Colonel Strang, who was admitted to the Board of Directors for his military expertise, *Projectile Factories of Thomas Firth & Sons*, p.4; *Modern Armour Piercing projectile*, p.8.
[47] *Firth - Brown Souvenir, 1954*, p.39.
[48] See, "The Story of a Great Steel Firm Edgar Allen & Co. Ltd", *Edgar Allen Magazine*, vol.3, no.31, (June 1954), p.688; *Edgar Allen Magazine*, no.35, (Feb. 1955), p.117; T. A. Seed, *Pioneers for a Century, 1852-1952, Samuel Osborn Co. Ltd* (Sheffield, 1952), p.24; *Arthur Balfour & Co. Ltd., 1865-1965, Centenary*, p.15; *Industrial Sheffield 1919* (Derby, 1919), p.14, 15, 177; *The Baltic Steel Works Gazette*, vol.1, no.1, (Dec. 1919), pp.1-4; K. Barraclough, *Steelmaking Before Bessemer, vol.2: Crucible Steel: The Growth of Technology* (London, 1984), p.167; G. Tweedale, "Science Innovation and the Rule-of-Thumb: The Development of British Metallurgy to 1945" in J. Liebenhau (eds.), *The Challenge of New Technology: Innovation in British Business Since 1850* (Aldershot, 1988), p.68.
[49] Initially all of the steel was sold to tool manufacturers, but Firth's soon began to produce its own high-speed tungsten tools, *Firth Brown Souvenir 1954*, pp.39-41.
[50] Edgar Allen's was one of the first firms to install an electric arc furnace, *Edgar Allen Magazine*, no.40, (Dec. 1955), p.219; M. Sanderson, "The Professor as Industrial Consultant: Oliver Arnold and the British Steel Industry, 1900-1914", *Economic History Review*, vol.31, no.2, (1978), p.591; For a discussion of 'inducement effects', see ch.1. of this thesis and Moss, *Business Strategy*.

not only in their production, but also in their uses."[51] In 1908, therefore, they collaborated with John Brown and Co. in founding the Brown-Firth research Laboratories.[52] The Brown-Firth laboratory was a leading example of numerous research facilities which were established in Sheffield after 1900.[53] These laboratories were not only crucial to the evolution of high-speed steels, but also integral to the development of armaments. Indeed, "The contest...between guns and armour...necessitated continuous and expensive research."[54] Hadfield's, for example, spent "many thousands of pounds...on the working out of a single detail."[55] Such expenditure was not unusual, on average, armaments firms such as Firth's spent almost 12% of profits on R and D. As Sanderson has argued, therefore, "a good deal more research was undertaken in pre-war Britain than is realised", and this casts doubt upon the thesis that a failure to invest in research and development contributed to Britain's relative decline as a manufacturing nation.[56] Indeed, part 4 of this chapter will argue that research into specialist steels was crucial to the survival of the city's metal and engineering trades prior to World War One. However, what precisely did the research laboratories do?

The function of the Brown-Firth, and other laboratories, was threefold. Firstly, they worked in conjunction with the managerial focus upon product quality. That is, they became a key component of the firms' control mechanisms, allowing for a rigorous analysis of both raw materials and finished products. Secondly, they were instrumental in the development of product and process innovations. The laboratory staff particularly excelled at sub- or improvement-innovation: slight modifications to existing products which would allow them to meet new customer needs.[57] Thirdly, they provided a technical service for customers, carrying out experiments on their behalf and advising them on their choice of steel.[58] The activities of the research staff

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[51] *Firth-Brown Souvenir, 1957*, p.63.
[52] *The Brown-Firth Research Laboratories* (Sheffield, 1938), pp.6-7.
[53] *Vickers Ltd,. River Don Works Sheffield Metallurgical Products* (Sheffield, 1923), p.2-3; *Hadfield's Steel Foundry Co. Ltd* (Sheffield, 1905), p.23; Stansfield, *Samuel Fox*, p21; Balfour *Centenary*, p.24; J. O. Arnold & A. Mcwilliam, "The Application of Science to the Steel Industry", in W. Porter (eds.), *Sheffield 1910, British Association Handbook and Guide* (Sheffield, 1910) p.255.
[54] W. Ripper, "The War and University Education", *Industrial Sheffield 1919*, p.141.
[55] *Iron Steel and Allied Trades of Sheffield* (Sheffield, 1905), p.42.
[56] M. Sanderson, "Research and the Firm in British Industry, 1919-1939", *Science Studies*, vol.2, (1972), pp.111; Edgerton also suggests that more research was done than is often thought, D. E. H. Edgerton, *England and the Aeroplane: An Essay in a Militant and Technological Nation* (London, 1991), p.33; D. E. H. Edgerton & S. M. Horrocks, "British Industrial Research and Development Before 1945", *Economic History Review*, vol.XLVII, no.2, (1994), p.219-220.
[57] For example, both the Firth and Edgar Allen research laboratories did "much original work ...discovering the subtle modifications introduced in to the character of steel by different treatments and admixtures", *Industrial Sheffield 1919*, p.9; Edgar Allen News, no.1, (July 1919), p.1; for a discussion of improvement- or sub-innovations, see Rosenberg, *Exploring the Black Box*, p.14-15.
[58] *Brown - Firth Research Laboratories*, pp.6-8, *Firth-Brown Souvenir, 1954*, p.8; *Industrial Sheffield 1919*, p.9.

were crucial to the development of specialist steels which could be tailored to specific customer needs and they won Sheffield firms some very important orders, but, nevertheless, the intensification of protectionism in the 1890s placed intense market constraints upon the city's firms.[59] A final component of Firth's business strategy therefore, which I will now briefly discuss, was the development of overseas subsidiaries.

From the 1850s onwards, Firth's trade with America had been zealously cultivated with the result that it became the company's most important market. When tariffs began to undermine this trade, the firm's American agents advised them to acquire an American subsidiary. Firth's, initially proved extremely reluctant to invest overseas, but competitive constraints eventually forced the board's hand, and in 1896 the Firth-Sterling Steel Company was formed, through the acquisition of a controlling interest in the Wheeler-Sterling Steel Co. of McKeesport, Pennsylvania: an acknowledged specialist in the production of crucible steels and armour piercing projectiles.[60] Protectionism also informed Firth's decision to establish a branch-plant in Russia. Thus, in 1903, Firths purchased the newly-built Salamander works which were located in Riga, in order to manufacture steel and steel products behind the tariff wall.[61]. In part 4 of this chapter it will be argued that the American subsidiary performed much better than its Russian counterpart, because in America Firth's acquired a going concern with product-specific skills but, in Russia, it purchased a badly designed and poorly-equipped works, in an agricultural region deficient in the skilled human resources which, as the next part of this chapter will now argue, were crucial to the manufacture of high-quality steels.[62]

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[59]Tariffs also effected other firms, see SCA MD 3970, Edgar Allen Letter Book, 1892, p.7; *The Engineer* vol.59, (Nov. 1885), p.426; Pollard has stressed the effects of tariffs in the U.S., S. Pollard, *Britain's Prime and Britain's Decline: The British Economy, 1870-1914* (London, 1989), p.53; For a discussion of 'market constraints', see ch.1. of this thesis and Moss, *Business Strategy*.

[60]This reluctance may be explained by the management's focus upon direct supervision of the production process, discussed in part one of this chapter, see *Firth Brown Souvenir 1954*, p.37; Marshall & Newbould, *History of Firth's*, pp.71-72.

[61] *Firth-Brown Souvenir 1954*, p.41. Marshall & Newbould, *History of Firth's*, p.90.

[62] Diane Hutchinson has argued that, in geographic expansion of this kind, the take-over of a going-concern is often the best strategy as it provides the parent with the advantage of an "established team with product- or market-specific skills and knowledge, which would otherwise take a long time to develop." D. Hutchinson & S. Nicholas, "Modelling the Growth Strategies of British Firms", *Business History*, vol.29, no.4, (1987), p.53; several other Sheffield firms also established American subsidiaries, see G. Tweedale, "Transatlantic Speiciality Steels: Sheffield High-Grade Steel Firms and the USA, 1860-1940" in G. Jones (eds.), *British Multinationals Origins, Management and Performance* (Aldershot, 1986), p.75-95.

III

Education and Training

Firth's was able to develop a skilled workforce very quickly by poaching expert melters from Sanderson's. However, in order to develop a loyal workforce, the managers aimed to create 'company men', by recruiting and training a large number of apprentices each year.[63] The company culture also influenced the form that this training took, in particular, the assumption that human activity should be interesting and varied and constantly changing ensured that apprentices were given a comprehensive training, designed to inculcate the broad and flexible skills that were required to support flexible specialisation, which was itself an outcome of the assumption that the firm should be a responder to, rather than a shaper of its environment. For much of the nineteenth century, these skills were developed solely by experience within the firm, but it will be argued that from the 1890s onwards, in order to support the manufacture of new science-based products such as specialist steels, employees were encouraged to pursue courses of technical education, and technical education became a prerequisite for promotion to positions of responsibility. Thus, since quality was a core-value of the culture and since the nature of human activity was constantly changing, it will be argued that the management were able to quickly move away from traditional rule-of-thumb methods and introduce more formal programmes of technical education. However, for now I will focus upon the traditional methods of training and the skills which they produced.

In crucible steel production, team labour was common and the hierarchical nature of the system allowed apprentices to progress from cellar lad, to 'puller-out' and eventually to 'teemer', foreman and even department manager.[64] It was generally recognised that crucible furnace work required "a special constitution and training", and that men had to be caught while they were still young and "brought up to it", as it was not every man who could take on the duties of a 'puller-out', which consisted of "standing over the hole and lifting from a depth three feet below ground level a pot weighing 30 lbs. with its contents of 80 lbs. of molten steel, the whole at a temperature of 1,500 degrees centigrade." Equally, it was not every man who could grip the heavy pot with a pair of tongs, balanced on the knee, and then teem (pour) the molten steel into the moulds without catching the sides, the result of which would have been impurities in the

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[63]Many of these were sons or relations of existing workmen. Family ties in Firth's workforce mirrored family control of the business, and in 1920 it was noted that many of the workers were direct descendants of the firm's first employees, *The Bombshell*, vol.4, no.1, (Jan. 1920), p.12; *The Bombshell*, vol.3, no.11, (Nov. 1919) p.410; Lloyd-Jones & Lewis, "Personal Capitalism", p.401. These authors have argued that family links were common in the workforce of most Sheffield firms and that these mirrored family control in the business structure.

[64] Lloyd-Jones & Lewis, "Personal Capitalism", pp.400-402; G. Tweedale, "Science, Innovation and the Rule-of-Thumb", p.59.

steel.[65] Such tasks required a careful training, and fortunately Harry Brearley's autobiographical publications provide the business historian with excellent details on Firth's training programme, which was eminently practical and designed to develop brute strength, manual dexterity and particularly observational skills. Thus, Brearley considered that Firth's, and indeed Sheffield's, reputation for tool steel depended upon the acute observation of workmen, or managers who had been workmen. Their inherited knowledge, which had been acquired by trial and error methods, had produced a 'rule-of-thumb' which enabled them to determine when the steel was satisfactory, and to judge the carbon content and hence hardness of a fractured ingot, and the uses to which it could be put, simply by looking at its crystalline structure. [66]

School leavers who joined Firth's were usually apprenticed to a relation or close friend and they began working in the furnaces as cellar lads. The cellar lads were required to tread the clay for the crucible pots and produce truncated cones of baked clay, complete with their covers or lids. These duties enabled them to "begin at once to learn something about the properties of the materials with which they had to work and to accept responsibility for an appreciable part of the furnace tools."[67] Additional duties included the transportation of the bar-iron and steel scrap to the melters at the furnaces. Brearley informs us that this "was of great value as it gave the cellar lads an early familiarity in moving about the furnaces."[68] But more importantly, once at the furnace, they had the opportunity to observe the skilled operations of pulling-out and teeming. This learning was not purely passive, for early in their training they were encouraged to imitate the skilled workmen. Initially, they would practice by pulling-out an empty pot from a fireless furnace. But, once the apprentice masters were satisfied that they had "got the grip and swing of some masterful workmen" and could skilfully manage the empty pot, its weight was gradually increased by adding "more and more water up to the limit of the young operator's skill and strength."[69] Having mastered this, the cellar lads began to practice teeming, balancing the tongs on their knees and pouring the water into the moulds. Only when these cold-working operations had been successfully completed, were they allowed to begin supervised pulling-out from a fired crucible furnace, and start working their way through the labour hierarchy. Under this system of training, learning continued long after any formal apprenticeship was completed, and the ability of the teemer to manufacture a wide variety of steels, and to determine the

65 *Visit to a Sheffield Steel Works, W. Jessop and Sons, c.1911*, paper written to be read before the Keighley Association of Engineers, March 11th 1911, pp.13-15.
66 Brearley was employed by Firth's and is often personally credited with the invention of stainless steels, H. Brearley, *Steelmakers* (London, 1933), pp.75-79.
67 *Ibid.*, pp.42-43.
68 *Ibid.*, pp.42-43.
69 *Ibid.*, pp.49-52.

hardness of a fractured ingot and the uses to which it could be put, was a product of long experience at the furnace face.

An important question to explore therefore is: was this system of training, and the skills which it developed, adequate to Firth's needs? Many economic historians have condemned British industrialists for their reliance upon 'rule-of-thumb' methods and traditional training techniques, claiming that a lack of technical education constrained industrial performance.[70] Nevertheless, as Pollard has argued, "the death-knell of 'rule-of-thumb' methods would sound at different times in different industries", and it would also have varied from firm to firm, depending upon the technologies that they used and the products which they manufactured.[71] For most of the nineteenth century, the traditional training methods employed at Firth's appear to have been perfectly adequate. The first sign of a deficiency in rule-of-thumb methods did not materialise until 1884, when the firm erected its first Siemens furnace. The workforce was unfamiliar with a furnace that owed much of its success to scientific research and, in order to maintain quality control, the firm found it necessary to appoint a chemist and establish a new analytical laboratory.[72] Nevertheless, it would be easy to exaggerate the deficiency of rule-of-thumb at this time. As chapter 2 argued, there was no clearly-articulated science of metallurgy, and deficiencies in elementary education meant that the majority of the workers were in no position to benefit from scientific instruction.[73] However, from the 1890s onwards, as elementary education became more widely diffused and as Firth's expanded its specialist steel trade, there developed an urgent need for technical, and especially metallurgical, education. Indeed, the production of specialist alloys fundamentally changed the technological context in which Firth's operated and dramatically altered its human resource requirements. Because the hardness and other properties of alloy steels were no longer solely determined by their carbon content, they could not be graded in the traditional way, that is, by observation of the fractured surface of an ingot. The development of these steels therefore created an immediate need for Firth's to exploit the new science of metallurgy, and when the firm installed an electric arc furnace which permitted greater control of the melt, the need for such knowledge became even more pronounced.[74] Thus, a range of product and process

[70] See C. Barnett, *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (London, 1986); F. Crouzet, *The Victorian Economy* (London, 1980); M. Dintenfass, *The Decline of Industrial Britain*, 1870-1980 (London, 1992); B. Elbaum & W. Lazonick, (eds.), *The Decline of the British Economy: An Institutional Perspective* (Oxford, 1986). G. W. Roderick & M. D. Stephens, *Education and Industry in the 19th Century: The English Disease* (London, 1970).
[71] Pollard, *Prime and Decline*, p.202.
[72] Marshall & Newbould, *History of Firths*, p.57; Edgar Allen's appointed a chemist to run their analytical laboratory which was established to support the Siemens furnace in 1881. "The Story of a Great Steel Firm, Edgar Allen & Co. Ltd.", Edgar Allen Magazine vol.3, no.31, (June 1954), p.688.
[73] Brearley, *Steelmakers*, pp.53-55; Tweedale, "Science, Innovation and Rule-of-Thumb", p.64.
[74] Brearley, *Steelmakers*, p.89; SLSL, BBSTQ, R. A. Hadfield, Personal Collection, R. A. Hadfield, *Address when declaring open the new engineering and metallurgical laboratories at the 21st*

innovations meant that the work process was no longer fully understandable by the traditional methods of training. In what follows, it will be argued that the management were acutely aware of this and that they sought to acquire a tighter control over the labour process, in order to reposition their education and training policy and manage their human resources in line with the changing needs of the workplace.

In order to explore how Firth's realised this goal, this chapter will test the Firth's case-study against the 5-point model of labour management devised by Katherine Stone. This model was derived from an empirical examination of the techniques which American manufacturers used to break worker control over the labour process in order to develop mass production and economies of scale during the late nineteenth century. It therefore provides the business historian with a valuable framework for examining the differences in labour management in the United States and Britain. It will be argued that because Firth's need to acquire tighter control over the labour process was informed by product and process innovations rather than a strategy of output expansion, the company only made use of the latter three techniques described in table 1.2.[75]

Anniversary Celebrations of the Sheffield University, July 2nd 1926 (Sheffield, 1926), p.18; R. A. Hadfield, "Presidential Address to the Faraday Society", 1914, p.25; Tweedale claimed that the science of metallurgy was only definitely emerging c.1900. Tweedale, "Science, Innovation and the Rule-of-Thumb", p.69. C. H. Desch claimed "Formerly, the great knowledge possessed by the steel workers was entirely empirical, but with the introduction of new processes and especially with the invention of alloy steels containing tungsten, chromium, vanadium and other metals, scientific study of steel became an imperative necessity", C. H. Desch, *The Steel Industry of South Yorkshire: A Regional Study*, a paper read to the Sociological Society on 24th January 1922, p.137.

[75] K. Stone, *The Origins of Job Structures in the Steel Industry*, conference paper on Labour Market Stratification at Harvard University, March 16th to 17th 1973, p.114.

Table 1.2: Stone's Model of Labour Management.

Technique number	Description of the Labour Management Technique
1	The re-education of foremen. Stone claims that new training programmes were devised in order to teach foremen how to maintain discipline, and to provide them with the techniques necessary for handling men and developing team-work.
2	The creation of a new type of skilled worker, one whose skills were highly specialised and limited in their scope.
3	The creation of a recruitment and welfare department
4	The development of a pay hierarchy based on mental skills.
5	The recruitment of college graduates to management positions. Stone claims that the effect of this policy was "to take knowledge from the skilled workers and transfer it to the side of management."

(Source: K. Stone, *The Origins of Job Structures in the Steel Industry*, conference paper on Labour Market Stratification at Harvard University, March 1973.)

The first technique, the re-education of the foremen, does not appear to have been used by Firth's, or any other Sheffield firm prior to World War One. The only change in the foreman's education was the inculcation of formal technical knowledge, which became a pre-requisite for promotion to this position. Firth's foremen received no formal training in the development of team-work and techniques for handling men. However, there perhaps was no great need for this instruction, for, as has already been noted, the assumption that human relationships were characterised by co-operation lay at the heart of the company culture and team-work was a central feature of the firm's steel making operations.[76]

The second technique, the creation of a new type of skilled worker, one whose skills were highly specialised and limited in their scope, was not extensively used in Sheffield because flexible specialists such as Firth's required workers with broad, adaptable skills.[77] Indeed, as Scranton has argued, flexible specialists "depended...on skilled

[76]Chapter 5 will argue that, during the inter-war years, the teaching of techniques for handling men became more important to the city's manufacturers, as economic depression placed a premium upon reductions in the costs of production.

[77] Some large vertically-integrated concerns, such as John Brown's, Vickers and Cammell's, were geared up for the mass production of heavy naval armaments using embryonic flow production techniques, and here the introduction of repetition work and labour-saving devices did lead to some de-skilling. However, rapid changes in military requirements, and the high standards of quality, demanded many skilled workers, and generally, as C. More points out, there is no evidence of widespread de-skilling; rather, the

workers whose shop-floor versatility made productive diversity feasible."[78] Moreover, Firth's organisational culture precluded the acceptance of the Taylorite principle of the fundamental laziness and stupidity of the workers, which underpinned de-skilling and the intense sub-division of the work process.[79] The director of Firth's research laboratory for example, claimed that the worker must have "imagination and flexibility", or "'wings' to enable him to fly", concluding that under the Taylorite system "the only possible use for wings was to fly away to a job fit for human beings."[80] The assumption that the nature of human activity should be varied interesting and changing therefore set strict limits upon de-skilling. Nevertheless, the remaining three techniques in Stone's model were used by Firth's, and it is to a detailed consideration of how they were used that I now turn.

During the late nineteenth century, as Firth's business operations grew and the workforce burgeoned, it became impossible for the Firth brothers to interview each and every employee. Recruitment was, therefore, increasingly delegated to foremen. Unfortunately, due to the product and process innovations discussed earlier in this chapter, the firm's human resource requirements were becoming more sophisticated and top management soon realised that the foremen were incapable of assessing the capabilities of applicants, and of ascertaining who was best suited to a particular job. In the final decade of the nineteenth century, therefore, the company began to develop a more centralised and systematic recruitment procedure which was administered by a separate welfare department.[81] This department aimed to ensure that all apprentices admitted to the firm had the educational attributes which chapter 2 identified as necessary for further technical instruction. Increasingly, therefore, apprenticeships were only given to those youths who had passed standard four of the Board of Education examinations; that is, to those youths who had mastered the 3 "R"'s and acquired some elementary scientific knowledge.[82]

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persistence of one off or batch production led to a continuing demand for skilled workers in many industries, C. More, "Skill and the Survival of Apprenticeship", in S. Woods (eds.), *The Degradation of Work: De-skilling and the Labour Process* (London, 1982), p.121; Levine has remarked on the general lack of interest in Taylorism in Britain prior to World War One, Levine, *Industrial Retardation*, p.63.

[78]P. Scranton, "Diversity in Diversity: Flexible Production and American Industry 1880-1930", p.41.

[79]Littler claims that Taylorism was based upon the idea that "the natural instinct and tendency of men is to take it easy which may be called 'natural soldering', (Taylor 1903)." Moroever, "any man phlegmatic enough to do manual work was too stupid to develop the best way, the 'scientific way' of doing a job", C. R. Littler, *The Development of the Labour Process in Capitalist Societies* (London, 1983), p.51; see also B. Doray, *From Taylorism to Fordism: A Rational Madness* (London, 1981).

[80] Brearley, *Steelmakers*, pp.141-42; Lloyd-Jones & Lewis claim that "The delivery of quality goods was related to the explicit rejection of mass production", Lloyd-Jones & Lewis, "Personal Capitalism", p.383.

[81]H. Brearley, *Stainless Pioneer: Autobiographical Notes* (Birmingham, 1989), p.49.

[82]SUA 5/1/2 (ii), Chapman Collection, papers relating to the history of the Sheffield Technical School, vol.2, p.385.

Firth's was not alone in tightening up its recruitment procedures in this way. Vickers also developed a more elaborate scheme for the recruitment and selection of its apprentices. It required all boys wishing to enter the works to bring certificates stating the standard they had passed, and to provide school reports on their attendance and behaviour.[83] In addition, both Firth's and Vickers monitored the progress of their employees, identifying those for whom promotion was most appropriate. By this method they were better able to manage their human resources, and in particular, to create a pay hierarchy based upon mental skills which is discussed below.[84]

From the 1890s onwards, Firth's made extensive use of the fourth of the American techniques, that is the development of a pay hierarchy based upon mental skills. The directors made it clear to their workers that, since the manufacture of their products now required a high level of technical knowledge, promotion and pay rises would be the reward, not only for practical skills and loyalty to the company, as in the past, but for the correlation of these qualities with technical expertise. In order to develop such expertise, Firth's introduced a scheme designed to encourage apprentices to attend evening classes. Under this scheme, all apprentices who made at least 80 per cent of the possible attendances at classes in subjects such as engineering and metallurgy, had their fees remitted by the firm, and the management provided pay rises in reward for each examination passed.[85] As was noted earlier, the organisation of labour within the firm was inherently hierarchical and the career profile of Mr. Colin Shaw, contained in appendix C, is a typical example of how promotion through this hierarchy became dependent upon the acquisition of formal technical qualifications. The management argued that the career of Mr. Shaw "should serve as a spur to the many apprentices of the firm who are interested in technical education, for he is one of our own lads having risen in the firm from apprentice to foremen."[86] Thus, the Firth brothers used role-modelling as a mechanism for culture embedding and reinforcement. That is, they explained to their employees why a particular promotion was being granted. When James Rossiter Hoyle, for example, was promoted to the Board of Directors in 1893, it was emphasised that this was a reward, not only for his technical knowledge and marketing expertise, but also his loyalty to the firm, "his personal interest in his subordinates and his ready appreciation of their work."[87]

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[83]CA 622 (4), Sheffield Higher Education Sub-Committee Minute Book, no.1, April 1903 - June 1907, p.52.
[84]*Ibid.*, p.49.
[85] CA 681/9/2, City of Sheffield Education Committee Annual Report, 31st March 1905, p.10; see also SUA VIII/1/66-69, Sheffield University Evening Department Letter Books.
[86] *The Bombshell*, vol.6, no.6, (June 1922), pp.228-231.
[87]Hoyle was very much in the mould of Mark Firth, thus it was claimed that Hoyle had been a "great human influence in a busy hive of industry, compelling, by the force of his personality, a loyal and willing service", *Ibid.*, vol.6, no.1, (Jan. 1922), pp.5-7.

Firth's was only one of many Sheffield firms to adopt schemes to encourage technical education and to develop a pay hierarchy based on mental skills. Vickers, for example, remitted the fees of all apprentices who made 75 per cent of the possible attendances at evening school, and successes in examinations were rewarded by the payment of one shilling extra per week per subject.[88] Vickers' scheme was, in fact, particularly sophisticated. By 1903 its apprentices were admitted in 3 distinct grades, each grade following a differentiated training programme, described in Table 1.3:

Table 1.3: Vickers Education and Training Scheme

1	Those youths admitted direct from elementary school were required to spend 6 months in the works and 6 months at technical school for a period of 3 years, before taking up a full-time post.
2	Those youths who had already passed a course at the Sheffield Technical School, or a similar institution, were required to undergo one years training in various works departments, followed by a 2-year period in the drawing office.
3	Those youths with a board or grammar school education, who had passed a 2-year course at the Sheffield Technical School, were allowed to enter the works at 18 at a scale of pay which took the years at the technical school as equivalent to the same time spent in the shops. They were provided with experience in various works and commercial departments and groomed for positions of responsibility.[89]

(Source: SUA VIII/1/2, Sheffield Technical School Minute Book, no.2, p.222.)

A similar scheme was also operated by Davy Brothers. This firm specialised in the manufacture of heavy machinery such as automatic hammers, and it had a global reputation for the quality of its high-speed presses.[90] To maintain a competitive advantage in the manufacture of such intricate machines, the company required significant skills in product design, and in order to develop these, the management paid for its apprentices to enrol on the university's work's pupils' course, which was discussed in chapter 3. The work's pupils' certificate was only awarded to those pupils who spent 6 months at the works and 6 months at the university for a period of three years. During this intensive training programme apprentices were taught mechanics, the strength of materials, the theory of structures, steam engineering, the theory and

[88]CA 622 (4), p.49; SUA VIII/1/2, Sheffield Technical School Minute Book, no.2, p.223.

[89]This mirrored the traditional premium apprenticeship system which operated at many firms including Firth's where, upon the payment of about £50, an apprentice was provided with an in-depth training in all aspects of the business in order to fit him for the highest positions in industry.

[90]*Davy High-Speed Forging Presses* (Sheffield, 1921), p3, 56.

practice of machine tools, machine drawing and design.[91] In other words, every conceivable subject required for high-quality draughtsmanship. Not surprisingly, therefore, Davy Brothers could claim that "Our staff and workmen are in a unique position for carrying out the design and manufacture of forging presses...with special attention paid to all parts of construction."[92]

Vickers and Davy Bros. were amongst Sheffield's largest firms, and they were the first movers in the field of technical education. If the Firth's case-study is to be placed in a broader and more representative context, therefore, there is a need to explore what other firms were doing. It appears that Firth's scheme was not atypical. Indeed, a number of firms made the excellent evening classes provided by the Sheffield University, which were discussed in chapter 3, an integral component of their training programmes. By 1906, for example, Samuel Osborn's and Jonas & Clover's had introduced a scheme for the technical education of their employees. These firms paid the fees of all employees who made 75 per cent of the possible attendances at evening classes, and provided wage increases in reward for exam success. Moreover, like Firth's, they emphasised that the acquisition of formal technical qualifications would be the key to promotion, and that no apprentice without these qualifications would be admitted to the drawing office.[93] This scheme was emulated by Joseph Beardshaw and Sons in 1908, and, in that year, Michael Sadler found that 18 out of 34 engineering firms which he visited, provided paid day-release, whilst 28 granted certain facilities to encourage attendance at evening classes.[94] Down to World War One, the number of Sheffield firms adopting such schemes continued to increase and, by 1920, Edgar Allen's could claim that "The majority of employers take an active interest in the education and training of their young employees and many firms give a substantial increase in wages each year depending on the number of exams passed."[95] In conclusion, the evidence presented here clearly contradicts the received wisdom that employers neglected the technical education of their employees.[96] Indeed, in what follows it will be argued that firms

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[91]W. Ripper, "Engineering Industry of the District", in Porter (eds.), *Sheffield 1910*, p.284; SUA VIII/1/2, pp.491-492, 529.
[92]*Davy Presses*, p.3; as table three in Appendix C shows, only a small number of students qualified for the work's pupils' certificate prior to 1919. Thus, many of Vickers' and Davy Brother's apprentices must have failed the examinations or not sat them. However, this does not mean that their learning experience was not eminently useful.
[93]Seed, *Pioneers for a Century*, p.38; SUA VIII/1/2, p.338, 342.
[94]M. E. Sadler, *Continuation Schools in England and Elsewhere* (Manchester, 1908), pp.284-291; SUA VIII/1/2, p.377.
[95]*Edgar Allen's Works and Sports Magazine*, no.2, (July, 1920), p.22; Sheffield University Evening Department Letter Books, SUA VIII/1/66 and 67; CA 681/9/2, City of Sheffield Education Committee Annual Report, March 31st 1905.
[96]Floud has also criticised the consensus view, R. Floud "Technical Education and Economic Performance, Britain 1850-1914", *Albion*, vol. 14, (1982), pp.153-171.

such as Firth's recruited a number of applied science graduates, training them for positions as departmental managers.

Firth's made good use of graduate recruitment, the fifth of the labour management techniques described by Stone. As table one in Appendix D shows, the firm recruited 10 graduates / associates from Sheffield University and at least three graduates from other institutions. Some of these graduates, were trained for positions as departmental managers. A. B. Winder, for example, (associate metallurgist and Mappin medalist), was recruited from the Sheffield Technical School in 1893. He entered the firm's Siemens department where his works training began at the very bottom of the ladder, and he worked at every branch in the department before being promoted to a managerial position.[97] Firth's however, did not only use graduates as departmental managers, rather it sought to recruit leading metallurgists, such as Dr. W. H. Hatfield and G. Stanfield (MMet) into its research laboratory.[98] Such graduates worked out detailed recipes for the manufacture of specialist alloys, and the workers increasingly operated in accordance with their specifications. However, it was not a simple case of de-skilling, the workers required substantial metallurgical knowledge if they were to follow these specifications, and under the guidance of the departmental manager, they retained responsibility for responding to problems and developments at the furnace face. Hence, the importance of the firm developing detailed schemes of technical education.

Firth's policy of recruiting graduates to positions in the laboratories was not atypical. Many of the city's larger firms developed an expert research staff. By 1922 for example, Robert Hadfield could claim that "No less than 11 members of his research laboratory had been trained at Sheffield University."[99] In addition, many of the city's larger firms also recruited graduates to managerial positions. In 1903 for example, it was noted that the managerial staff of one of the large works in the city was "practically manned by past students at Sheffield University," and in 1907 Sir Joseph Jonas reported that many steel firms employed science graduates on their managing staff.[100] As tables one and two in Appendix D show, many of the largest firms, such as Hadfield's and Vickers, employed numerous graduates, and these firms, like Firth's, admitted technical experts and military specialists on to the board of directors. Nevertheless, in order to place the Firth's case-study in a broader context, there is a need to explore whether smaller firms were recruiting graduates and how they were used.

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[97]*The Bombshell*, vol.5, no.3, (March 1921), p.85.

[98]*Ibid.*, vol.4, no.9, (October 1920), p.365.

[99]No figures are available on the overall size of the research staff, see Hadfield, *Address, When Declaring Open, the New Engineering and Metallurgy Labs.*, p19.

[100]SUA 5/1/33, Chapman Collection, papers relating to the history of the Department and Faculty of Metallurgy, 1907-1966, pp.5-6; see also Sanderson, "Industrial Consultant", p.397.

As table two in Appendix B shows, prior to 1919, approximately 70 Sheffield steel and engineering firms had recruited at least one applied science graduate from the Sheffield University and many had recruited far more.[101] Graduate recruitment was not therefore only confined to the city's largest and best known firms, such as Firth's, and this challenges Hoskins' argument that the steel industry was "slowly penetrated by science and failed to appreciate that it was entering a new technical phase."[102] Unfortunately, the lack of business records makes it extremely difficult to ascertain what graduates in the smaller firms were doing but it will be argued below that Charlotte Erickson may well have underestimated the number of steel manufacturers who received a technical training prior to World War One.

Erickson's analysis of the education of a sample of steel manufacturers lies at the heart of a current orthodoxy, which claims that the formulation of business strategy in the steel industry suffered from a lack of technical expertise. In order to qualify as a steel manufacturer for the purposes of her study, firms had to produce steel by either the Bessemer or the open-hearth process, and in order to weight the study in favour of the large public company, she adopted a definition which excluded the smaller electrical and crucible steel industries, as well as the diversified finishing trades.[103] She, therefore, effectively dismissed a large portion of Sheffield's industrial structure, on the explicit assumptions that small crucible and finishing firms were "inherently conservative", and owner managers "rarely had any kind of professional or specialist training."[104] It will be argued that these assumptions were misleading, and that after 1880 the training of sons for managerial succession underwent a significant transformation.

In contrast to the early nineteenth century, when training for succession was based solely within the firm, after 1880, the son's tour of the works was increasingly supplemented by formal study at technical schools and universities, and, as table three in Appendix D shows, a number of them became graduates. Indeed, 3 sons of the tyre and axle manufacturer, John W. Baker, qualified as associates in engineering or metallurgy and 2 of the sons of the Sheffield tube specialist, S. E. Howell, graduated as

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[101] In addition the University turned out 400 trained analytical chemists who were absorbed into local industry, SUA VIII/127/1, Professor Arnold Letter Book, no.1, p.571. Of course firms also recruited graduates from other universities, for example Firth's had absorbed graduates form at least 4 other universities.

[102] T. H. Burnham & G. O. Hoskins, *Iron and Steel Industry in Britain, 1870-1930* (London, 1943), p.246.

[103] C. Erickson, *British Industrialists: Steel and Hosiery, 1850-1950* (Cambridge, 1959), p.1.

[104] *Ibid.*, p.53, 61.

members of the Institutes of Mechanical and Civil Engineers.[105] Of course, the precise make-up of sons' training programmes varied. Some, such as Wilton Lee, followed a full-time degree course and only began their tour of the works on completion of their studies.[106] Others, Lawrence Brittain, for example, received a year's training in the works prior to taking up a full-time degree course, possibly in order to prevent them from developing an aversion to manufacturing.[107] The vast majority, however, were not following degree programmes and they acquired their technical education by evening study, their days being spent in practical work at the shops. Robert Balfour, for example, combined evening instruction in metallurgy with day training in every one of Arthur Balfour's commercial and technical departments. Indeed, it was claimed that Robert Balfour "had done any job at any level", that "he knew every man in the company" and that he had "visited many overseas markets."[108] As Scranton has argued "to be a practical manufacturer, a proprietor had to know not just the outlines of the business but the intimate details of the materials and machinery and the commercial and financial mazes of uncertain markets."[109] Overseas travel was, therefore, frequently made an integral component of the sons' training, it enabled them to familiarise themselves with customer requirements and to establish friendly relations with their clients; indeed this was a key aspect of the city's personal style of management. In the next part of this chapter it will be argued that the combination of formal technical education with the tour of the works and overseas travel, ensured that training for succession in smaller family firms was adapted to meet new environmental contingencies, and, in particular, it enabled family-managed enterprises such as Spear and Jackson's, to introduce a series of product and process innovations which enabled them to operate at the cutting-edge of specialist steel technology.[110] However, the focus is on Thomas Firth and Sons, and fortunately an excellent stock of business records allows for a detailed examination of the performance of this company.

[105]For a short history of John Baker's see, *A Lifetime in Steel: A Pictorial History of Iron and Steel Making in Rotherham* (Rotherham, 1987), p.15; see also C. W. Spalding, *Tubes of Steel: the History of Howell & Co. Ltd, 1865 -1971* (Sheffield, 1971),pp.4-7.

[106]Wilton Lee's vacations from Cambridge University, where he was studying metallurgy, engineering and economics, were spent at the works, *Lee Steel, 1874-1974* (Sheffield, 1974), p.8.

[107]Brittain also followed courses in accountancy, marketing, French and Spanish, Pollard, *Three Centuries of Sheffield Steel*, pp.74-75.

[108]*Balfour Centenary*, p.32.

[109]P. Scranton, "Learning Manufacturing: Education and Shop Floor Schooling in the Family Firm", *Technology and Culture*, vol.27, no.1, (Jan. 1986), p.43.

[110]As Locke argued, "Higher Education only became of major importance when, during the 'second industrial revolution', the nature of the entrepreneurial function changed", R. R. Locke, *The End of the Practical Man: Higher Education and the Institutionalisation of Entrepreneurial Performance in Germany, France and Britain, 1880-1940* (London, 1984), p.293.

IV

Education, Training and Business Performance

Sheffield's focus upon quality meant that in quantitative terms it was rapidly superseded as a steel-making centre. This supercession can be inferred from changes in the international distribution of steel production. Whereas in 1870 Britain produced 43 per cent of the worlds steel, by 1913 this figure had dwindled to 10 per cent as competitors turned out large quantities of cheap steel.[111] The city's commitment to meeting diverse customer needs also meant that Sheffield manufacturers were unlikely to be as efficient as mass producers in the U.S. Indeed, T. H. Burnham and G. O. Hoskins argued that "the fundamental fault with the British steel industry was its low productivity per man."[112] However, quantity of output per man was not as important to Sheffield manufacturers as the quality of output, they sought to compete not on the tonnage of steel but on its quality and high value.[113] Thus, as chapter one argued, in assessing business performance there is a need to focus upon those indicators which related to the operative goals, that is, the business strategy that firms pursued.[114] Given Firth's business strategy, two important indicators of business performance are product quality and employee satisfaction. Employee satisfaction is not easy to measure, as I am not in a position to conduct employee interviews; however, Firth's large number of long-service employees and the equally large number of families which had two or three generations working simultaneously for the firm, is suggestive of a contented workforce, as is the notable absence of strike action.[115] Firth's commitment to investing in its human resources, through paternalism, education, training and promotion must have played some part in this, and, moreover, it will be argued that education and training was critical to the maintenance and improvement of product quality.

It has been claimed that "as companies head towards the new millennium, what separates winners from losers is the ability to manage change, anticipate it, prepare for it and turn it into a competitive advantage."[116] The recruitment and training initiatives introduced by Firth's during the late nineteenth century and its increasing commitment

[111] B. Elbaum, "The Steel Industry Before World War One", in Elbaum & Lazonick (eds.), *Decline of the British Economy*, p.51.

[112] Burnham & Hoskins, *Iron and Steel in Britain*, p.49; more recently McCloskey has argued that the productivity differentials between Britain and the U.S. were not as great as Burnham and Hoskins suggest, D. N. McCloskey, *Economic Maturity and Entrepreneurial Decline: British Iron and Steel, 1870-1913* (Harvard, 1973), p.14.

[113] J. O. Arnold & A Mcwilliam "Iron and Steel Industries of Sheffield", in Porter (eds.), *Sheffield 1910*, p.226.

[114] "Historians appear to have forgotten that the quantity of steel produced is only one economic indicator, value must also be taken into account", Tweedale, *Steel City*, p.12.

[115] *The Bombshell*, vol.5, no.3, (March 1921), p.83; *John Bedford and Sons*, p.37.

[116] T. Q. Spitzer & P. M. Tobia, "People-Wise Organisations: The Human Side of Change", *Management Review*, (Oct. 1994), p.44.

to R & D, provided the new science-based skills which the changes in its products and processes demanded. In particular, they enabled the firm to improve product quality and meet the exacting requirements of the 'new' chemical and automobile industries, which provided a large and growing market for its specialist alloys. Indeed, the shifts in the education and training of the workforce, and the development of the Brown-Firth research laboratories, facilitated the invention of stainless steel, arguably the most significant metallurgical breakthrough of the twentieth century, which enabled the firm to further enhance its reputation for excellent product quality.[117]

Firth's and Sheffield firms generally were noted for the high-quality of their products, indeed, the name Sheffield became synonymous with quality goods.[118] Contemporaries clearly believed that quality paid, and that quality was dependant upon technical education which had become an integral part of the business strategy, not only at Firth's, but at many other firms.[119] One well-known Sheffield manufacturer, for example, claimed that "notwithstanding tariffs" his firm had "broken right in to the markets of the U. S. and Germany commanding them as they could not have some years before. Quality told", he claimed, and it was "knowledge and applied science that taught how quality might be obtained." [120] Technical education was in fact of crucial importance to the city's strategy; indeed, the president of the Associated Chamber of Commerce, claimed that "for the time past, Sheffield manufacturers have made the excellence of quality their first consideration. Because of this, the city is doing a good trade all over the world, and as long as they continue to act on this principle and encourage technical education, they need have no fear for the future of Sheffield."[121] Technical education was, of course, particularly important in the development of specialist steels. Both businessmen and educationalists considered that investment in research and technical education had enabled Sheffield to develop a substantial lead over foreign competitors in the manufacture of these steels. In 1903 for example, A. J. Hobson could claim that "large quantities of high-speed steel are exported to both America and Germany and as these two countries are our most serious manufacturing rivals we can feel satisfied with the state of affairs in which our supremacy in this industry is so practically acknowledged by them."[122] By 1907, this supremacy was such that Sheffield was supplying the United States with nearly a half of its annual

[117] *Brown-Firth Research Lab.*, p.7.
[118] J. W. Derry, *The Story of Sheffield* (London, 1915), p.164, 172.
[119] "Sheffield lives prosperously...not on the tonnage of its steel but on its quality and high value...all ambitious firms have a scientific staff", *Ibid.*, p.172.
[120] J. H. Stainton, *The Making of Sheffield 1865-1914* (Sheffield, 1927), p.145.
[121] LD 1986/6, Sheffield Chamber of Commerce Minute Book, no.6, pp.100-05.
[122] A. J. Hobson, "Sheffield Industries Cradle of the Modern Steel Trade: Highest Qualities in the World", SLSL Newspaper Cuttings Relating to Sheffield, vol.9; *Edgar Allen magazine*, no.41, (Feb. 1956), p.251.

consumption of high-speed steels.[123] In this key industry of the 'second industrial revolution', therefore, as Professor Arnold emphasised, Sheffield firms such as Firth's were market leaders, they had invested in research and development, recruited scientific graduates and encouraged the technical education of their employees with the result that "In the first decade of the twentieth century they were unbeatable in high-speed steels."[124] Indeed, the differing outcomes of Firth's foreign investments clearly illustrate the importance of technical knowledge and skilled human resources. In America, as was argued earlier, Firth's acquired a company which had a highly skilled workforce, that possessed both the practical skills and the technical knowledge needed for the successful manufacture of alloy steels and projectiles. In consequence, the performance of this subsidiary, from 1896 down to 1919, was extremely impressive, and it made a significant contribution to the profits of the parent. [125] In Russia on the other hand, Firth's acquired a poorly built works in an agricultural centre. It was forced to invest in new plant and equipment and train up a large number of Russians. The available evidence suggests that "by slow degrees" they "became reasonably able" to do most of the work required of them.[126] However, in Riga these skills were quite unique, and in the context of a scarce labour market the furnace men, struck for higher wages. Firth's felt unable to pay more, and was therefore forced to train up another set of workers. During the time required to train up a new set of melters, the subsidiary gained a reputation for product failure, and, in consequence, it made constant losses, draining capital reserves from the parent. By 1910, Firth's was paying over £20,000 per annum in interest on debts and was looking to divest itself of its interest in Russia.[127] Having established that technical education was crucial to the strategy, one question remains, to what extent did this strategy translate into financial success?

The financial data which is available indicates that Firth's was a very profitable concern. Clearly a strategy based upon quality production and technical education paid. From 1896 to 1918, as table four in Appendix D, shows the firms annual net profit never fell below £50,000 per annum, and the average yearly profit was £105,000 per annum.[128] In a recent article in *Business History*, Estu Ab'e has argued that the percentage annual return of net profit to capital employed at Bolckow Vaughan (a Middlesbrough-based steel firm) was in the region of 6 per cent and that this was

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[123]G. Tweedale, "Sheffield Steel & America: Aspects of the Migration of Special Steelmaking Technology, 1850-1930", *Business History*, vol.25, no.3, (1983), p.233.
[124]*The Engineer*, vol.XCVIII, (August 1904), p.143; Letter from Prof. Arnold to Editor of the Times, April 1st 1916, in SUA VIII/127/1, Prof. Arnold Letter Book, no.1, p.571; Pollard, P*rime and Decline*, p.29.
[125]Tweedale, "Transatlantic Speciality Steels", p.82.
[126] Brearley, *Stainless Pioneer*, pp.43-64.
[127] For details on the financial performance of the Riga Subsidiary, see G. Tweedale, *Steel City*, pp.151-160.
[128]See table in Appendix.

relatively good for the period, Firth's return was significantly larger, averaging at 7.4 per cent per annum.[129] The organisation was generally robust, from 1893 to 1900, as table four in Appendix D shows, the value of its annual sales more than doubled. However, in the depression which followed the Boer War, sales and profits declined. At this point, Firth's neighbour, John Brown and Co., acquired an interest in the firm, but this was essentially a defensive merger, a product of the 1900-4 merger wave identified by Gospel.[130] Management structures remained unchanged and the firms' only collaboration came in the field of research. Following the merger, profits and sales at Thomas Firth & Sons increased, and during the run up to World War One, the organisation began to enjoy record profits. A similar picture emerges at other Sheffield firms, Hadfield's can be most effectively compared with Firth's, as both these firms "eschewed vertical integration and concentrated on the more specialised alloy steels" Tweedale claims that Firth's was less dynamic than its neighbour, but the average annual profits at Firth's were larger than Hadfield's (which averaged at £56,417 p.a., from 1890-1914) Nevertheless, this is not to belittle the achievements at Hadfield's, indeed the success of the firm was astonishing, founded in 1872 on a 4 acre site, by 1914 it had risen to become the fourth largest firm in Sheffield.[131]

Turning now to examine the performance of Sheffield's three largest firms: Vickers, Cammell Laird's and John Brown's (all of which were vertically-integrated owning mines, steel-making and shipbuilding facilities.)[132] It is clear that Vickers was the more successful. Indeed, as table five in Appendix D shows its financial record prior to World War One was outstanding. From 1890 to 1913 net profits averaged at a colossal £912,019 per annum, and the shareholders in this firm enjoyed high dividends.[133] From 1890 to 1910 profits at John Brown's, on the other hand, averaged at £71,742, and the rate of return on the capital employed was around 8.10 per cent per annum. According to Pollard and Robertson, for a firm of Brown's stature these figures were "respectable, but by no means spectacular."[134] Still, the firm was clearly in an healthy condition and its profits would have been considerably larger if it were not for the poor performance of its subsidiary the Coventry Ordnance Works.[135] This company was part owned by Brown's, Cammell's and Beardmore's, and it had been established in 1905 with a view

[129]E. Ab'e, "The Technological Strategy of a Leading Iron and Steel Firm: Bolckow Vaughan & Co. Ltd., Late Victorian Industrialists Did Fail", *Business History*, vol.38, no.1, (January 1996), pp.45-76.
[130]See Gospel, *Markets and Hierarchies*.
[131]Derry, *Story of Sheffield*, p.166; G. Tweedale, "The Business and Technology of Sheffield Steel making", in C. Binfield et al (eds.), *The History of the City of Sheffield: vol.2, Society, 1843-1993* (Sheffield, 1993), p.163.
[132]Derry, *Story of Sheffield*, p.162.
[133]From J. D. Scott, *Vickers a History* (London, 1962), pp.389-91.
[134]From S. Pollard & P. Robertson, *The British Shipbuilding Industry, 1870-1914* (London, 1979) pp.81-2.
[135]SCA, records of Firth-Brown Ltd., Firth-Brown Box 336, Annual Reports of the Coventry Ordnance Works.

to meeting the military demand for guns and ammunition. However, from its foundation until 1916 it failed to deliver a profit.[136] To a large extent this can be attributed to the restrictive and collusive practices of Vickers and Armstrong's, who acted to shut out new competitors.[137]

At Cammell Laird, profits over the period 1890 - 1910 averaged at £163,469, however this disguises the losses made in 1907 and 1908, which can be attributed to Cammell's part ownership of the ill-fated Coventry Ordnance Works, and irregularities in prices at Cammell's Grimesthorpe works, which saw the firm temporarily removed from the naval list.[138] Moving away from the big three, what can we say about the performance of Sheffield's numerous small- and medium-sized enterprises? Unfortunately, the business historian is confronted by a dearth of financial data. However, as Lewis has shown, many of the small Sheffield firms were able to survive the blast of foreign competition, and this in itself is suggestive of a dynamic performance.[139] Moreover, contemporaries were clearly of the opinion that Sheffield's smaller producers were performing well. In 1910, for example, William Ripper claimed that "we see side by side with these huge concerns (Vickers, Cammell's and John Brown's) large numbers of small and flourishing engineering and other businesses engaged in the manufacture of specialities...."[140] For example, Howell & Co. specialised in boiler tubes, W. T. Flather in cycle spokes, and John Bedford and Sons in mining spares.[141] Such firms appear to have secured a sound performance through the exploitation of a market niche but, as J. H. Soltow argues, "the small firm however strongly entrenched in its niche had to be flexible enough to adapt to changes in market demands."[142] Thus, Arthur Lee and Sons had specialised in cold-rolled steel strip for the cycle trade, but as this market began to fail, it diversified into the production of alloy steels for motor cars. Its success in executing this switch, can be inferred from the fact that between 1907 and 1915, as table six in Appendix D shows, its profits increased four-fold.[143] Similarly, profits at Spear & Jackson's, which under the guidance of Leslie Jackson Combe (a university trained metallurgist), also increasingly focused on alloy steels, increased five-fold during the period 1905 to 1912.[144] It appears, therefore, that "on the eve of the first world war many of Sheffield's steel and engineering firms were enjoying unparalleled

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[136] *Ibid.*
[137] C. Trebilcock, *The Vickers Brothers, Armaments and Enterprise, 1854-1954* (London, 1977) p.93.
[138] Information on Cammell Laird from Tweedale, *Steel City.*
[139] See M. J. Lewis, "The Growth and development of Sheffield's Industrial Structure" (Unpublished PhD, Sheffield City Polytechnic, 1989).
[140] W. Ripper, "Engineering Industry of the District", p.259.
[141] *W. T. Flather Ltd, Standard Steel Works* (Sheffield, 1950), p.3.
[142] J. H. Soltow, "Origins of Small Business and the Relationship between Small and Large Firms: Metal Fabricating and Machine Making in New England, 1890-1957", in S. W. Bruchey (eds.), *Small Business in American Life* (New York, 1980), p.195.
[143] *Lee Steel,* p.9.
[144] Lloyd-Jones & Lewis, "Personal Capitalism", p.382.

prosperity" and the development of technical education and a strategy based upon quality production was instrumental in this.[145] Indeed, Tweedale's evidence indicates that companies such as Edgar Allen's, Jonas and Colver and Arthur Balfour were doing extremely well. He concludes therefore, that 1914 saw the city at its 'zenith'.[146] However, this is perhaps going too far. The period after 1870 was distinguished from the previous 20 years by the increase in overseas protection and the unprecedented expansion of foreign competition, which was felt not only in neutral markets, but also in the home market and in imperial markets, and the depressions of 1877-79, 1885-86, 1892-93, 1903-5 and 1908-11 began to undermine business confidence.[147] In addition, whilst the development of specialist steels and high-speed tools enabled some firms to do very well, and whilst the armaments industry could bring large if somewhat precarious profits, Tweedale's own exhaustive study of the cutlery industry has shown, the rate of innovation and profitability in this sector was far less impressive.[148] Interestingly, whilst a culture based upon product quality led to innovation and good profitability in the steel sector, an identical culture in cutlery led to technological retardation and failing profitability. This clearly shows the difficulties of drawing causal links between culture and performance. Indeed, as chapter 7 will argue, during the depressed conditions of the inter-war years, customers had to be cajoled into buying Sheffield's better quality and, therefore, more expensive steels, and investment in technical education in this era reaped much smaller dividends. However, prior to World War One Sheffield was able to enhance its reputation for quality by investing in technical education and developing new science-based products such as specialist steels which enabled firms such as Firth's to enjoy a good rate of return upon their capital and provide high dividends for their shareholders. Thus the thesis that an under-investment in technical education contributed to Britain's relative decline as a manufacturing nation may well have been over-stated. Technical education was integral to the business success that Sheffield firms enjoyed in the two decades prior to World War One.

[145]A. D. K. Owen, *A Report on Unemployment in Sheffield* (Sheffield, 1932), p.22.
[146]Tweedale, *Steel City*, p.22.
[147]Owen, *Unemployment in Sheffield* (1932), p.12.
[148]Tweedale, *Steel City*.

Chapter 5: Businessmen, Education and Training: Sheffield in the Inter-War Years.

According to William Ripper, writing in 1919, Sheffield businessmen had learnt two significant lessons from the First World War. The first was the need for amalgamation and rationalisation, and the second, the importance of scientific research and its corollary, the scientific and technical graduate.[1] Ripper and many others believed that the nation had embarked upon a new epoch in which science was to play a central role. The technical journal, *The Engineer*, for example, proclaimed that "British manufacturers were more impressed than at any previous time with the value of the scientifically trained worker."[2] Contemporaries clearly felt that the war had marked a watershed in business attitudes towards technical education, that the position of the graduate in industry was now assured, and that businessmen would henceforward be committed to education and training as a long-term investment in human capital. Nevertheless, economic historians have been far less sanguine. They have argued that business attitudes changed very little following World War One. In particular, they claim that British industrialists remained reluctant to employ scientific graduates and that, although the supply of scientists and technologists increased very slowly, there were no signs of an un-satisfied industrial demand. Indeed, it is has been argued that, in a context of severe economic depression, many firms reduced, rather than increased, their scientific staff, and manufacturers continued to regard their workers as a variable cost to be minimised during periods of economic flux, rather than as a resource to be developed.[3]

This chapter examines business attitudes towards, and demands for, technical and commercial education in Sheffield during the inter-war years. The crux of the argument presented here is that, although contemporaries such as Ripper exaggerated the extent

[1]Dr. W. Ripper, "The War and University Education", *Industrial Sheffield and Rotherham 1919* (Derby, 1919), pp.111-112.
[2]*The Engineer*, vol.125, (1918), p.341.
[3]Historians have tended to garner the majority of their evidence from official reports, such as the Balfour Report of 1927. Cotgrove, for example, makes extensive use of the Balfour Report. He quotes this report as follows: "In the iron and steel industry...it may be said that of recent years the supply of engineers and technical chemists has exceeded the demand." According to Cotgrove, "the general picture in the inter-war years is one of rough balance between the supply of scientists, technologists and the various grades of trained technicians and craftsmen and the demands of industry." He adds further "the apathy of industry towards technical education in the inter-war years and the small demand for scientific manpower are not surprising in view of the apathy of industry...towards both research and the application of science to production", S. F. Cotgrove, *Technical Education and Social Change* (London, 1958), esp. pp.76-78; C. Barnett, *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (London, 1980), p.212; K. Burgess, "British Employers and Education Policy, 1935-45: A Decade of Missed Opportunities?", *Business History*, vol.36, no.3, (July 1994), p.31; P. W. Musgrave, *Technical Change, The Labour Force and Education: A Study of the British and German Iron and Steel Industries, 1860-1900* (London, 1967), esp. pp.148-49; H. F. Gospel, *Markets, Firms and the Management of labour in Modern Britain* (Cambridge, 1992), esp. pp.60-70, 174-176.

of the change in business attitudes, economic historians may well have erred in the opposite direction. As chapter 2 emphasised, many Sheffield steel manufacturers were more enlightened than the received wisdom suggests, even before World War One.

The Evidence for Condemnation

It is not difficult to condemn Sheffield businessmen for their attitude towards education and training. One can compile a range of evidence to support the current orthodoxy . The majority of the city's businessmen clearly failed to accept education and training as an *essential* investment in human resources. The business community's response to the collapse of the post-war boom in 1921 was a highly conservative one. Manufacturers aligned themselves with financial orthodoxy, encouraging both local and national government to balance the budget through cuts in educational expenditure. The Sheffield Chamber of Commerce, for example, recommended: firstly, until times were more prosperous free education should be confined to certain elementary pupils, there should be a drastic simplification of the elementary curriculum and a reduction in staff and staff salaries. Secondly, there should be a reduction in investment in higher education and particularly secondary education. Thirdly, there should be no further capital expenditure; in other words, no new schools or extensions to old schools until the trade depression passed. And fourthly, the clauses of the 1918 Education Act dealing with day continuation schools should be scrapped.[4]

Only one firm explicitly opposed these recommendations on the grounds that, "it would be a bigger disaster to this country to discourage theoretical study than it would be to have too many trained for the posts available."[5] This firm was Thomas Firth & Sons, a company which, as chapter 7 will argue, consistently espoused the need to regard the workforce as a resource, rather than as a cost. This firm attempted to convince the local business community that cuts in education were a false economy, since they simply mortgaged the city's future for the sake of the present, but Sheffield manufacturers were not to be swayed.[6] Their response to the 'Great Depression' of 1929 to 1932 was

[4]The recommendation to abolish day continuation schools was a complete U-turn for the Sheffield business community, for, as chapter 2 argued, during World War One a resolution was passed in favour of the principle of extending the day continuation system. However, businessmen were so committed to cuts in expenditure that when Geddes (a former Minister of Transport) visited the city in 1922 he was presented with a stainless steel axe: a gift which was symbolic of Sheffield's commitment to the Government's economy campaign. In addition to cuts in educational expenditure, the Sheffield Chamber of Commerce also recommended cuts in welfare provision and armaments expenditure, a most peculiar request given the nature of the local economy. For full details of all the requests made by the Chamber of Commerce, see LD 1986/10, Sheffield Chamber of Commerce Minute Book, no.10, 29th August 1921, pp.88-93, 117-118.

[5]Letter from H. S. Burns (Welfare Supervisor of Thomas Firth & Sons) to the Editor of *Engineering*, September 14th 1922, *Engineering*, vol.114, (1922), p.44.

[6]They supported Geddes argument that "although education was highly desirable...it was the work of a visionary with only one eye to the future to educate children for higher posts and advancement in industry when in the very doing of it he was going to kill the industry and commerce to which these children

identical to that of 1921 to 1924: businessmen again demanded a decrease in educational expenditure on the grounds that, if they were to compete successfully with foreign competitors, an immediate reduction in taxation was essential.[7]

Economic historians have severely criticised British business for such short-termism, particularly since businessmen in competitor economies are alleged to have retained a commitment to education. In addition, they have claimed that British businessmen not only recommended cuts in educational expenditure, but also deliberately abused the apprenticeship system. It is argued that this abuse took two forms: on the one hand, there was a reduction in the number of indentured apprenticeships provided by manufacturing industry and, on the other, apprentices who were taken on under verbal agreements were increasingly misused as a source of cheap labour; that is, they were kept in one department, often at one machine on which they could rapidly become productive, rather than provided with a broad-based comprehensive training which would enable them to become skilled craftsmen.[8]

Again, there is ample evidence to support these claims: the number of indentured apprenticeships offered by the metal and engineering trades decreased significantly during the 1920s, and many Sheffield manufacturers were inclined to "make the boys stick to repetition jobs and...use them as money making machines instead of teaching them their trade."[9] However, it will be argued later in this chapter that in direct contrast to the received wisdom, Sheffield manufacturers were vociferous in their demands that local colleges provide an enhanced theoretical and practical instruction, which would compensate for the decline of the apprenticeship system, which was, in part, but a reflex of the increasing sub-division of labour.

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would have to look for a livelihood", Speech by Sir Eric Geddes to the Sheffield Chamber of Commerce, LD 1986/10, 9th May 1922, p.117.

[7]LD 1986/15, Sheffield Chamber of Commerce Minute Book no. 15, Half Yearly Meeting of the Members of the Sheffield Chamber of Commerce, 29th October 1930.

[8]Rather than admit indentured apprentices, manufacturers preferred to take apprentices on under verbal agreements which could be more easily reneged, A. McKinlay, "A Certain Short-sightedness: Metal Working Innovation and Apprenticeship, 1897-1931", in H. F. Gospel (eds.), *Industrial Training and Technical Innovation: A Comparative and Historical Study* (London, 1991), pp. 96-98.

[9]In 1926 only 54% of Sheffield steel and engineering firms employed apprentices or learners, and the number of apprentices taken on by almost every company declined during the 1920s. In addition, approximately 97% of apprentices were bound by verbal agreements which could be more easily reneged, *Ministry of Labour Report of an Enquiry into Apprenticeship Training for the Skilled Occupations in London and Northern Ireland (London, 1926)*; The tendency to make boys stick at simple repetition jobs was criticised by Mr. Varley (a local manufacturer) at a Conference of representatives of the Sheffield Foundry Trade, May 6th 1924, SUA 5/1/2 (ii), Chapman Collection, papers relating to the history of the Sheffield Technical School , vol.2, pp.384-387; see also SUA VIII/1/3, Sheffield University Applied Science Minute Book, no.3, pp.217-218.

In addition, a number of arguments may be made in defence of the city's businessmen. Firstly, many manufacturers were disappointed with the increasingly academic orientation of the city's day secondary schools, which is explored in chapter 6. They wanted technical and vocational secondary schools, and were reluctant to see money ploughed into a sector of the education system which continued to cater badly for their needs. Secondly, during the inter-war years, Sheffield firms were embroiled in a battle for survival in which taxation per capita was higher than abroad, and in which the domestic market remained for too long unprotected, whilst foreign competitors sheltered behind high tariff walls, free to dump their goods on the open British market. It is, perhaps, not surprising that in these circumstances investment in education and training was not accorded a high priority by the bulk of Sheffield's manufacturers, whose major concern was the revision of fiscal policy, in particular the introduction of protectionism and imperial preference.[10] Thirdly, as chapter 6 will argue, when protectionism for the steel industry was finally granted by the Import Duties Act of 1932, Sheffield businessmen immediately responded by investing in the refurbishment and re-equipment of the local university. This investment pre-dated the economic recovery, which, as chapter 7 argues, only began to be felt towards the end of 1933. It appears, therefore, that businessmen not only wanted protectionism as a precondition for rationalisation, as Tolliday has argued, but also as a precondition for investment in education. Prior to 1932, most manufacturers could see little point in educating and training the workers in an environment of unreciprocated free trade, where they felt unable to compete on equal terms with protected and subsidised foreign competitors. But, after 1932, as chapter 7 will emphasise, businessmen began to take on more apprentices, particularly as the recovery gained momentum. Nevertheless, it will be argued that they could not make up for a decade of neglect, and labour shortages began to constrain the re-armament campaign. However, for now I will focus upon the many positive features of business attitudes towards technical education, and the changes in business demands, which the standard economic history texts have largely overlooked.

The Evidence for Enlightenment

Although the city's businessmen were unwilling to invest large sums in education and training prior to 1932, they were, nevertheless, keen to retain their scientific staff and skilled workers. The onset of trade depression did not lead to redundancies for metallurgists and engineers, and whilst Sheffield manufacturers shed unskilled and semi-skilled workers, who were regarded as a secondary point in the labour market, they did all they could to hold on to the skill on which their businesses depended. Indeed, manufacturers emphasised that "even in times of depression", it would be "a

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[10]For a detailed discussion of dumping and protectionism see M. J. Lewis, "Sheffield's Industrial Structure, 1880-1930" (Unpublished PhD, Sheffield City Polytechnic, 1989), esp. ch. 9.

short sighted policy to dispense with the experts" who were crucial to their "profit earning capacity."[11] They therefore ran their plant on short time and accepted orders at barely remunerative prices, in order to retain some semblance of an employment contract for their scientific staff and skilled workers, many of whom had been with their respective companies for over a quarter of a century.[12] In this respect, the city's firms were clearly more enlightened than the received wisdom allows.

Sheffield businessmen were acutely aware of the importance of scientific expertise to their strategy of manufacturing high-quality steels which could be tailored to closely-defined customer requirements. Robert Hadfield, for example, emphasised that without scientific graduates "modern steel-making with its complex nature, specially of those types carried on in Sheffield (in other words specialist alloys) would be impossible", whilst Arthur Kingsford Weber, Governing Director of Spear and Jackson, argued that "the manufacture of steel is a most intricate, delicate and highly scientific process which demands not merely good materials and good men but the very best chemical and metallurgical brains."[13] The most compelling evidence of the business community's appreciation of the importance of scientific graduates to its competitive performance, however, is contained in the annual reports of the Faculties of Engineering and Metallurgy at the Sheffield University. These reports indicate that the university's supply of graduates only exceeded the industrial demand in 1922, whereas from 1914 to 1921, 1926 to 1930 and 1933 to the end of our period, the industrial demand for engineering and particularly metallurgy graduates far outstripped the university's ability to supply them. Indeed, Sheffield businessmen complained that the supply of graduates from the university was deficient, not only in a quantitative but also a qualitative sense, as they found it increasingly difficult to procure graduates of sufficient ability to occupy posts of responsibility.[14] The next chapter on educational provision probes the reasons

[11] *Vickers News*, vol.8, no.95, (May 1931), p.5.
[12] Gospel has examined how firms may attempt to retain some form of an employment contract by working short-time, for example, rather than shedding staff, see Gospel, *Labour in Modern Britain,* esp. pp.63-66.
[13] SLSL, BBSTQ, R. A. Hadfield, Personal Collection, *Address When Declaring Open the New Engineering and Metallurgical Laboratories at the 21st Anniversary Celebrations of the Sheffield University, July 2nd 1926* (Sheffield, 1926) p.19; A. K. Weber, "The Prestige of Sheffield Steel", *The Engineer*, vol.148, (1929), pp.443-444.
[14] In 1918, Dr. W. H. Hatfield (Director of the Brown-Firth Research Laboratories) stressed that the shortage of metallurgists was not merely a war shortage, Dr. W. H. Hatfield, "Presidential Address to the Sheffield Association of Chemists", February 8th 1918, in *The Engineer*, vol.125, (1918), p.129; In 1921, Dr. Ripper emphasised that there was no difficulty in placing engineering and metallurgy graduates, indeed demand exceeded supply, Rippers report was presented before a meeting of the Sheffield Chamber of Commerce, 27th September 1921, LD 1986/10, p.91; In 1922, the Sheffield University Applied Science staff reported that "Great difficulty has been found in finding posts for the large number of students who completed their studies at the end of the last session", SUA 5/1/33, Chapman Collection, papers relating to the history of the Department of Metallurgy, p.56; for Complaints that business demands exceeded the supply of engineering and metallurgy graduates for much of the inter-war years see: SUA VIII/1/4, p.20,139; SUA VIII/1/5, Sheffield University Applied Science Minute Book, no.5, p.117; SUA VIII/1/7, Sheffield University Applied Science Minute Book, no.7, p.23; SUA VIII/1/6,

for these inadequacies, but here it may be stated that the university's failure to satisfy business demands conflicts with the orthodox view of an excess supply. Of course, it could be objected that Sheffield manufacturers would have been able to satisfy their graduate requirements from other sources and that a local shortage in no way undermines the thesis of a national glut. However, whilst I would accept that this argument can be applied with some confidence to the supply of graduate engineers, with regards to metallurgists it is far less persuasive. Sheffield University's Faculty of Metallurgy was the nation's leading centre for metallurgical instruction and research, and deficiencies here were bound to have national ramifications.[15] In 1927, the technical journal *The Metallurgist* claimed that throughout the nation there was, and had been for several years, "a great dearth of graduate metallurgists" and that too few students were entering themselves for metallurgy degrees. The journal expressed the fear that "in a few years time there will be no fresh crop of youths and well-trained men ready to go out into the world with a sufficient scientific grounding to advance themselves into the position of competent metallurgists." In addition, it considered that the quality of those coming through was also inadequate to industrial needs, and that "if some 5 or 6 of the nation's leading metallurgists were swept away....There would be...a very serious difficulty in replacing them by men of anything like the same calibre."[16] Later, in 1929, the journal again found itself forced to remark upon "the marked shortage of scientifically trained metallurgists" expressing its "grave concern" that metallurgists were still not coming forward in adequate numbers nor in adequate quality.[17] Clearly, with regards to this specialised branch of scientific expertise, the received wisdom that supply exceeded demand does not appear to be correct.

Not only was there a growing industrial demand for graduates, but also a widening scope for their employment within the firm. Industrialists continued to require metallurgy graduates to support the expansion of their research activities, and to supervise quality control, but they also began to allocate the position of salesman to expert metallurgists who were "competent to advise and assist the customer with reference to his choice of material."[18] Moreover, they increasingly sought to promote graduates who had proved themselves in the capacity of works manager, to the board of directors. Indeed, one businessman expressed the opinion that "every board of directors ought to possess sufficient technical knowledge and ability...as any body whether public

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Sheffield University Applied Science Minute Book, no.6, pp.91, 141; *Quality*, vol.8, no.10, (July 1937), p.405; SUA VIII/1/8, Sheffield University Applied Science Minute Book, no.8, p.33.

[15]Ideally one would want figures showing the proportion of metallurgy graduates that came from Sheffield University, however, such figures are unavailable. Nevertheless, contemporaries clearly regarded Sheffield University as the leading centre of metallurgical education.

[16]*The Metallurgist*, vol. 3, (1927), pp.33-34.

[17]*The Metallurgist*, vol.5 (1929), p.113.

[18]*Careers Open to Students of the Applied Science Department* (Sheffield 1937), p.9.

or private which wielded power without such knowledge may be likened to a motor car out of control and sooner or later disaster was inevitable."[19] Thus, businessmen did not merely want graduates who were capable of becoming analysts, as the received wisdom would have us believe; rather the graduate labour market was increasingly viewed as a source of managerial and commercial talent, and in order to support their policy of promoting graduates to more senior positions within the firm, businessmen demanded significant modifications in the composition of the Sheffield University's metallurgy and engineering degree programmes. These demands will now be considered below.[20]

Businessmen recognised that, as chapter 3 argued, graduates from Sheffield University had always received a first class training in the theoretical and practical aspects of steel manufacture, which had helped the city to maintain its reputation for product quality. However, they claimed that the education of science graduates was too narrowly technical and that, in consequence, many graduates failed to develop the business acumen that would fit them for positions of responsibility. Businessmen therefore demanded that subjects such as economics and works routine should be included in degree programmes, in order to prepare students for positions as works managers.[21] Such business demands were a common feature of the technical press. In 1922 for example, it was argued that the present training of graduates "fails in so far as little or no instruction is given in economics and the student is given no encouragement to study...the causes and effects of the fluctuation in prices of materials, or to realise the necessity and importance of cost-analysis".[22] Many businessmen, not only in Sheffield but throughout Britain, felt that these subjects needed to be added to degree courses, because although science graduates had been integral to the maintenance and improvement of product quality, they had not sufficiently fulfilled the other role identified for them in chapter 2; that is, businessmen considered that graduates had not significantly reduced the costs of production. As price-competition became more intense, businessmen became strongly of the opinion that subjects such as works organisation and business practice should be integrated into degree programmes.[23] They considered that technical knowledge alone could only equip the graduate for subordinate positions but not for the higher posts where their need was most urgent. They therefore demanded that more commercial and managerial studies should be

[19] SLSL, BBSTQ, R. A. Hadfield, Personal Collection, *Advances in the metallurgy of Iron and Steel: A Presidential Address Delivered to the Faraday Society* (June 11th 1914), p.262.
[20] Economic historians have argued that firms mainly used graduates as analysts, see for example Cotgrove, Technical Education, esp. pp.89-100; J. P. Hull, "From Rostow to Chandler to You: How Revolutionary was the Second Industrial Revolution?", *Journal of European Economic History*, vol.25, no.1 (Spring 1996), p.204.
[21] See SUA VIII/2/2, University of Sheffield Advisory Committee for the Foundry Department, Minute Book, 20th June 1944, pp.17-18.
[22] *The Engineer*, vol.113, (February 1922), p.134.
[23] *Ibid.*; *Engineering*, vol.117, (1924), p.311.

integrated into the degree programme, and that a modern language should be provided for those scientists who intended to become salesmen.[24] The education and training of salesmen preoccupied Sheffield businessmen during the inter-war years, and the training of salesmen therefore warrants further attention here.

In the 1920s business demands for the study of foreign languages were loud and insistent. In 1929 the Sheffield Chamber of Commerce reported that local manufacturers were increasingly impressing upon the educational authorities the importance of the teaching of foreign languages.[25] Indeed, businessmen, such as A. J. Balfour, were convinced that "they could not over-estimate the importance of foreign languages for unless they had salesman who understood foreign languages, studied foreign markets, advised principals at home of what was wanted, and pushed the name of the firm and the articles it manufactured, they would not sell many products no matter how good their quality."[26] In particular, businessmen continued to be vociferous in their demands for the study of the Spanish language. As chapter 2 argued, businessmen had begun to demand better provision for the teaching of this language prior to World War One, but after 1914, as protectionism in Europe and America intensified, businessmen came to regard the Spanish language as ever more crucial to the exploitation the South American market.[27] The Russian language on the other hand, which, up until 1924 had been supported by an annual grant from Douglas Vickers (chairman of Vickers Ltd.), fell from favour as the political upheavals in Russia meant that this market could offer limited prospects of immediate business.[28] Nevertheless, in the hostile environment of the 1920s, businessmen looked to education in modern languages as a competitive weapon and they demanded that the Sheffield Chamber of Commerce provide the city's sales representatives with facilities for the study of overseas markets, which would deliver detailed up-to-date information on openings for trade, market conditions, tariff revisions, government regulations, shipping questions, languages and cultural values.[29] For example, Thomas Styring & Co. demanded that the Sheffield Chamber of Commerce provide lectures on the means by which firms could increase their export business with India.[30]

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[24] *American Machinist European Edition*, vol.65, (1926), p.211.
[25] LD 1986/14, Sheffield Chamber of Commerce Minute Book, no.14, meeting of the Sheffield Chamber of Commerce Education Committee, 7th October 1929, p.E6.
[26] LD 1986/11, Sheffield Chamber of Commerce Minute Book, no.11, speech by A. J. Balfour at a Sheffield Chamber of Commerce Meeting, October 12th 1926, p.29.
[27] *Engineering*, vol.131, (1931), p.547.
[28] LD 1986/10, Sheffield Chamber of Commerce meeting, 3rd January 1924, p.240.
[29] LD 1986/13, Sheffield Chamber of Commerce Minute Book, no.13, meeting of the Education Committee of the Sheffield Chamber of Commerce, 7th October 1929, pp.A56-A57.
[30] LD 1986/10, Request by Thomas Styring and Co. presented at a meeting of the Sheffield Chamber of Commerce, 30th October 1923, p.202.

Interestingly, however, after 1930, there was a marked decline in business demands for the study of modern languages and overseas marketing. One may speculate as to the reasons for this. One possible explanation is that the city's businessmen were happy with the existing provision.[31] However, another, and perhaps more convincing, explanation may reside in the increasing orientation of trade towards the domestic market, particularly following the Import Duties Act of 1932. During the protectionist era, Sheffield manufacturers' key concern became domestic sales and it appears that this reduced the need of businesses for expert linguists. From 1932 onwards, specialist steel firms focused upon the requirements of domestic growth industries, such as chemicals, aeroplanes and motor vehicles, and they were therefore less concerned with the linguistic capabilities of their salesmen than with their technical knowledge. Indeed, during the 1930s, businessmen began to realise that there was a need to co-ordinate production and distribution, and that they had hitherto drawn far too strong a line between the education and training requirements of their commercial staff on the one hand, and their skilled workers and technical staff on the other. Of particular concern was the education and training of salesmen. Businessmen came to the conclusion that the traditional training of salesmen, which combined practical experience in various works and administrative departments with the study of commercial subjects, such as weights and measures, was becoming increasingly inappropriate given the rapid rate of technical change within the steel and engineering industry.

Under the traditional system salesman only acquired an empirical knowledge of the company's products, plant and equipment, they did not develop any understanding of the scientific principles which informed the production process. This lack of scientific and technical knowledge made it exceptionally difficult for them to understand product and process innovations, which occurred subsequent to their tour of the works, and this undermined their attempts to identify customer needs and make an informed recommendation, a key concern for Sheffield firms many of whom, as chapter 7 will argue, continued to produce on a bespoke basis. Due to their lack of scientific knowledge, salesmen were forced to enter into extensive communication with their firm's technical staff, and learn the information which they received from them by rote "repeating it parrot fashion to the customer without any real understanding of what they were talking about."[32] As the case-study of Firth Brown's in Chapter 7 demonstrates,

[31]The Sheffield Chamber of Commerce remarked in 1929 that, because the local evening schools had responded well to recent business demands, Sheffield's firms had every reason to be satisfied with the facilities which the city provided, LD 1986/13, meeting of the Education Committee of the Sheffield Chamber of Commerce, 7th October 1929, p.A57.

[32]See request from Sheffield Chamber of Commerce for technical lectures for commercial men, presented to Applied Science Department of Sheffield University, SUA VIII/1/4, Sheffield University Applied Science Minute Book, no.4, 24th June 1930, p.85; LD 1986/15, meeting of the Education Committee of the Sheffield Chamber of Commerce, 8th May 1930, p.A2; *University of Sheffield Department of Applied Science Prospectus, 1930-31*, preface.

this had a double negative impact, on the one hand, it led to excessive transaction costs which in a context of severe competition and trade depression were extremely difficult for firms to bear; on the other, it produced delays in answering customer queries, which, in a buyers' market, invariably led to a loss of business.[33] In consequence, Sheffield manufacturers became convinced that if industrial performance was to improve, their existing and future sales staff must be given an enhanced technical education. In 1930, therefore, they demanded that the university devise a technical course that was especially geared to the needs of salesmen and commercial staff. In particular, they asked the university to provide lectures on: ores, their classification and distribution, the chemistry of steel-making, ingots and ingot-making, forging and rolling, common types of defects and their causes, types of steel their properties and uses, the heat-treatment of steel, the testing of steel, and the reading of blue-prints and drawings. They requested that special attention be focused upon the last five of these subjects, for they argued that such knowledge would enable the salesman to readily identify a specific customer need and make an appropriate recommendation.[34] The importance of identifying and satisfying customer needs also stimulated business demands for the provision of courses in market research, advertisement, sales management and business statistics, which would complement the salesman's technical lectures.[35] Initially, businessmen emphasised that the technical lectures should not cover any subjects in great depth, but provide the most necessary and useful knowledge for salesmen. However, as the specialist steel industry became more complex, and as Sheffield firms developed a bewildering range of corrosion- and heat-resistant alloys, a number of firms, as was argued earlier in this chapter, began to recruit graduate metallurgists and engineers whom they could train for the position of salesmen.[36] However, I now turn to examine the development of business demands for supervisory and managerial education.

During the inter-war years the education and training of supervisory and managerial staff became an object of concern. In particular, the debate over the function of the foreman and the education and training which he required was a recurring theme in the

[33]Transaction theory would suggest that the internalisation of the sales function, through the development of a firm-specific sales force and the abandonment of selling through outside agencies should reduce transaction costs. However, inadequacies in the education and training of salesmen meant that transaction costs escalated. There is a substantial literature which shows some of the weaknesses of transaction theory, for example, R. A. D' Aveni and D. J. Ravenscroft, "Economies of Integration Versus Bureaucracy Costs: Does Vertical Integration Improve Performance?", *Academy of Management Journal*, vol.37, no.5, (1994), pp.1167-1206.
[34]SUA VIII/1/4, request from the Sheffield Chamber of Commerce for technical lectures for commercial men, presented to Applied Science Department, 24th June 1930, p.85.
[35]See *Quality*, vol.4, no.2, (September 1932), p.23; *Quality*, vol.3, no.10, (July 1932), p.11; LD 1986/17, Sheffield Chamber of Commerce Minute Book, no.17, meeting of the Education Committee of the Sheffield Chamber of Commerce, 3rd May 1932, pp.E7-E9; LD 1818, Sheffield Trades Commercial Society Minute Book, meeting of the Sheffield Trades Commercial Society, May 27th 1935.
[36]*Careers Open to Students of Applied Science*, pp.9-11.

technical press. Indeed, there was a growing awareness that the traditional training system was inadequate to modern business needs. Prior to World War One, as Chapter 4 argued, the training of foremen was based upon practical experience in the works, combined with evening instruction in subjects such as mechanics and metallurgy. Whenever a company had a vacancy for a foreman, the usual strategy was to promote the best, or in other words, the most skilled workman in the relevant department. That is, the worker who had mastered his craft and acquired an accredited theoretical knowledge of the technical principles which informed the production process. During the inter-war years, businessmen remained convinced of the necessity of this training, for they believed that if foremen did not possess a detailed working knowledge of the company's products and processes, the workers would not respect them and their position would become untenable. However, a number of businessmen came to the conclusion that whilst the traditional system ensured that foreman knew all about materials, they knew very little about works organisation and managing men.[37] They emphasised that under the traditional system foremen were "not taught in the works how to organise or supervise" and there were "no facilities for systematic instruction in such subjects at evening schools."[38] Nevertheless, some businessmen believed that there was a science and an art to foremanship which could be taught, and that it was necessary to integrate the foremen into the managerial hierarchy by teaching them supervisory skills. They emphasised that under the old system of simply promoting the most skilled worker, a number of problems could and, indeed, had emerged. The first was that, on occasion, the firm simply lost one of its most skilled and productive workers and acquired a poor foreman. The second was that the foremen continued to affiliate with the workers from whose ranks they had been promoted, rather than with their fellow managers, and this had a detrimental impact upon the organisation's productivity.[39]

The debate over the role and training of the foreman occurred in a context of trade depression, intense foreign competition and, in consequence, an overriding need for firms to rationalise and execute economies in production. It was these competitive pressures which informed the demand for an education and training which would allow the foreman to ensure that "a job went through the works not somehow but to the best advantage of the firm."[40] The foreman of the future was to organise production to ensure not only the maintenance of product quality, but also economy in the process of manufacture which would keep down costs and enable Sheffield to meet more

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[37]LD 1986/13, meeting of the Education Committee of the Sheffield Chamber of Commerce, 21st March 1929, pp. D4-D7; *Engineering*, vol.114, (1922), p.14.
[38]*Engineering*, vol.114, (1922), p.14.
[39]*American Machinist European Edition*, vol.66, (1927), p.315.
[40]*Ibid.*

effectively the intense price-competition of low-cost American and German producers.[41] The approach of local business to the education and training of the foreman was two-fold. Large firms such as Vickers, as chapter 7 will argue, set up their own in-house training programmes, but others requested that the University design special courses on industrial administration for foremen and junior executives.[42]

The question of management training, generally, was a vexed one. The two major rationalised units of the inter-war steel industry, the United Steel Companies Ltd. and the English Steel Corporation, were clearly of the opinion that their need for leadership and administrative skills could not be met by the Sheffield education system, which though well adapted to meeting business requirements for technical and commercial expertise had, prior to World War One, acquired no experience of managerial education. These huge combines therefore adopted a dual strategy which will be examined in Chapter 7. On the one hand, they made use of national and international conferences on subjects such as scientific management but, on the other, they developed their own in-house training programmes designed to deliver the functional specialists which their large-scale business operations required. The demand for local colleges to develop management studies therefore came from the city's more traditional family and personally-managed firms. Initially, the demand was for individual subjects, such as cost accounting, industrial administration, and scientific management.[43] However, by the late 1930s, there were demands for a comprehensive course in business management, which would unite such subjects in a systematic programme of managerial studies. These demands were spearheaded by A. K. Wilson, Governing Director of Spear and Jackson, who complained that in his younger days he had been hampered by an inability to obtain help in problems of management. Indeed, he claimed that, until recently, there had been nowhere to go in Sheffield for advice or education on management issues. He therefore requested that the university provide a comprehensive course in business management especially designed for sons who intended to follow their fathers into the headship of a business.[44] This request was

[41]Firth's argued that "...the proper qualification for a foreman is...that he shall be an effective group leader. It is being widely accepted that the administrative part of the foreman's job is...important...he must secure in his team a coherence of effort, a conformity of method, a high quality of workmanship and a productive good-will. He must prevent the wastage of labour and limb. He must curtail manufacturing costs. He must accomodate the new man to his crew and the new idea to his workshop practice", *The Bombshell*, vol.14, no.1, (Jan. 1930), p.26.
[42]LD 1986/13, meeting of the Education Committee of the Sheffield Chamber of Commerce, March 1929, pp.D4-D7; LD 1818, Sheffield Trades Commercial Society Minute Book, Sheffield Trades Commercial Society Meeting, May 27th 1935.
[43]LD 1986/13, meeting of the Education Committee of the Sheffield Chamber of Commerce, March 1929, pp.D4-D7; LD 1795, Sheffield Trades Technical Societies Handbook, p.135; LD 1818, Sheffield Trades Commercial Society Minute Book, meeting of Sheffield Trades Commercial Society, May 27th 1935; *Quality*, vol.4, no.2, (September 1932), p.23; *Quality*, vol.3, no.10, (July 1932), p.11.
[44]Mr. A. K. Wilson, "A Course for Business Management", *Quality*, vol.10, no.11, (1938), p.8.

interesting in that, during the inter-war years family firms had more or less abandoned the pre-war strategy of using science degrees in the training of sons for managerial succession. Indeed, after 1924 the sons of only 3 Sheffield manufacturers graduated in metallurgy or engineering at the Sheffield University.[45] It would appear that in the adverse market environment of the inter-war years, proprietor-managers felt that their sons were needed in the firm and could not be allowed the luxury of following a university degree. However, it was felt that time could be spared for evening technical classes and for the study of administrative subjects such as works organisation. This was symptomatic of the business community's growing concern with the cost of production, which became as important a consideration as the traditional focus upon the maintenance and improvement of product quality.[46] It was hoped that by studying subjects such as works organisation and scientific management, sons would be able to execute economies in production which would allow the firm to maintain product quality, whilst simultaneously lowering its price, thereby enabling it to compete more effectively in world markets. I conclude, therefore, that the question of management training was a nettle which the business community in general grasped only tentatively in the inter-war years, but here and there, the grasp was firmer.[47]

Thus far I have concentrated upon business demands for changes in the training of salesmen and managers in the steel and engineering industry, but what of the ordinary worker? Prior to World War One, steel and engineering manufacturers focused attention upon the technical education of apprentice melters and engineers. The training of foundrymen, on the other hand, was not seriously considered. Indeed, Robert Hadfield, a pioneer in the manufacture of large steel castings, was alone in his pre-war condemnation of their training. He claimed that this side of technical education had "been relegated far too much to chance", and demanded that technical schools provide facilities for foundrymen to "study the scientific principles behind their craft."[48] However, following the difficulties which many firms experienced in the

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[45]The database shows that between 1924 and 1932 the sons of only three Sheffield manufacturers graduated in metallurgy or engineering at Sheffield Univeristy. We lack details from 1932 to 1940, Eason Database (Alumni MDB) 1997.

[46]This training was, of course, also less expensive than a full-time degree course.

[47]In addition to the course in business management, Sheffield manufacturers requested that a Junior Chamber of Commerce be established in order to interest young men in industrial and social affairs. They demanded that the problems and issues which the Chamber of Commerce dealt with every day should be submitted to this Junior organisation, and that the Junior body should elect representatives who could submit its views to the parent; the aim being to secure their eventual integration into the chamber proper. Of course it could be argued that such training was more about securing the survival of the Chamber of Commerce rather than local industries, but such a view is undermined by the demand that members of the Junior body attend lectures on management subjects at the university, LD 1986/12, minutes of the Membership Committee of the Sheffield Chamber of Commerce, 25th July 1927, pp.A42-A46.

[48]R. A. Hadfield, Presidential Address to the Iron and Steel Institute, *Journal of the Iron and Steel Institute*, no.1, (1905), p.88.

manufacture of large castings during World War One, more businessmen became convinced of the need to enhance the technical attributes of the foundrymen along the lines suggested by Hadfield. In particular, two major conferences emphasised the need for foundry boys to receive a training comparable to that traditionally provided for engineering apprentices.[49] Indeed, businessmen passed a resolution in favour of a foundry apprenticeship which would incorporate a systematic programme of technical studies.[50] This resolution stipulated that all foundry apprentices should attend evening classes during the first 2 years of their training programme and, if required, for a further five years. In particular, businessmen demanded that from the age of 14 to 16 the foundry apprentices technical education should focus upon classes in arithmetic, mechanical drawing and special chemistry, which would be held under the auspices of the district evening schools. From the age of 16 to 18, however, businessmen demanded that the more able apprentices take further classes in maths, machine drawing and metallurgy, which would be provided by the Central Intermediate Technical College. And, in addition, it was further argued that apprentices who had managerial potential should be encouraged to complete their studies at the Sheffield University, which was asked to devise a course especially designed to meet the needs of foundry managers.

The manufacturers recognised that, if this scheme was to be successful, the apprentices' theoretical studies would have to be supported by an all-round practical training. In particular, they recognised an acute need for apprentices to obtain moulding experience in addition to a detailed working knowledge of pattern-making and cupola work. They considered that such broad-based training would have two advantages. Firstly, it would prevent pattern-makers and moulders who had no knowledge of each other's work from blaming one another for product failure, thereby improving co-operation within the firm. Secondly, it would attract boys with a superior education into the foundry. This was considered particularly important because of the poor quality of entrants into the foundry trade. Previously, they had been forced to recruit foundry managers from the engineering workshops, and such recruits had lacked the necessary moulding experience to be successful in their new jobs.

[49]Two conferences of representatives of the Foundry Trade were held at the Sheffield University on May 6th and May 29th 1924, SUA 5/1/2 (ii), Chapman Collection, papers relating to the history of the Sheffield Technical School, vol.2, pp.384-387; SUA 5/1/2 (iii), vol.3, p.391-397.

[50]This apprenticeship was modelled upon the schemes established by Thomas Firth & Sons and Hadfield's, 2 Sheffield firms which were regarded as leaders in the field of human resource management. Firth's Welfare Supervisor, A. C. Marshall, emphasised that, if the apprenticeship schemes were to be successful, it was necessary that firms follow Firth's policy of selective recruitment, rather than merely accept the boys because they had relatives at the firm. He recommended they accept only those boys who had obtained standard VII are above. It was resolved that the trade adopt this recruitment procedure, *Ibid.*

Businessmen acknowledged that the ideal location for the broad-based practical training which the apprentice required was the firm, but they admitted that it would be extremely difficult for them to provide such training at a time of economic dislocation and increasing specialisation, . They therefore requested that the university provide a comprehensive practical training in casting, moulding, refractories, pattern-making and design, in addition to its more theoretical instruction in metallurgy.[51] Of course, the negative effects of increasing specialisation were also felt in some engineering workshops where, as stated earlier, there was a growing tendency to recruit youths under verbal, rather than written, agreements and keep them in one shop and often at one machine, rather than provide them with an all-round training.[52] It is these abuses of the apprenticeship system which economic historians have so deplored, however Sheffield manufacturers were not unaware of the adverse long-run consequences of their actions and took steps to counteract them. In particular, they asked the university not only to provide training in general scientific principles, which would make the apprentices more flexible and adaptable, but also to establish facilities which would allow them to acquire a practical experience of precision tool work. Businessmen hoped that such training would enable apprentices, whose experience within the firm was very narrow, to obtain the broader theoretical and practical knowledge which they would require in order to set up automatic machines and obtain positions of responsibility.[53] Thus, manufacturers clearly recognised the disadvantages of the traditional apprenticeship system in an era of rapid technical and organisational change. They had no quarrel with a Ministry of Labour report in 1926 which emphasised that "the prevalence of such changes...made...unsatisfactory a training which was given solely in the workshop."[54] They understood that in their own interests, and the interest of the boys, workshop training needed to be supplemented by a knowledge of principles acquired in school. In particular, as chapter 7 will argue, Sheffield's flexible specialists recognised a need for youths with general industrial knowledge and intelligence who would be able to adapt rapidly to changing customer demands. Thus, businessmen requested significant modifications in the secondary school syllabus. They wanted

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[51]All the details of business demands for foundry education were garnered from the conferences, *Ibid.* A demand that was echoed by the roll and forge masters, who requested that the University establish facilities where their apprentices could be taught to work out the development of sections and acquire practical experience in applied geometry and heat-treatment, LD 1809, Sheffield Rolling, Forging and Trades Technical Society Minute Book, meeting of Sheffield Rolling, Forging and Tilting Trades Technical Society, 1922, p.21.

[52]Manufacturers were disinclined to offer indentured apprenticeships under adverse market conditions as this made it more difficult for them to terminate the employment. Similarly, at a time when they needed to lower costs of production, they were encouraged to keep the apprentice at a machine on which they would rapidly come productive whilst being paid a lower wage than even the unskilled operative.

[53]SUA VIII/1/3, p.217-218.

[54]*Ministry of Labour Report of An Enquiry Into Apprenticeship and Training for the Skilled Occupations in Britain and Northern Ireland, 1925-26*, (London, 1926), p.302. It would be interesting to explore the trade union opinion on this, but unfortunately I have been unable to find any comment on it.

secondary schools with a more vocational and practical bias. They claimed that the existing secondary school syllabus only provided a training on a broad cultural basis for the professions, but neglected their needs for more scientifically and commercially-trained personnel. Indeed, as far as many steel and engineering manufacturers were concerned, investment in the secondary school system was of little use to them, unless there was a recasting of the curriculum from the age of 11 upwards.[55]

During the inter-war years, even manufacturers in the more conservative cutlery sector began to demand a more technically-educated manpower. Indeed, as chapter 8 will argue, in the First World War cutlery manufacturers had to abandon their traditional strategy of intense product differentiation and concentrate their attention upon the mass production of standardised products, such as spring knives and razors, and this convinced some manufacturers of the need to mechanise the industry, and to support this with a shift in the education and training of the workforce.[56] In particular, they recognised that the "production of standard cutlery was not so much a cutler's, as an engineer's problem", and that it must therefore be "solved by engineering methods." This they argued, created a need for all their operators to acquire some elementary knowledge of engineering, and necessitated the employment of a skilled engineer who could maintain and repair their plant and equipment.[57] In addition, they recognised that the development of stainless-steel in 1913 had also undermined their traditional methods of production and industrial training. Thus, two of the main processes in cutlery production were hardening and tempering. In hardening, the apprentice forger was traditionally taught how to raise the metal to a clear red heat before quenching it in oil or water. Having mastered this art, he would then be taught how to temper cutlery. Tempering was vital for successful manufacture because hardening tended to create a hard but brittle product which had limited uses. In tempering the cutlery, the apprentice learned how to use a coke-hearth to re-heat products before allowing them to cool gradually in order to restore their plasticity. Of course, different products had to be heated to different temperatures according to the composition of the metal from which the products were made and the requirements of the finished article. The key to tempering was therefore to raise the product to exactly the right temperature, but the range of temperature required to produce the practical varieties of temper was a very narrow one, which was traditionally judged by eye; that is, inferred from the colour of the metal whose surface passed through various shades of colour as its temperature increased. Each colour represented a particular temper which was especially suitable for a given product. Tempering was therefore an extremely exacting process and the

[55]LD 1986/15, meeting of Education Committee of Sheffield Chamber of Commerce, 21st October 1930, p.E15.
[56]See SUA VIII/1/3, July 1917, p.108.
[57]SUA /5/1/2 (ii), March 9th 1918, p.206-207.

apprentice did not usually develop his master's delicacy of judgement until long after his formal training had been completed. In other words, hardening and tempering were exceptionally skilled operations whose success was traditionally reliant upon the manual dexterity and observational qualities of the forger. Indeed, the skills were wholly empirical and owed nothing to scientific research. However, stainless-steel, which became an increasingly important raw material in cutlery manufacture during the inter-war period, undermined these traditional skills and demanded a more scientific approach.[58] Because its properties were not solely determined by its carbon content, the temperature of this steel and, therefore, its temper could not be confidently inferred from the colour of its heated surface. Stainless-steel, therefore, required the abandonment of rule-of- thumb methods, the instalment of furnaces fitted with pyrometers, and the development of a workforce which possessed some metallurgical knowledge and in particular the ability to read dials.[59] Thus, cutlery manufacturers began to demand technical education particularly for old workmen whose craft skills, which had been acquired through a long apprenticeship, were becoming redundant. They requested that the university provide two distinct courses in metallurgy and engineering and that each course provide not only theoretical instruction but also practical instruction in, for example, the use of pyrometers, furnaces and testing equipment.[60] The first of these courses was to focus upon the properties of materials. Indeed, manufacturers demanded that this course provide a scientific knowledge of the constituents of steel and the effect of each on its treatment. They asked that the student's training be focused upon the heat-treatment of stainless-steel and its working in all the stages of production, from the melting, through the forging and rolling processes, to hardening, tempering and grinding.[61] However, they asked that the second course focus upon the principles of production, especially, the application of electricity in the workshops, the construction and use of abrasive wheels, the use of machine tools and grinding machines, and the principles of inspection, measuring and machine drawing, in order to support their attempts to break into the mass markets for cheap machine-made cutlery. Thus, whilst technical education for the steel industry prior to World War One had been geared towards improving product quality, in the cutlery industry it was

[58]Details of the traditional skills and training were garnered from G. I. H. Lloyd, *The Cutlery Trades: An Essay in the Economics of Small Scale Production* (Sheffield, 1913).
[59]M. Walton, *Sheffield's Story* (Sheffield, 1968), pp.245-247.
[60]SUA 5/1/2 (iii), vol.3, p.497; LD 1803, Sheffield Cutlery Trades Technical Society Minute Book, meeting of Sheffield Cutlery Trades Technical Society, April 29th, 1929.

[61]LD 1803, meeting of Sheffield Cutlery Trades Technical Society, 29th April 1929; LD 1807, Sheffield Trades Technical Society Minute Book, meeting of Sheffield Tool Trades Technical society, July 21st 1926; LD 1805, Sheffield File Trades Technical Society Minute Book, meeting of Sheffield File Trades Technical Society, March 25th 1925.

designed to support moves into the quantity trade which had hitherto been dominated by Germany and America.[62]

How may I sum up this survey? On one level, businessmen clearly appear to have held a somewhat contradictory attitude towards education and training. They expected local schools and colleges to develop new courses and acquire equipment to support practical instruction, but they demanded a reduction in educational expenditure. They went to great lengths to retain their skilled workers but, prior to 1932, they did little themselves to secure the supply of future craftsmen. They demanded more and better graduates from the Sheffield University, but for much of our period they were not prepared to invest in it. However, a lot of these apparent contradictions can be explained by the adverse environment which business worked in prior to 1932. Once protectionism had been granted, they not only requested more and better education, but were also prepared to finance it, secure in the knowledge that macro-economic policy was now better suited to their needs. I believe, therefore, that rather than dwell upon the negative features of business attitudes during the 1920s, we should emphasise the more positive features which have been largely neglected in the standard economic history texts. Sheffield steel and engineering manufacturers demanded more and more graduates and looked to promote them to positions of responsibility; they also recognised the need to integrate the key functional activities of production and distribution through changes in the education and training of salesmen. Multi-product, multi-process and multi-national steel firms were beginning to request education and training schemes that were specifically tailored to the needs of managerial and supervisory staff, and even some manufacturers in the cutlery sector were beginning to recognise a need for technical education which would support the manufacture of machine-made stainless-steel cutlery. However, the next chapter, will emphasise that the economic depressions of the 1920s had a profoundly negative impact upon the city's education system and, in particular, its ability to meet business demands for technical, commercial and managerial personnel.

[62]See all *ibid.*

Chapter 6: Education and Training in Depression and Recovery: Sheffield in the Inter-War Years.

This chapter will argue that the economic depressions of the 1920s and early 1930s placed severe constraints upon educational expenditure, and that this had adverse consequences for provision at all levels of the education system. In particular, it will be argued that during the 1920s Sheffield University lost its pre-war position as a leading provider of higher technical education and became unable to meet business needs for well-trained metallurgists and engineers. However, following the inauguration of protectionism in 1932, local business invested heavily in this institution, and this remedied many of the deficiencies that had emerged in its curricula and equipment during the previous decade. By World War Two, the university had been re-established as a centre of excellence, both in terms of teaching and research. Nevertheless, it will be argued that the damage caused to Sheffield's secondary education system was more pronounced and more lasting. Here, the curtailment of educational expenditure further exacerbated pre-war deficiencies in day secondary school provision, which were discussed in chapter 3, whilst undermining Sheffield's extensive system of evening instruction. Since the damage caused to this sector was the more lasting, and because weaknesses here had important ramifications for both the quantity and quality of students entering higher education, part one of this chapter provides a detailed account of developments in Sheffield's elementary and secondary school provision. Part two then examines the vagaries in the quality of the university's metallurgy and engineering courses, whilst part three explores the extent to which the local education system satisfied business needs for technical, commercial and managerial personnel, which were outlined in chapter 5.

I

Elementary and Secondary Education in Sheffield 1918-1940.

During the period 1914 to 1920, there were no elementary schools built in Sheffield. The increase in the number of children who required elementary education during these years forced Sheffield's elementary schools to admit more pupils than they were equipped to take. In consequence they became "crowded to over flow", and the pupil teacher ratio increased from 39 to 1 in 1911, to 43 to 1 in 1920. In that year Sheffield's Director of Education, Mr Percival Sharp, was forced to admit that the overcrowding in the city's elementary schools was becoming "very serious" and that it formed "an hindrance to effective instruction...rendering...education in its best sense almost impossible." Moreover, despite a policy of maximum pupil intake, almost 550 children were temporarily denied an elementary education due to the lack of accommodation. Sharp recognised therefore that given these circumstances "a very material improvement in the conditions of the elementary schools" was "an absolute necessity" and that this could "only be effected by the building of new schools."[1]

The situation at the secondary level, in 1920, was no more encouraging. Two years earlier, the Sheffield Education Committee had accepted the principle of providing a free place for every child who obtained more than fifty per cent of the marks in its secondary school entrance examinations, but it was simply in no position to do this.[2] Indeed, Sharp predicted that even after the schools being built at Abbeydale and Firth Park came on stream, the number of places available would not exceed 3,200, this for a potential 40,000 students. In order to compensate for the lack of accommodation the city's secondary schools were also forced into a policy of maximum recruitment, and this had an extremely deleterious effect upon the quality of the education which they could provide.[3] The headmaster of the Sheffield Central, for example, complained that overcrowding entailed the occasional teaching of two classes in the same room and the use of rooms which were simply unfit for teaching.[4] Local educationalists were, in fact, acutely aware that the education provided within the city's schools had fallen below the pre-war standard, and that there was an urgent necessity to add to Sheffield's educational infrastructure. Nevertheless, it will be shown that many of these much-needed additions were delayed for more than a decade, due to the policy objective of returning to the gold standard and the onset of economic depression in 1921.

A deflationary policy was a prerequisite for a return to gold at the pre-war parity, this necessitated a reduction in public expenditure and education became a major victim. The economies in educational expenditure began in 1920, but were accelerated following the collapse of the brief post-war boom. Thus, the Geddes Axe of 1922 aborted Fisher's continuation schools and cut investment in the education system by a colossal £6.5 million.[5] Moreover, from 1921 to 1924, the Board of Education placed severe constraints upon educational expenditure, refusing most capital investment projects, and the provision of education, not only in Sheffield but throughout the nation, was allowed to deteriorate.[6] However, as economic conditions improved in 1924, the

[1]CA 681/9/17, City of Sheffield Education Committee Annual Report, March 1920, pp.3-6; see also D. Hey, "Sheffield Schools, 1918-60", in C. Binfield et al (eds.), *The History of the City of Sheffield: vol.2, Society* (Sheffield, 1993), p.22.
[2]CA/681/18, City of Sheffield Education Committee Annual Report, March 1921, p.43.
[3]CA 681/9/17, pp.3-6.
[4]Report by the headmaster of the Sheffield Central Secondary School for Boys, 4th April 1924, in CA 321, Secondary Schools Sectional Sub-Committee Minute Book, no.2, p.6.
[5]For a more detailed discussion of post-war economies in education, see M. Sanderson, "Technical Education and Economic Decline, 1890-1980", *Oxford Review of Economic Policy*, vol.4, no.1, (Spring 1988), pp.38-37; for a succinct review of Sir Eric Geddes' career as a businessmen and politician (he was Minister of Transport 1919-22), see K. Grieves, *Sir Eric Geddes: Business and Government in War and Peace* (Manchester, 1989).
[6]CA 622 (9), Higher Education Sub-Committee Minute Book, no.13, CA 622 (9), p.299.

board declared a willingness "to give...sympathetic consideration to proposals for the provision of new...schools and the extension of existing schools..." and it gradually relaxed its controls on expenditure.[7] Unfortunately, because the depression in Sheffield was so prolonged and so severe, the relaxation of central controls did not result in a large-scale building programme. Rather, local government continued to exercise financial restraint, and allowed for the development of only a very few new schools.[8]

The policies of both local and national government had a very serious impact upon the city's education system; indeed, as Pollard has argued, "government economy and the local burden of unemployment starved education of funds" and, in consequence, "buildings and standards of teaching deteriorated."[9] During the early 1920s, the city's elementary schools, for example, were becoming more and more overcrowded, and Sharp expressed his "grave fear of the break-down of the elementary system." In the absence of additional accommodation, the city's elementary schools were forced to seek "greater effectiveness" by "a drastic simplification of their curriculum." Thus, the hope was that the elimination of other subjects from the timetable would improve the teaching of the 3 "R"'s to unmanageably large classes, but this was an extremely retrograde step, which deprived many children of a grounding in elementary science; knowledge of which, as chapter 2 argued, was a prerequisite for success at the technical classes provided in the city's evening schools.[10] However, conditions in Sheffield's elementary schools did begin to improve during the late 1920s due to a falling birth rate and the construction of several new schools, which finally secured accommodation for each and every child.[11]

Nevertheless, the development of Sheffield's secondary education system was even more severely constrained by the economy campaigns of the 1920s, and throughout the inter-war period, day secondary school provision remained a weak point in the city's educational apparatus. Table one A and one B in Appendix E, for example, compare Sheffield's secondary school provision with that of other leading towns, for the years 1911 and 1921. As the tables show, pre-World War One, Sheffield's provision fell far short of that provided by other centres, and although the completion of the Firth Park and Abbeydale secondary schools in 1920 increased the number of places available,

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[7]Board of Education Circular, 11th April 1924, in CA 622 (6), Higher Education Sub-Committee Minute Book, no.8, pp.3-19.
[8]CA 681/9/19, Sheffield Education Committee Annual Report, March 1930, pp.3-10; A. W. Chapman, *The Story of a Modern University* (Oxford, 1955), p.342.
[9]S. Pollard, *A History of Labour in Sheffield* (Liverpool, 1959), pp.261-262.
[10]See Report of the Director of Education for Sheffield (Percival Sharp), 6th June 1924, in CA 321, Secondary Schools Sectional Sub-Committee Minute Book, no.2, p.22-24; further details of the simplification of the elementary school curriculum can be found in H. K. Hawson, *Sheffield: The Growth of a City* (Sheffield, 1968), p.92.
[11]*Ibid.*

Sheffield's provision remained inferior to that of other towns. Indeed, in 1921 Sheffield provided only 33 secondary school places per thousand elementary school children, compared with a mean average of 55 for this sample.[12]

The prolonged trade depression in Sheffield dictated that conditions would improve very little during the first decade of the inter-war years. Aside from the building of a school at Nether Edge, there were no major additions to the secondary education system until 1933. Throughout the 1920s, therefore, the number of secondary school places in Sheffield remained extremely small, and the number of children who passed the city's entrance examinations, but who were denied access to secondary education, continued to increase. Having said this, the Sheffield Education Committee did offer pupils a cheaper, bastardised form of secondary education, through the provision of intermediate schools. Between 1924 and 1926, four such schools were established at Greystones, Marcliffe, Carfield and Owler Lane. They provided a 3-year course of general education which was "wider in content than that given in an ordinary elementary school", and which was open to children from the ages of 12 to 15. Unfortunately, this age range made it extremely difficult for the pupils to sit examinations, and precluded the possibility of more advanced instruction. Thus, the intermediate schools could never substitute effectively for a quality secondary education but, what they did do, if only in part, was ameliorate the effects of the drastic simplification in the elementary school curriculum, referred to earlier in this chapter.[13]

One cannot deny that there was a severe quantitative deficiency in Sheffield's secondary school provision and, from a business point of view, this quantitative problem was compounded by qualitative inadequacies in the secondary school syllabus. The culture of King Edward VII School (discussed in chapter 3) dictated that it would maintain its pre-war focus upon the classics and continue to neglect industrial demands for a more technical and vocational curriculum. Her Majesty's Inspectors, themselves, complained

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[12]By 1924, small additions to the city's secondary schools had brought Sheffield's total provision of places up to 3,270, which was divided as follows:
Provided
King Edward VII (fee paying) 550 pupils; Central Secondary School for boys (free) 610 pupils; Central Secondary School for girls (free) 540 pupils; Firth Park Secondary School for boys (free) 490 pupils; Abbeydale school for girls (free) 430 pupils
Non-provided
Girls High School (fee paying) 250 pupils; Notre Dame High school (fee paying) 400 pupils.
If we assume that the elementary school population remained constant, then by 1924 Sheffield's provision per 1,000 elementary pupils had increased to 39, still far below the mean average of our sample in 1921. In fact the city's elementary population rose during these years and, therefore, the actual provision of places per 1,000 elementary pupils would have been even lower than 39, see Report of the Director of Education (Percival Sharp), 6th June 1924, in CA 321, pp.22-24.

[13]For a detailed discussion of intermediate schools, see W. H. G. Armytage, "Education in Sheffield", in D. L. Linton (eds.), *Sheffield and Its Region: A Scientific and Historical Survey* (Sheffield, 1956), esp. p.7; see also Hawson, *Growth of a City*, p.92.

that the teaching of science at this school was "severely handicapped by the inadequate time allowance", and that those pupils who left the school at 16 did not receive "such a knowledge of science, or training in scientific method as would seem desirable in a community like Sheffield where the industries" were "predominantly of a scientific character." Similarly, King Edward's failure to provide a commercial education was also condemned. Indeed, Her Majesty's Inspectors argued that the school had seriously neglected the needs of students destined for a career in business.[14] Nevertheless, despite these criticisms, King Edward's retained an academic ethos and remained geared towards the professions. Indeed, its successes in the school and higher school certificates were remarkable and continued to substantiate its claim to provide an education "equal to public schools of the highest type."[15]

While King Edward's maintained an excellent scholarly record, it offered little to local business and its failure to develop day commercial education was not atypical. During the 1920s, none of Sheffield's secondary schools provided a large commercial curriculum, and this undermined their ability to deliver business needs for more commercially-trained personnel. Indeed, many parents withdrew their sons from the Central Secondary School because of its reluctance to provide instruction in subjects such as type-writing and shorthand, which were regarded as prerequisites for clerical positions in local industry. Nevertheless, none of the secondary schools responded to these market signals and it appears that the lasting legacy of Morant's period of office at the Board of Education was the effective confinement of commercial education to evening schools.

The Sheffield Central and Firth Park secondary schools did, however, provide an effective technical education, which combined theory with laboratory training and workshop experience. But technical subjects were increasingly offered as a small part of a more general curriculum. The orientation of all Sheffield's secondary schools, during the 1920s, became more and more academic due to the inauguration of the school certificate examinations in 1917. These examinations required pupils to demonstrate average ability in a wide range of subjects and therefore precluded the

[14]Report of Her majesty's Inspectors on King Edward VII School, June 1923, in CA 630 (51), King Edward VII School Correspondence with the Board of Education, pp.3-10.
[15]In 1930, for example, King Edward's obtained more distinctions in the Oxbridge School Certificate examinations than any other school in the country, Report of Her majesty's Inspectors on King Edward VII School, March 1928, in CA 322, p.3; Headmaster's Report on King Edward VII School, 20th October 1930, in CA 622 (7), Higher Education Sub-Committee Minute Book, no.11, p.158; Fortunately King Edward VII School was restored to the Board of Education grant list in 1917 and therefore, although it gave little to the business community in terms of skilled personnel, after 1917 the local economy did not have to bear the burden of financing the school alone - see Her Majesty's Inspectors Report on King Edward VII, June 1923, in CA 630 (51) pp.3-10.

early and intensive specialisation in science, which many businessmen demanded, and which had been a characteristic of the curriculum for those pupils who had followed the special science and engineering courses at the Central Secondary School prior to World War One.[16] Thus, during the 1920s, the secondary education system became increasingly unable to deliver business needs, for both technical and commercial personnel. However, in chapter 3 it was argued that, prior to 1914, an extensive and effective system of evening schools compensated for weaknesses in secondary education. There is, therefore, a need to examine whether the city's evening schools continued to serve business needs.

Following World War One, the Sheffield Education Committee continued to provide an impressive evening school network. In 1921, for example, the Central Secondary Evening school was established as the Central Commercial College and Intermediate Technical school.[17] It provided a broad commercial and scientific curriculum, covering subjects such as book-keeping, accounts, commercial correspondence, metallurgy, mechanics and technical drawing, and was well-equipped with scientific apparatus. The teaching in this college was considered to be very good, courses were provided up to intermediate degree level, and the qualifications achieved by the students were of a high standard. The college formed the apex of the organised system of commercial education in Sheffield, and its technical classes prepared students for entry to the university. Her Majesty's Inspectors' reports consistently emphasised that the college provided a high quality vocational education, and that it was supported by a thick and thriving undergrowth of district evening schools.

The teaching in both the central and district schools, appears to have been very effective; indeed, it was reported that engineering science was "well taught with a good sequence of experimental work", whilst machine-drawing was of an "astonishingly high standard" and the teaching of subjects, such as shorthand and book-keeping, was "generally sound."[18] In this respect, the city's evening schools continued to compensate for deficiencies in day secondary education. However, during the early 1920s, as table two in Appendix E illustrates, the number of students in evening schools, and particularly those taking technical subjects, declined. In part, this was a reflex of the depressed condition of local industries, but it was also a product of the simplification of the elementary school curriculum, which deprived many pupils of a training in

[16]Prior to World War One, as chapter 3 argued, some pupils, usually the least able, were encouraged to take special science and engineering courses, see chapter 3 and Report on School and Higher School Certificates, 1st April 1927, in CA 322, Secondary School Sectional Sub-Committee Minute Book, no.3, p.3.
[17]CA 681/9/18, p.21.
[18]Her Majesty's Inspectors Report on Evening Education in Sheffield, 31st July 1924, in CA 622 (6), p.320.

elementary science, which was essential for further technical instruction. The diminution in the number of students coming through the evening school route was very worrying, given the limited vocational education in day secondary schools, discussed earlier in this chapter. Her Majesty's Inspectors expressed their serious concern over the decrease in the proportion of ex-elementary scholars, who continued their education by joining evening classes (see table three in Appendix E). Thus, although the quality of the evening education was well maintained, in a hostile economic environment, the output of the schools was significantly reduced, and this throws into sharp relief the city's failure to develop a day technical school during the 1920s, which is discussed below.[19]

Local educationalists were not unaware of business demands for a more vocational secondary education, which were discussed in chapter 5. Percival Sharp emphasised that "with its enormous volume of highly skilled industries", Sheffield required a school which "would prepare boys for skilled occupations and the more advanced classes in applied science at the city's university." Moreover, he condemned Sheffield's failure to meet business requirements for "a well organised school of commerce."[20] In response to Sharpe's critique, the Sheffield Education Committee devised plans for 2 new secondary schools, one of which was to be a of a technical type and was intended to "form a direct nexus between the secondary education system and the skilled industries of the city" whilst providing the Applied Science Department of the Sheffield University with "a much more copious stream of students for its degree courses in technology."[21] These plans were approved by the Board of Education in 1927, but spending cuts during the Great Depression, ensured that they were not realised until 1933. At this date the Central Secondary School was transferred to an out of town site at High Storrs, and the old buildings were re-equipped for a junior technical school and a day commercial college.[22] The decision to build a junior technical school, rather than a secondary school of a technical type, was informed by the higher level of grant that was available for such schools, which admitted pupils at the age of 13 rather than 11, and provided an intensive 3-year course of vocational study.[23] The school clearly filled an important niche in Sheffield's educational apparatus. It was geared towards preparing students for entry into the engineering and building trades, and the timetable was divided as follows:

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[19]*Ibid.*

[20]Report by the Director of Education for Sheffield (Mr. Percival Sharp), 6th June 1924, in CA 321, pp.22-24.

[21]Report to the Higher Education Sub-Committee, 12th September 1928, in CA 322, pp.223-224.

[22]Her Majesty's Inspectors Report on the Central Secondary School, November 1934, in CA 323, p.6.

[23]Report by the Secretary of Education for Sheffield, 10th April 1933, in CA 622 (9,) pp.14-16; see also D. W. Thoms, "Market Forces and Recruitment to Technical Education: The Example of the Junior Technical Schools", *History of Education,* vol.10, no. 2, (1981), pp.125-132.

Table 1.1, A Sample of the Junior Technical School Timetable, 1933

Subject	No. of Hours per week
English	5
French	3
Maths.	5
Science (Physics, Chemistry, Mechanics)	5
Technical Drawing (Geometrical & Machine)	4.5
Workshop Practice	4.5
Physical Education	3

(Source: CA 681/9/23, City of Sheffield Education Committee Annual Report, March 1934, p.12.)

Clearly, the curriculum was a highly technical one, which catered for the subjects demanded by local industrialists. Moreover, the school possessed an excellent staff which had industrial experience in turning, fitting, pattern-making, steel-making, drawing office and civil engineering work. This experience was a valuable asset for the school, for it not only ensured that the students' learning experience was eminently practical, but also secured business support for the school. Thus, local firms contributed to the equipment of the school, which was considered to be at the cutting-edge of technology, and allowed pupils to visit their works in order to gain first-hand industrial experience. The school was, in fact, held in high regard by local manufacturers, who, as the previous chapter argued, had been critical of the traditional secondary school curriculum, and vociferous in their demands for more vocational education. Not unexpectedly, therefore, its students were eagerly recruited by local firms; indeed, businessmen complained that they could not procure the number of students they required. This was not surprising as the school was unable to cope with a yearly intake greater than 150 pupils. Given this small intake, and the fact that the school did not produce its first cohort for industry until 1936, local firms could have obtained no more than 450 students from this school prior to World War Two, a figure which ultimately represented too little, too late.[24]

[24]See Official Opening of the Sheffield Junior Technical School, 1st December 1933, in CA 681/9/23, pp.11-12; CA 681/9/25, Sheffield Education Committee Annual Report, 31st March 1936, p.15;

In addition, the recruitment of pupils at the age of 13 rather than 11, had important consequences for the quality of the pupils that the school could procure. The Sheffield Secretary for Education, himself, admitted that only the less intelligent or less industrious boys were left after the traditional secondary schools had made their selection at the age of 11. Nevertheless, he did not regard this as a problem and argued that "some of the boys who were found to be unable to take reasonable advantage of the instruction provided at the secondary and *even the intermediate schools* might be found...suitable for transfer to the Junior Technical School at the age of 13."[25] Thus, the Junior Technical School was conceived, from the outset, as a poor relation to the city's ordinary schools. Indeed, it was regarded as a repository for the less able, and in consequence, as table four in Appendix E shows, the examination results of its pupils were not at all impressive.

The history of the Sheffield Junior Technical School, fits in neatly with the national picture of under-development and under-achievement. Despite a Board of Education T (technical) drive in 1935, which was aimed to ensure that the technical schools should not remain the Cinderella of the education system, there were by 1938, only 248 technical schools in Britain, and a third of LEA's were still without them. At the end of our period, therefore, technical schools only catered for about 3 to 4 per cent of children. This failure to develop an extensive system of technical schools, represented a serious educational missed opportunity at a time, when, as chapter 5 claimed, industrialists were looking to technical education as a substitute for the decline of the apprenticeship system. Indeed, as Sanderson has argued, the Junior Technical school would have provided the basis for an effective industrial training but the inter-war years saw a dangerous failure to bring this bud to blossom, and it appears to me that it was in this period, rather than before 1914, that the English education system began to fail Britain's manufacturers.[26]

Unfortunately, very few records are available for the Day Commercial College that was established in Sheffield in 1933, but available evidence suggests that its syllabus mirrored that provided in the Evening College. In particular, there was a focus upon subjects such as book-keeping, shorthand and commercial correspondence, but also provision for the new managerial subjects, such as industrial administration. It is

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Headmaster's Report on the Sheffield Junior Technical School, in CA 681/9/26, Sheffield Education Committee Annual Report, 31st March 1937, pp.12-13.

[25]Report by the Secretary of Education for Sheffield, 10th April 1933, in CA 622 (9), pp.14-16.

[26]See M. Sanderson, "Technical education and economic Decline", pp.38-47; S. J. Curtis and M. E. Boultwood, *An Introductory History of English Education Since 1800* (London, 4th edition 1960), pp.190-191; B. Bailey, "The Development of Technical Education, 1934-1939", *History of Education*, vol.10, no.1, (March 1987), pp.49-65, esp. p.56.

impossible to assess the quality of this provision due to the lack of sources but, with only three classrooms, the college could not provide more than 100 places per annum. This meant that it provided very few recruits for industry prior to World War Two; in fact, fewer than 300. Its impact therefore, was severely limited, and again it simply represented far too little, far too late.[27] Moreover, if we consider secondary provision in Sheffield as a whole, there were, by 1939, only 4,000 pupils in Sheffield's secondary schools, and the city's provision of places per 1,000 elementary pupils remained well below the national average.[28] Thus, there were clear quantitative deficiencies in secondary school provision. What is more, due to the assumptions built into the secondary education system, very few pupils, as tables five and six in Appendix E show, chose to enter local industry especially in blue collar occupations.[29] In the final analysis, therefore, it appears that the city's secondary school system was unable to deliver business needs for technically- and commercially-educated personnel, which as chapter 5 demonstrated, were becoming increasingly sophisticated. Thus, in chapter 7 it be will argued that, as trade recovered in the mid-1930s, and as re-armament gained momentum, local firms began to suffer from acute human resource constraints. However, I now turn to examine developments in the equipment and curricula of Sheffield University.

II

The Sheffield University in Depression and Recovery.

A key problem for Sheffield University during the inter-war period, was the reluctance of secondary school pupils to enrol themselves on degree courses in metallurgy and engineering. Although considerably more enrolled than prior to World War One, the numbers involved remained relatively small compared to enrolments on arts courses. Indeed, in 1925, Professor Ripper deplored the "small number of boys from Sheffield secondary schools who applied for admission to the Department of Applied Science", and concluded that "the lack of suitable candidates was a serious matter in view of the

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[27]Nevertheless, it was the first day school to cater for commercial education in Sheffield since the passing of Morant's regulations for secondary schools in 1904, see chapter 3 and the Report of the Principal of the Central Day Commercial College, 14th October 1933, CA 323, Secondary School Sectional Sub-Committee Minute Book, no.8, p.74.

[28]Pollard, *Labour in Sheffield*, pp.261-262. It is well-known that throughout Britain there was an insufficiency of secondary school places, but in Sheffield, a key industrial centre, this insufficiency was even more pronounced. According to Aldcroft, "though the window of educational opportunity had been widened a little by the end of the inter-war period, it was still a very restricted one. The vast majority of youngsters left elementary school at the age of fourteen having received limited advanced instruction....", D. H. Aldcroft, *Education, Training and Economic Performance 1944-90* (Manchester, 1992), p.6; C. Barnett, *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (London, 1986), p.201.

[29]See tables five and six in Appendix E for the occupations that secondary school pupils took up on completing their studies.

vital importance of applied science to the chief industries of the city."[30] One could, perhaps, explain the small number of candidates solely by reference to the depression in local industries: Dr. Moore suggested that "the reason why secondary school boys did not make application...was the fear that they would be unable to obtain suitable posts on the completion of their training in view of the present state of trade."[31] However, as the previous chapter argued, the graduates turned out by the university during the inter-war years had no difficulty in finding a job and, for the bulk of our period, the demands of industry were in excess of supply.

The university took great pains to communicate this to the city's secondary school pupils but, before the late 1930s, their response was less than enthusiastic. It may be that the sight of unemployed relatives was more persuasive than the sales patter of the university staff, and that this created rigidities in the graduate labour market but, on the other hand, as chapter 3 demonstrated, the small number of entries into the Applied Science Department was not a new phenomenon, beginning before the onset of depression in 1921.[32] Ripper had bemoaned the lack of candidates coming forward as early as 1911. In that year he attributed the university's minuscule intake to the cultural bias of the city's schools towards the professions, and it appears that the increasingly academic orientation of the secondary school curriculum during the inter-war years continued this bias, depriving the Applied Science Department of not only the quantity but also of the quality of recruits it needed.[33] J. H. Andrew, Professor of Metallurgy, complained that the most able boys were creamed off for the professions, and the university was merely the recipient of a few second-class scholars.[34] These quantitative and qualitative deficiencies in the student intake had a double negative impact. Firstly, they meant a small income from student fees, and, secondly, and more importantly, they ensured that both the quantity and quality of graduates remained below the level required by business.[35]

The limited income from student fees would not have been such a problem for the university, if it were not for the reduction in moneys available from other sources. In the depressed conditions of the 1920s, businessmen reneged upon their financial commitments to the University and, as table seven in Appendix E shows, grants from

[30]Report by William Ripper on Admissions to the Applied science Department of Sheffield University, 2nd October 1925, in CA 321, p.176.
[31]*Ibid.*
[32]*Ibid.*
[33]W. Ripper, Report on the Present Position of the Supply of Properly Prepared Students to the Sheffield Trades and Industries, 7th October 1911, SCA, MD 3433.
[34]Report by J. H. Andrew, Professor of Metallurgy, Sheffield University, 8th March 1932, in SUA 5/1/33, Chapman Collection, papers relating to the history of the Faculty of Metallurgy, pp.114-121.
[35]*Ibid.*

local government were significantly reduced.[36] By 1928, therefore, the university was facing a financial crisis, which required cuts in the administrative and academic staff. Moreover, it could not afford to run its furnaces very often, or make extensive use of the laboratory equipment. This had an extremely damaging effect upon the quality of the students' learning experience, and dismayed businessmen, who, as chapters 2 and 5 argued, had always regarded practical experience in steel manufacture and analysis, as a key component of the graduates' training.[37] In a report written in 1932, therefore, J. H. Andrew was forced to admit that the prestige of the Faculty of Metallurgy was "at a rather low level", that the equipment was both "inefficient and inadequate" and that the research work was "not of a type likely to appeal to industry." He pointed out that research was largely in the hands of physicists and chemists who had taken up post-graduate scholarships in metallurgy, and argued that, as a result, many of the projects were of "a highly theoretical nature." He emphasised that metallurgical graduates did not pursue post-graduate research because of the inadequacies in their first degree programme, which did not provide sufficient knowledge to make them into competent researchers. Indeed, he maintained that the undergraduate metallurgy course had become "totally inadequate for modern requirements", since "far too much time was given up to chemical analysis so that the students on completion of their courses were trained analysts rather than competent metallurgists." Andrew argued, therefore, that the curriculum needed to be "completely remodelled in order to ensure that a student received instruction in all methods (theoretical and practical) pertaining to the production treatment, physical and chemical examination of steel." Moreover, in order to support moves in this direction, he demanded "considerable additions to the equipment", much of which was extremely antiquated and inefficient. In particular, the metallographic equipment was exceedingly bad, the visual microscopes were beyond repair, and the heat-treatment furnace was extremely poor.[38] In addition, given that the x-ray examination of steels had become increasingly important to local manufacturers, the university's lack of x-ray equipment was a serious deficiency. There was also an acute need to acquire a high-frequency induction furnace. Pioneered by Edgar Allen's in 1927, this furnace had proved itself capable of manufacturing the very best steels, at a more economical price than the traditional pot crucibles. It was therefore essential to

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[36]John Roach, "The University of Sheffield.", in C. Binfield et al (eds.), *The History of Sheffield: vol.2, Society* (Sheffield, 1993), pp.351-352; Chapman, *Modern University*, p.347.

[37]Thus, in the pre 1914 era, although the University did not usually obtain the city's most intelligent pupils the quality of the training which it provided tended to produce metallurgists and engineers who were adequate to business needs. However, during the inter-war period not only was the quality of the student intake falling, but the quality of the training provided by the University was also falling behind business needs, see SUA VIII/1/4, Sheffield University Applied Science Dept. Minute Book, no.4, p.37; SUA VIII/1/3, Sheffield University Applied Science Dept. Minute Book, no.3, p.395.

[38]Report by J. H. Andrew, Professor of metallurgy, Sheffield University, 8th March 1932, SUA 5/1/33, pp.114-121; report also contained in SUA VIII/1/4, pp.240-247.

the city's industries that the university begin to turn out students who were familiar with these furnaces, and who could be trained up for managerial positions.[39]

Clearly, whereas prior to World War One (as shown in chapter 3) the Metallurgy Department had encouraged the diffusion of innovations such as the electric arc furnace, by 1932 it had fallen behind best-practice techniques and could not deliver business demands for a practical training on the latest scientific apparatus. The economic depressions had a no less damaging effect upon the curriculum and equipment of the Faculty of Engineering. In the Mechanical Engineering Department, for example, the heat engines and hydraulic plant had become extremely antiquated, whilst in the Electrical Engineering Department none of the alternators were considered suitable for carrying out the tests required by local firms. What is more, it was argued that the engineering students were not being provided with an adequate education in the fundamentals of chemistry, physics and maths.[40]

The depressions of the 1920s clearly had a very bad impact upon the curriculum and equipment of the university. However, following the inauguration of protectionism in 1932, businessmen began to invest in the university and shortly afterwards more capital became available through increased grants from local and national government. This enabled the university to be rapidly restored to its former position as a leading centre of scientific research and education. In 1932, for example, the metallurgy curriculum was significantly improved by the introduction of more advanced classes in inorganic and physical chemistry, higher physics and maths. Moreover, the students benefited from more extensive lectures on iron and steel, more laboratory and furnace experience, and systematic instruction in research methods.[41] In addition, in 1933 further progress was made with the introduction of associateship and degree courses in metallurgical founding. These courses were a direct, if somewhat belated, response to the business demand discussed in chapter 5. They focused upon both the theoretical and practical aspects of foundry work, providing instruction in physics, chemistry, maths, casting-conditions, core-making, moulds and moulding, sands, refractories, pattern-making, and the metallography of cast materials.[42] In order to support this, and other courses, the university used money from local business, to replace many of the old furnaces with

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[39]*Ibid.*; "The History of Edgar Allen & Co. Ltd.", in *Edgar Allen News*, vol.137, no.437, (November 1958), p.243-244.

[40]See Report by Sheffield University's Professor of Electrical Engineering, October 1933, in SUA VIII/1/5, Sheffield University Applied Science Dept. Minute Book, no.5, p.6; Report by Sheffield University's Professor of Mechanical Engineering, 10th March 1936, in SUA VIII/1/6, Sheffield University Applied Science Department Minute Book, no.6, p.89.

[41]See SUA 5/1/33, p.125.

[42]*Ibid.*, p.125, 162.

more modern plant. Indeed, it established a model foundry, which proved of great value, not only for teaching, but also for research.

This foundry contained a complete battery of furnaces, including a 2-ton Siemens furnace, a 30-cwt. Greaves-Etchells electric furnace, a non-ferrous melting furnace and a small high-frequency induction furnace, which, as chapter 7 will argue, was becoming crucial to the production of heat- and corrosion-resistant alloys, in which local firms specialised.[43] The Institute of British Foundrymen, which provided part of the funds for this equipment, considered that it enabled the university staff to provide the students with "a scientific interpretation of every foundry operation" and "a knowledge of how these operations were best carried out." It claimed that the students therefore, entered industry with "a trained mind" and would be "of the greatest possible value to their firms."[44]

In addition to the development of the experimental foundry, the metallurgical laboratory was also completely re-equipped with modern apparatus such as, transformers and epidiscopes; more importantly, an x-ray laboratory was also established. The building of the x-ray laboratory, which contained an electron diffraction plant of the latest pattern, was made possible by a donation of £20,000 from the local businessman, Robert Hadfield. It allowed students to examine the atomic structure of steel and correlate this structure with the steel's physical and chemical properties. The laboratory thus opened up a new field to the students and placed the university "in a position pre-eminent amongst centres for the teaching of ferrous and non-ferrous metallurgy." Indeed, this provision could once again be considered unique, for its plant and equipment allowed any material or alloy to be melted, cast, forged, heat-treated and tested by all the methods that were then available. By World War Two, the university was building up a global reputation for the quality of its research work and this had a direct bearing upon the fortunes of local industry.[45] Improvements in the Faculty of Engineering were equally dramatic. Of particular note, was the installation of high-tech. equipment, such as the new Crossley single-cylinder, high-speed gas engine, and the integration of more intensive classes in physics, maths and mechanics.[46]

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[43] *Ibid.*, p.125; *Sheffield University Magazine*, vol.2, no.1, (June 1939), pp.6-9.

[44] Visit of the Institute of British Foundrymen to the Sheffield University Metallurgy Department, 3rd July 1935, in SUA 5/1/33, p.162; Robert Hadfield (Head of Hadfield's Ltd, a local Specialist Steel firm) also provided £5,000 towards the purchase of the foundry plant and equipment, *Sheffield University Magazine,* vol.2, no.1, (June 1939), pp.6-9.

[45] *Sheffield University Magazine*, vol.2, no.1, (June 1939), pp.6-9; SUA VIII/1/4, p.263; SUA VIII/1/8, Sheffield University Applied Science Minute Book, no.8, p.80-82; SUA VIII/1/6, Sheffield University Applied Science Minute Book, no.6, p.92.

[46] *Sheffield University Magazine*, vol.1, no.2, (1938), p.91.

Unfortunately, however, despite these improvements in the university's equipment and courses, the number of metallurgy and engineering graduates produced during the inter-war years failed to keep pace with business demands. As tables eight (a and b) in Appendix E show, although the number of awards in metallurgy and engineering granted by the university during the period 1919 to 1942 was significantly larger than in the period prior to World War One, the overall output remained rather small, on average no more than 60 awards in metallurgy and engineering were made each year. Moreover, as tables ten to sixteen in Appendix E show, in contrast to the pre World War One era when Sheffield firms usually provided employment for 60 per cent of the university's cumulative total of metallurgy and engineering graduates, during the inter-war years Sheffield firms only accounted for 39 per cent. Thus more and more graduates were turning to careers outside of Sheffield industries and outside of manufacturing generally. This meant that the university was simply unable to meet the sheer volume of business demand for graduate metallurgists and engineers.[47] Moreover, although the university improved its equipment and the technical aspects of its degree programmes, it did little to meet business demands that science undergraduates study managerial and commercial subjects, such as cost-accountancy and business administration. The only move in this direction, was the requirement that science students study a foreign language, a move which would have leant some support to the new policy of recruiting technical graduates for training as salesmen, discussed in chapter 5.[48] Management studies, such as business administration, however, were not integrated into the degrees, and this disappointed businessmen who were seeking to appoint the commercially-aware graduate to positions of responsibility. Indeed, the failure to incorporate commercial and management studies into degree programmes, perhaps partly explains industrialists' continued complaints that they could not procure not only the quantity but also the quality of graduates that they required, even after the improvements in the university's equipment and curricula.

[47]Of course, during the inter-war years, manufacturing industry was obtaining a smaller proportion of a much larger cumulative graduate population. Therefore, the actual number of graduates employed by local firms was increasing and this pays testimony to the magnitude of the business demand for graduates during the inter-war years that was discussed in chapter 5. Moroever, it should be added that, as table nine in Appendix E shows, during the inter-war period, engineering expertise also became available through the ordinary and higher national certificate route. Higher national certificate courses in mechanical and electrical engineering were designed to fit students for management positions and offered local business an alternative to graduate recruitment but even this could not satisfy the demand. During the inter-war years a greater proportion of the cumulative graduate population aquired jobs in the public sector , in education and abroad than prior to 1919. There was also a larger proportion of the student body whose employment was unknown but we do know that the majority of these students lived outside of Sheffield and their services were therefore lost to local industries. There are no further alumni returns after 1929, however, as chapter 5 argued, during the 1930s local industry consistently complained that the supply of graduates was inadequate to its needs, thus it is likely that the trend for graduates to work outside of Sheffield manufacturing industry, which began in the 1920s and which is identified in tables ten to sixteen in appendix E, continued in the 1930s.

[48]M. Boylan and G. Riloy, *The University of Sheffield: An Illustrated History* (Sheffield, 1981), p.15.

However, another part of the explanation was the quantitative and qualitative inadequacies in day secondary education, discussed earlier in this chapter. These inadequacies ensured that too few students had either the ability, or the inclination, to pursue metallurgy and engineering degrees, and therefore the university continued to provide the majority of its lectures at a sub-degree level, just as it had done prior to 1914. The university's sub-degree and evening work is considered below.

In the inter-war period, the university continued to provide many of the evening courses in metallurgy and engineering that it had done prior to World War One. During the 1920s, these course were poorly attended, but, as the recovery gained momentum in the 1930s, attendances regained and then exceeded their pre-war level. I do not intend to examine these old courses in any detail, suffice it to say that the reduction in attendances during the 1920s would have compounded the deficiencies in day secondary education. Rather, here I shall focus upon the new training initiatives that were introduced by the university and, in particular, the new courses in precision tool work and business administration.

During the inter-war years the university staff attempted to compensate for the decline in the quantity and quality of apprenticeships provided by local engineering firms, leading to the introduction of a special course which focused upon high-class precision tool work. This course combined theoretical studies with practical experience in the workshops and laboratories, and was open to apprentices who had acquired at least 3 years' practical experience. The course focused upon practical training in plate and limit gauges, the production of dyes, jig tools, pattern-making, fitting, turning, tool-making and the setting up and production of repetition work. In short, the course followed "as nearly as possible the practical work of a modern engineering works tool room." Students were required to conform to workshop discipline and attend on four, eight-hour days per week. Of particular importance to businessman, who, in a context of severe price-competition, as chapter 5 argued, were becoming increasingly concerned with the costs of production, was the university's commitment to "keeping an accurate account...of the cost of every job, so that the efficiency of the students from a commercial viewpoint" could be effectively assessed.[49] The course was essentially conceived as an antidote to the increasing specialisation and sub-division of labour, and was designed to meet business demands for the university to provide apprentices with all-round skills which would "fit them for more responsible work." The course was highly regarded by local businessmen and clearly tailored to a perceived industrial need. However, one can exaggerate the impact of the course, the patchy sources which have

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[49] Extract from the *Sheffield University Applied Science Prospectus, 1927-28*, in SUA VIII/1/3, p.354; see also SUA 5/1/2 (ii), Chapman Collection, papers relating to the history of the Technical School, vol.2, pp. 214-218.

survived do not suggest a large output of students, and the course could not possibly have compensated for the decline of the apprenticeship system. Indeed, as chapter 7 will argue, by the mid-1930s Sheffield firms began to experience acute shortages of skilled labour. Of course, had the university course been supported by the development of a junior technical school earlier in the period, these shortages may not have been so pronounced but the failure to develop such a school before 1933 left the university to bear the burden alone.

The precision tool programme, however, was not the only method by which the university sought to provide for the needs of the heavier trades. In response to business demands, it developed numerous courses in different aspects of management and commercial studies. For example, courses on scientific management, overseas marketing, salesmanship, industrial administration, business economics, works management, costs- and works-accountancy and office organisation. Moreover, such subjects were also provided at a more elementary level, in the Central Commercial College and a few of the district evening schools. It is extraordinarily difficult to assess the effectiveness of this provision. We lack details on the composition of the courses and no examination results are available. The attendances of these courses were subject to wild fluctuations, following the contours of the economic cycle. The only obvious and sustained reduction in attendance came during the 1930's, for the course on overseas marketing: a feature which we can perhaps relate to the decline in business demand for such subjects, which chapter 5 attributed to the increased focus upon domestic sales.[50] The range of courses provided by the university was impressive, and they represented an important addition to the city's educational apparatus. However, the courses at the university and elsewhere appear to have been introduced in a rather ad-hoc fashion. For example, Her Majesty's Inspectors considered that the classes in business economics formed "a rather disconnected or loosely connected series of lectures on various topics and lacked any co-ordinated idea running through."[51] They, and local businessmen, were keen to see the disparate subjects united in a coherent and comprehensive course of management studies. Nevertheless, such a course came only at the end of our period in 1938, largely due to the initiative of the local businessman, A. K. Wilson. The attendance on this course was excellent, in excess of 300 students per week, and both educationalists and businessman regarded it as a major development in management education. The teacher was one of the best in the country, he was a regular contributor to *Engineering* and the *Times Trade Supplement*, and the available

[50]LD 1818, Sheffield Trades Commercial Society Minute Book, meeting of Sheffield Trades Commercial Society, December 3rd 1935.
[51]Her Majesty's Inspectors Report, July 1925, in CA 622 (6),p.320.

evidence suggests, that the training which he provided for his students, was of a very high standard. However, it came too late to have any real impact during my period.[52]

Nevertheless, another important educational innovation introduced by the university during the inter-war years, was the development of a technical course specifically tailored to the needs of commercial personnel. This course concentrated upon steels, their properties and uses, and the reading of drawings and blue-prints. It provided a useful technical education, particularly for sales staff, and prepared the way for a fuller integration of the key functional activities of production and distribution. Unfortunately, however, it did not cover all the technical details that businessmen demanded and, as chapter 7 will argue, sales staff who attended this course remained deficient in technical knowledge of the products they sold. Not surprisingly, therefore, a number of firms adopted the policy of training technical graduates for the position of salesman, as they were better able to inform customers on their choice of material.[53]

However, perhaps the most significant educational innovation introduced by the university during the inter-war years was the development of trades technical lectures that were explicitly designed to re-train or re-skill old craftsmen in the city's cutlery and allied trades, who, as chapter 5 argued, were having to come to terms with increasing mechanisation and new and intractable alloys, such as stainless-steel. Because these lectures were so important, and because they were intimately connected to the city's cutlery trade, they will be considered in detail in chapter 8, which examines the various methods by which cutlers were re-skilled during the inter-war years. However, I will now consider whether the education system met the needs of business for technical, commercial and managerial personnel during the inter-war years.

III

Economic depressions in the 1920s and early 1930s clearly had a severe impact upon the city's educational provision. Cuts in educational expenditure made it extremely difficult for the local education system to respond to business needs for technical, commercial and managerial personnel. Indeed, it is perhaps surprising that so much was achieved, given the constraints within which the education system was forced to operate. Taking each category in turn, dealing first of all with management education, it is clear that the education system failed to fully meet business requirements. The evolution of management studies in Sheffield and, indeed, throughout Britain, was slow and patchy and it is little wonder that the larger steel companies, whose need for

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[52]See *Quality* (Journal of the Sheffield Chamber of Commerce), vol.10, no.1, (Oct. 1938), p.8; *Quality*, vol.10, no.7, (April 1939), p.268.
[53]See SUA VIII/1/4, p.85.

functional specialists was greatest, were forced to develop the managerial talent they required through in-house training programmes. It is possible that the needs of the smaller firms were increasingly provided for, with the development of courses on cost accountancy and industrial administration, but the inability to develop a coherent course in business management prior to 1938, represented a clear educational failure, especially when one considers the facilities for management education that were becoming available in competitor economies, such as Germany and the United States.[54] The university's failure to integrate management studies into degree programmes in metallurgy and engineering also led to a significant skills gap. Thus, businessmen were increasingly seeking to promote graduates to positions of responsibility, but their attempts to do this were undermined by the graduates' lack of managerial and commercial training, and businessmen complained that they could not procure the quality of graduates that they required.

The question of technical expertise can be conveniently considered at two levels, graduate and non-graduate. Due to quantitative and qualitative deficiencies in the secondary education system, the university's annual output of metallurgy and engineering graduates, although larger than prior to World War One, remained small. Moreover, during the inter-war period, more graduates turned to careers outside of manufacturing and the supply of scientific personnel therefore failed to keep pace with the demand among local businesses. Furthermore, during the period 1920 to 1932, the university was providing industry with sub-standard recruits. During these years, more and more firms were attempting to develop a capability in the manufacture of specialist alloys. This required a substantial research-drive and, therefore, well-trained metallurgists. But, whilst industrial needs had become more sophisticated, the university could only offer trained analysts, rather than competent researchers. Again, therefore, there is clear evidence of a significant skills gap, which only began to close after the re-equipment of the university in 1932.

Looking below degree level, the increasingly academic orientation of the secondary school curriculum, the failure to develop a technical school prior to 1933, and the reduction in numbers studying technical subjects in evening schools created a major problem. When local industries recovered in the 1930s, they found it exceedingly difficult to procure both the quantity and quality of recruits that they required. In addition, because of the decline of the apprenticeship system, during the 1920s, there

[54]The inadequacies in Britain's formal management education in universities has been stressed most recently by Matthews. He points out that by 1932 there were already 200,000 students on MBA courses in American universities, but Britain's first graduate business schools did not appear until 1965, D. Matthews, M. Anderson & J. Richard, "The Rise of the Professional Accountant in British Management", *Economic History Review*, vol.L, no.3, (August 1997), pp.424-425.

was little talent coming through that route either, and, in consequence, the late 1930s were characterised by acute shortages of skilled labour and technical expertise. Indeed, as chapter 7 will argue, these shortages were still making themselves felt in the 1950s.

Day commercial education in Sheffield was also very limited prior to the development of the Day Commercial College in 1933, which ultimately had little impact prior to World War Two. However, deficiencies in day provision were ameliorated by the Evening Commercial College which was established in 1921, and which turned out a large body of students who were well-trained in subjects such as accountancy, book-keeping and modern languages. However, it is doubtful whether the supply was adequate to meet business needs; in particular, the failure to provide salesmen with an effective technical education created major problems for batch producers, who relied upon salesmen to identify the customers' needs and make an appropriate recommendation.

In direct contrast to the period before 1914, when educational provision was more or less adequate to meet business needs, the reduction in educational expenditure which occurred between the wars prevented local schools and colleges from meeting more sophisticated business demands for technical, commercial and managerial expertise. Clearly, therefore, the depressions of the 1920s had a severe impact upon educational provision and, in the next chapter, I ask to what extent was the relationship reciprocal: in other words, did the inadequacies in educational provision which have been highlighted here, have a significant impact upon business performance? In order to explore this issue, I will test the business performance of Thomas Firth & Sons and Edgar Allen's, two companies which remained committed to education and training and which made the best use of the facilities available to them, against the performance of other firms, which during the period 1918 to 1933, increasingly neglected education and training as an investment in human capital.

Chapter 7: Education, Training and Business Performance: Sheffield Steel and Engineering Firms in the Inter-War Years.

As chapter 5 argued, during the difficult business environment of the 1920s, the vast majority of Sheffield steel manufacturers pursued a business strategy based upon quality production. They did all they could to retain the scientific staff and skilled labour upon whom their businesses depended, but they neglected education and training as an investment in human capital.[1] In order to explore the relationship between education, training and business performance, this chapter examines whether those firms which adopted alternative strategies, or which invested heavily in education and training, experienced a greater degree of business success. The chapter is divided into four parts. Part one sets the context in which strategic decisions were made, by exploring the business environment in which firms operated. Part two then provides a detailed case-study of the Vickers organisation, which went down-market and embarked upon a strategy of product diversification, acquiring a number of subsidiaries. This decision by a firm normally associated with high-quality armaments, warrants close examination. In particular, did it develop the organisational structure and functional specialists required to manage its more diverse business activities? Part three focuses upon Firth's and Edgar Allen's. These are important companies to study because they became leading producers of high-quality corrosion-resistant alloys, and because they remained committed to the education and training of their workforce. *Ceteris paribus*, we would expect these firms to have enjoyed a greater degree of business success than the many other companies, which reduced their investment in their human resources. However, part four will argue that during the inter-war years their financial performance, like that of Vickers, was not unusually good. A commitment to education and training did not, therefore, deliver the key to financial success, at least not in the short-run. Indeed, it will be argued that other factors over which manufacturers had little control, were the more important determinants of business performance.

I

Following the end of the brief post-war boom in 1921, Sheffield steel and engineering firms operated in a hostile business environment. In foreign markets they faced tariffs, some of which were virtually prohibitive, whilst imperial trade suffered as the colonies embarked upon a policy of import substitution.[2] In addition, domestic macro-economic

[1] *Ministry of Labour Report of an Enquiry into Apprenticeship and Training for the Skilled Trades in Britain and Northern Ireland, 1925-26* (London, 1926), pp.14-20.
[2] *The Bombshell*, vol.11, no.12, (Dec. 1927), p.444.

policies did little to help manufacturing industry. The return to gold at the pre-war parity for example, over-valued the pound, placing exports at a cost disadvantage, whilst unilateral free-trade allowed foreign competitors to dump their products on the open British market.[3] To compound these problems firms had made significant extensions to their plant and equipment in World War One, and, following the Washington Treaty on the Limitation of Armaments in 1922, much of this capacity was rendered redundant.[4] During the 1920s therefore, there were simply too many steel and engineering firms, chasing too few orders, in a world where purchasing power was severely restricted.[5] Having outlined the basic features of this decade, I will now examine how the Vickers organisation attempted to deal with this difficult business environment.

II

Vickers: A Case-Study

Vickers was, by 1900, already different to the majority of Sheffield firms. Firstly, it was considerably larger than other manufacturers; secondly, whilst it retained a small commercial steel section, almost all its capacity was geared towards the heavy armaments trade; and, thirdly, it pioneered mass and flow production techniques. Given its long commitment to armaments, the Washington Treaty posed a major problem for Vickers. The sheer scale of its plant meant that the batch production of specialist steels would not absorb all its productive capacity and it needed to find alternative outlets for its manufacturing resources.[6] Vickers, therefore, adopted a three-pronged strategy. Firstly, the company moved down-market seeking to compete with foreigners in the manufacture of the cheaper bulk steels. Secondly, it sought to broaden its product range by adapting plant and equipment, which had been designed for the manufacture of armaments, to the mass production of a diverse range of peace products, including cuddly toys and sewing machines. And thirdly, in order to expand product diversification further, it acquired a number of manufacturing subsidiaries, such as the British Westinghouse electrical company.[7] In what follows, it will be argued that this switch from a 'defender' type business strategy, to a 'radical prospector' strategy, was undermined by a combination of organisational failings and cultural constraints.[8]

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[3]*Ibid.*, p.444; R. Lloyd-Jones & M. J. Lewis, "Personal Capitalism and British Industrial Decline: The Personally Managed Firm and Business Strategy in Sheffield, 1880-1920", *Business History Review*, vol.68, no.3, (Autumn 1994), pp.408-409.

[4] CUL, records of Vickers Ltd., Vickers Document 629, Folder 157, *Conference on the Limitation of Armaments, Washington 1921-22, Treaties and Resolutions* (Washington, 1922).

[5]L. Daniels, "Metropolis of Steel, Patterns of Sheffield's Industrial History" (Unpublished PhD, Sheffield City Polytechnic, 1980), p.10.

[6]*Vickers News*, vol.1, no.1, (Oct. 1919), p.1.

[7]*Ibid.*, p.1; vol.1, no.6, (March 1920), p.8; vol.1 New Series, no.4, (October 1924), p.72.

[8]Defenders have a narrow and stable product market domain. Prospectors continually search for new product and market opportunities. For a fuller discussion of defender and prospector strategies see

It is important to the business historian that organisational forms are not independent of the organisation in which strategies and capabilities develop. Thus, Schein makes a distinction between strategy and culture, assuming that the latter operates at a deeper level, sometimes frustrating the former.[9] At Vickers, product quality had long been a core value of the company culture and, during the 1920s, it acted as a 'defective compass', making it exceedingly difficult for the firm to move in the direction that the new strategy required.[10] For example, only a minority of Vickers' machines were general-purpose and suited to the production of peace products. Indeed, Vickers' chairman acknowledged that the company could not "...turn guns in to ploughshares without scrapping the plant required for the production of guns for plant required for the production of ploughshares." Similarly, he emphasised that since the heavy armaments trade was so specialised, they could not diversify into unrelated product lines, such as cuddly toys, without substituting for workers accustomed to armaments production, men trained from youth in the manufacture of cuddly toys.[11] Thus, as Lipartito has argued, when a firm has learned how to produce certain sorts of goods, it is unlikely to have the skills, or even the understanding of what it takes to produce other goods.[12] In addition, because the armaments trade demanded the very best steels, the firm had built up a stock of "carefully-trained" human resources, "who maintained the high-quality of product which was synonymous with the Vickers group."[13] This made it extremely difficult for Vickers to move down-market and manufacture cheaper steels. Since a firm's plant, equipment and human resources are artefacts of its culture, one can clearly see how the culture may have frustrated the business strategy.[14] That is the way things were traditionally done at Vickers, in particular, its tight quality-control mechanisms meant that "prices were invariably higher than competitors." Indeed, as Scott has argued, because of its long involvement with high-quality armaments, Vickers found it extraordinarily difficult to get down to the lower standards of the civilian market.[15] The firm's difficulties in this respect were not unique; indeed, Armstrong

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chapter one of this thesis and S. Raghuram, "Linking Staffing and Training Practices with Business Strategy: A Theoretical Perspective", *Human Resource Development Quarterly*, vol.5, no.3, (Fall 1994), pp.241-242.

[9]Schein cited in M. Rowlinson, "Strategy, Structure & Culture: Cadbury Divisionalisation and Merger in the 1960s", *Journal of Management Studies*, vol.32, no.2, (March 1995), p.122.

[10]For a discussion of culture as 'compass', see chapter one of this thesis and M. Alvesson, *Cultural Perspectives on Organisations* (Cambridge, 1993), p.18.

[11]*Vickers News*, vol.4, no.47, (May 1928), pp.380-81; vol.6, no.71, (May 1930), p.391.

[12] K. Lipartito, "Culture and the Practice of Business History", *Business and Economic History*, vol.24, no.2, (Winter 1995), p.7.

[13]*Vickers News*, vol.6, no.71, (May 1930), p.391.

[14]Schein has argued that there are 3 levels of culture: artefacts (surface manifestations such as plant, products, human resources and equipment), values, and assumptions. See chapter one of this thesis and E. Schein, *Organisational Culture and Leadership* (Oxford, 1989), pp.14, 33, 57.

[15]J. D. Scott, *Vickers a History* (London, 1962), p.138; see also CUL, records of Vickers Ltd., Vickers Document 621, no.3, material relating to the Crayford Works.

Whitworth's, Britain's other leading armaments manufacturer, also found that "the atmosphere", or in other words, the prevailing culture in its factories was one "that did not admit of any other than the highest standard of work being produced."[16]

What steps, then, did Vickers' directors take to overcome these constraints on their business strategy? In particular, were significant changes made in the firm's human and physical resources? Some armaments plant was replaced by plant geared to commercial products, part of the River Don Gun Works, for example, were refitted for the production of hacksaws and magnets. However, in a difficult business environment, the directors were reluctant to scrap expensive plant, which, given sufficient orders, could still make profits. In addition, the question of re-training the workforce was never seriously considered: for one thing, the directors associated education and training with the apprenticeship system; for another, the problem was that many of the workers were simply too skilled, and so committed to product quality that the production of anything but the best goods became extremely difficult . The directors considered that their only option, therefore, was the recruitment of new workers. However, Vickers, like many Sheffield firms, possessed numerous employees who had given the company a long and loyal service. Indeed, reciprocal loyalty was a central feature of the company culture and the directors were extremely reluctant to shed old and valued workers.[17] In consequence, there was little scope for the recruitment of new workers, nor any sustained attempt to train apprentices, in either the production of armaments or new peace products. Indeed, the number of apprentices taken on by Vickers declined throughout the 1920s, following the general trend identified in chapter five.[18] It therefore appears that Vickers' attempts to move down-market were further constrained by the cultural commitment to reciprocal loyalty. The only training initiative introduced during the 1920s came at the supervisory level, where "special feed and speed men were trained to monitor machine operations."[19] Details of this training are sketchy, but it appears to have been based upon in-house lectures in work-study and the principles of scientific management.[20] According to Vickers' chairman, this training enabled foremen to "glide through the shops exhorting the men to manufacture forgings faster than ever before."[21] Nevertheless, this was not sufficient to compete with American manufacturers, and Vickers' attempts to mass produce peace products, such as sewing machines, with existing resources, usually

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[16] *Armstrong-Whitworth, From Battleships to Tool Steels and Small Tools* (1923), p.14, in CUL, records of Vickers Ltd., Vickers Document 1168.
[17] *Vickers News*, vol.9, no.103, (Jan. 1932), p.237.
[18] CUL, records of Vickers Ltd., Vickers Document 58, no.101, particulars of Warship builders.
[19] H. F. Gospel, *Markets, Firms and the Management of Labour in Modern Britain* (Cambridge, 1992), p.22.
[20] SLSL, LS260, *Vickers Centenary Video.*
[21] *Vickers News*, vol.4, no.47, (May 1928), p.387.

resulted in a technically excellent product which, because of its high price, proved a commercial failure.[22]

Diversification through the purchase of going-concerns proved no more successful. Mitchell and Singh have argued that "expansion into new product areas may strain available resources cause the organisation to lose focus and lead to business failure"[23] The evidence for Vickers would support this argument. Vickers entered the electrical engineering and rolling stock industries in 1919, by acquiring the Metropolitan Wagon Co. and its electrical subsidiary British Westinghouse.[24] However, no attempts were made to adapt Vickers' organisational structure to enable it to control its new subsidiaries, and no management training programmes were developed in order to support its more diverse business activities. Indeed, the control of the electrical and rolling stock interests remained firmly in the hands of the established managements.[25] This type of holding company organisation does appear to have resulted in Vickers losing strategic focus, indeed, as Gospel argues, Vickers' failure to develop the multi-divisional form and train functional specialists, clearly contributed to the organisation's failing performance during the 1920s, and in 1926 the company was forced to write down its capital by over 13 million pounds.[26]

The directors were acutely aware that their strategy of product diversification had failed to deliver the anticipated outcome, and in 1927, the chairman informed the shareholders that Vickers would not, in future "...embark upon any enterprises upon which they had no practical knowledge."[27] This decision marked the end of the diversification campaign and the company quickly divested itself of its electrical and other miscellaneous interests, embarking upon a new strategy of rationalisation in the core product areas of armaments and steels.[28] This, as Scott has argued, placed Vickers in "a

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[22]For a full list of Vickers unprofitable ventures in peace products see CUL, records of Vickers Ltd., Vickers Document 58, no.79.

[23]W. Mitchell & K. Singh, "Spill Back Effects of Expansion: When Product Types and Firm Types Differ", *Journal of Management*, vol.21, (1995), p.82.

[24]CUL, records of Vickers Ltd, Vickers Document 695, no.267, notes of a meeting between J. D. Scott & Colonel A. T. Maxwell concerning the acquisition of the Westinghouse Electrical Co., 14th May 1959; Scott, *Vickers* p.142.

[25]*Vickers News*, vol.2, no.4, (Oct. 1925), p.76.

[26] Gospel, *Management of Labour*, p.47; R. P. T. Davenport-Hines, "Vickers as a Multi-National before 1945", in G. Jones (eds.), *British Multi-Nationals, Origins, Management and Performance* (Aldershot, 1989), p.43; There does not even appear to have been any discussion amongst the Vickers' directorate of the multi-divisional form advocated by Chandler, A. D. Chandler, *Scale and scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass. 1990)

[27]Chairman's Speech at Vickers Annual General Meeting, June 1927, in *Vickers News*, vol.3, no.36, (June 1927), p.346; see also Chairman's Speech at Vickers Annual General Meeting, 28th March 1928, in *Vickers News*, vol.4, no.47, (May 1928), pp.380-81.

[28]*Vickers News*, vol.3, no.26, (August 1926), p.32; Chairman's Speech at Vickers Annual General Meeting, June 1927, in *Vickers News*, vol.3, no.36, (June 1927), pp.344 - 347.

fundamental contradiction that of being an armaments firm in a country devoted to disarmament."[29]

In 1927, only 40 per cent of the company's capacity was in use and this made it difficult to bear the burden of high overheads. Vickers, therefore, joined forces with Armstrong-Whitworth's: the new holding company Vickers Ltd. acquired the vast majority of shares in the operating company Vickers-Armstrong's, and production was rationalised through the closure of inefficient shops, and investment in up-to-date equipment.[30] The formation of Vickers-Armstrong's was, however, just the beginning of Vickers' rationalisation programme. In 1929 it spearheaded the formation of the English Steel Corporation (ESC), which united the commercial steel interests of Vickers, Cammell Laird's and the Darlington Forge Co. This fusion of manufacturing capacity was accompanied by the closing down of redundant plant, and the concentration of production in shops combining the latest machinery with the latest shop practices. In particular, modernised production was centred at Vickers' River Don Works, which were augmented by a 3-million pound investment programme that facilitated the development of a fully mechanised Siemens melting department, especially designed for the manufacture of the cheaper bulk specialist steels.[31]

Nevertheless, the formation of the ESC was not without its problems, personal and group jealousies, together with adverse shifts in the business environment associated with the Great Depression, ensured that during its first four years the group made heavy losses, and human resource problems related to the failure to invest in education and training during the 1920s, proved even more intractable.[32] For example, although the companies comprising the ESC had retained their research staff during the 1920s, they had done very little to augment them and, in consequence, they were far behind in the development of the more specialist corrosion-resistant alloys, which they now regarded as a major profit earner for other firms. Initially, the ESC attempted to develop its own corrosion-resistant alloys, but its research staff failed to produce the desired results.

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[29]Scott, *Vickers,* p.182.

[30]CUL, records of Vickers Ltd., Vickers Document 58, no.79, Lord Plender's Report on the Vickers-Armstrong merger, 1927; *Vickers News*, vol.4, no.42, (Dec. 1927), p.180; according to Tolliday, the term rationalisation was often used imprecisely but it implied reorganising the industry through amalgamation which would eliminate excess capacity , concentrate production and release economies of scale and best practice methods, S. Tolliday "Steel and Rationalisation Policies, 1918-1950" in B. Elbaum & W. Lazonick eds., *The Decline of the British Economy: An Institutional Perspective* (Oxford, 1986), p.82.

[31]See *Vickers News*, vol.5, no.55, (January 1929), p.238; vol.5, no.58, (April 1929), p.343, 350; vol.10, no.112, (October 1933), p.134.

[32]See *Vickers News*, vol.6, no.61, (July 1929), p.3.

Innovation in specialist steels was slowing down during the inter-war years, which can partly be explained by the fact that most of the major alloys had already been discovered. However, informed contemporaries considered that innovation was being constrained by the dearth of well-trained metallurgists, which was discussed in chapter 5 of this thesis.[33] It is significant that the ESC attempted to circumvent these constraints by bringing Firth-Brown, a firm which, as part three of this chapter will argue, had invested heavily in research and developed its own technical expertise, through a comprehensive education and training programme, into the group.[34] Equally significantly, Firth-Brown rejected this overture, on the grounds that they "had hitherto not found undue difficulty in getting a reasonable return for their efforts to maintain high standards of quality" and "a lot of cheap material", which the ESC had been making, had resulted in "a definite loss to them."[35] Thus, as was discussed earlier in this chapter, Vickers' attempts to move down-market had been hampered by a failure to produce cheaply enough, particularly in an environment where subsidised competitors were able to dump their products on the open British market.

Nevertheless, following the introduction of protectionism, which reduced imports of cheap foreign steel, the ESC's trade improved and it became a leading supplier of bulk steels. Success here, enabled more resources to be put behind the development of corrosion-resistant alloys, and the ESC began to develop a small capability in stainless-steels.[36] This gave the company a bargaining lever in negotiations with Firth-Brown, which became anxious, lest this huge combine should move in to their markets. In 1934, therefore, the stainless-steel interests of Firth-Brown were merged with those of the ESC, forming Firth-Vickers Stainless Steels Ltd. However, the formation of Firth-Vickers was not the end of the problems for the ESC and for the Vickers' group generally. Indeed, as trade began to recover, the Vickers' group began to pay the price for taking on too few apprentices during the 1920s. The first indication of a shortage of skilled labour came as early as 1934. In order to counteract these shortages, and develop the functional specialists required to control its business interests, Vickers introduced a new apprenticeship scheme, which allowed apprentices, not only to obtain experience in different departments of a specific works, but to gain experience at

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[33] *The Metallurgist*, vol.3, (March 1927), p.33; vol.5, (Aug. 1929), p.113; G. Tweedale, "The Business and Technology of Sheffield Steel Making", in C. Binfield et al (eds.), *History of the City of Sheffield: vol.2, Society* (Sheffield, 1993), pp.173-175.
[34] *Vickers News*, vol.11, no.131, (May 1935), p.445.
[35] SCA, records of Firth Brown Ltd., Firth-Brown Box 177, W. H. Hatfield & A. Matthews (Firth Brown's Technical Representatives) Report Upon Co-ordination Possibilities Between Firth-Brown and the ESC, 1930.
[36] ESC's stainless-steels were marketed under the brand name 'Immaculate', *Vickers News*, vol.9, no.99, (Sept. 1932), p.106.

different companies within the group, thereby creating a reserve of future managers.[37] This mirrored developments at United Steels, a large vertically-integrated steel combine, which introduced a new training programme to develop the skilled workers and, in particular, the managerial talent, that its complex business operations required. This training programme, which is described in table 1.1, was very sophisticated, indeed, it provided a range of college, school and trade apprenticeships.

Table 1.1: United Steel's Education and Training Programme

Trade Apprenticeship	Reserved for boys of 14 to 16 years of age, designed to produce skilled tradesmen such as fitters, turners, moulders, and rod makers. Boys received some preliminary training in a work's school before going on the shop-floor. The firm paid for apprentices to attend evening technical classes, and those trade apprentices who displayed unusual aptitude were allowed to upgrade to the school scheme.
School Apprenticeship	Arranged for boys who had remained at school until 18 years of age and who had matriculated. This course lasted 4 years, apprentices received practical training in the works and paid day-release to follow advanced courses in metallurgy and engineering.
College Apprenticeship	Was of 2-year's duration and designed for those who had graduated from university. Apprentices received some thoroughly practical engineering experience, before specialising in their second year in the particular function for which they were considered to be most suited.
Management Development	The company made a feature of education and training for promotion, foremen and junior executives were sent on outward bound courses to build their self-reliance and enterprise, and provided with paid day-release to enable them to attend national management training centres and conferences on subjects such as scientific management.[38] However, a key part of the training programme was the provision of experience at each of the different companies comprising United Steels.

(Sources: RLSL, 442/b/23624 (V), records of the United Steel Companies Ltd, Address of Chairman, Sir W. Benton-Jones, at Annual General Meeting 17th Nov. 1948; *Vickers News*, vol.2, no.6, (Dec. 1925), p.130; P. W. S. Andrews & E. Brunner, *Capital Development in Steel: A Study of the United Steels Co. Ltd.* (Oxford, 1951), pp.166-67; *Engineering*, vol.125, (1928), p.817.)

The management training schemes developed by Vickers and United Steels clearly set an important precedent within the British steel industry, but nevertheless, the schemes did not appear until long after those established by comparable companies in Germany and the United States. This reinforces Chandler's argument that British firms failed to make an adequate investment in management.[39] Indeed, given Vickers' previous

[37]CUL, records of Vickers Ltd., Vickers Document 319, Board Minutes 3rd Oct. 1935; *Vickers News*, vol.13, no.146, (Aug.1936), p.41.
[38]Vickers staff also occasionally attended international conferences on scientific management, *Vickers News*, vol.11, no.123, (Sept. 1934), p.97.
[39]A. D. Chandler, *Scale and Scope*, see also J. Wilson, *British Business History, 1720-1994* (Manchester, 1995), esp.chs. 4 & 5. According to Matthews British firms failed to develop management

strategy of product diversification, this firm's scheme should have come much earlier. Moreover, during the 1930s, the effectiveness of United Steel's scheme was undermined by excessive centralisation, which starved management in the subsidiaries of any real responsibility, preventing rising stars from realising their potential.[40]

Looking further down the training ladder, the introduction of a new trade apprenticeship failed to compensate for the under-investment in human capital during the 1920s. Indeed, severe skilled labour shortages acted as a constraint on production throughout the next decade, and by 1937 Vickers was forced to acknowledge that it could not meet the demands of both its military and commercial customers, despite having free productive capacity.[41] In consequence, it had to scale down the commercial business that it had spent so long building up.[42] Nevertheless, it was still unable to cater adequately for military requirements, and shortages of skilled labour forced it to sub-contract work out to other firms.[43] Vickers' story was not atypical: almost all firms paid for their failure to recruit and train apprentices in the 1920s. Indeed, as early as 1934, the *Machinist* noted that the shortage of skilled labour was acting as severe constraint upon production.[44] This explains why Vickers "could not rely on drawing on skilled men from other firms and other districts", and was forced to devise its own training programme.[45] Nevertheless, two firms which appear to have escaped these human resource constraints were Firth's and Edgar Allen's, companies which, during the 1920s, were notable for their continued commitment to education and training. In the next section, therefore, I will briefly outline the evolution of business strategy at these firms, in order to set the context in which schemes of education and training were introduced.

III

Business Strategy at Firth's and Edgar Allen's.

During the inter-war years the directors of Firth's and Edgar Allen's continued to regard product quality as a 'sacred cow'. They, more than Vickers, were prisoners of their

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training programmes that were as sophisticated as those devised by companies such as General Motors in the U. S. and comparable companies in Germany. Indeed, management training by business and academia in Britain was, he claims, meagre, D. Matthews, M. Anderson & J. Richard, "The Rise of the Professional Accountant in British Management", *Economic History Review*, vol.L, no.3, (August 1997), pp.424-425.

[40]R. Peddie, *The United Steel Companies Ltd., 1918-1968: A History* (Manchester, 1969), pp.27-28.

[41]*Vickers News*, vol.13, no.151, (Jan. 1937), p.254.

[42]For references to skilled labour shortages, see CUL, records of Vickers Ltd, Vickers Document 722, Vickers' Quarterly Reports.

[43]*Vickers News*, vol.15, no.174, (Dec. 1938), p.230; vol.15, no.177, (March 1939), p.365; vol.15, no.179, (May 1939), pp.456-458.

[44]*American Machinist European Edition*, vol.78, (1934), p191; vol.79, (1935), p.69; vol.81, (1937), p.122; *Engineering*, vol.14, (1936), p.98; LD 1986/22, Sheffield Chamber of Commerce Minute Book, no.22, April 1937, p.A35.

[45]*Vickers News*, vol.13, no.146, (Aug. 1936), p.20.

company culture. The directors of Thomas Firth and Sons recognised that given the shifts in the business environment and, in particular, the low purchasing power of world markets, there was "a temptation to try to produce at a lower price by reducing quality."[46] However, because their firm had "always taken a pride in the quality of the goods supplied and the service rendered to customers", the directors dismissed competition on the basis of price as unworkable, given the "traditions" or cultural proclivities of the firm. Thus, as Scholz argues, "the process of strategy formulation does not only have to consider the capabilities of the company and the market situation, but also the restrictions which derive from the existent corporate culture...(and) The stronger the corporate culture the more it limits the feasible space for strategy decisions."[47] For example, Edgar Allen's directors emphasised that "In the past our business has been built upon the quality of our products and we think that it will apply even more strongly in the future....It is doubtful whether it would be possible for us to compete against overseas manufacturers in cheap products as ...their machinery has been adapted to these ends...while we can produce the same steels we cannot produce them so cheaply because our plant has not been designed for that purpose."[48] Thus, Edgar Allen's machinery, an artefact of its culture, constrained strategic change and, moreover, the directors believed that their employees were so committed to product quality that they would "rather go where they could use their skill to the utmost than be compelled to do shoddy work."[49] The directors of both firms therefore considered that they were bound by their culture which, in consequence, shaped their business strategy between the wars.

This strategy continued to be based upon the production of a wide range of high-quality steels, and steel products which were tailored to exacting customer requirements, using skilled and flexible labour. The directors considered that the advantage of this strategy

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[46] *The Bombshell*, vol.12, no.12, (Dec. 1928), p.454.

[47] J. G. Gonyea & O. M. Westall, "'Make Business Culture a Family Affair", *Works Study*, vol.43, (Sept/Oct. 1994), pp.9-10; Nelson and Winter have argued that the formulation of business strategy "reflects at any moment...the historically given routines governing the actions of a business firm...(and that)...firms are bound by precedent", cited in S. Zukin, "Introduction", S. Zukin & P. Dimaggio (eds.), *Structures of Capital: The social Organisation of the Economy* (Cambridge, 1990), p.6. In other words, as Zukin phrases it, economic decision-making is "culturally embedded", that is "shared collective understandings" will shape business strategies and business goals, Zukin, "Intro.", p.17. This means that the "same demographic, economic and social trends will be differentially noticed, interpreted and acted upon by individual companies", Gonyea, "Business Culture a Family Affair", pp.9-10; thus, as Casson points out, "it is the perception as well as the reality of environmental change that is important...(and) ...Solutions are subjective because of...the model or mental map used." Company culture, "a collective subjectivity, a shared set of values norms and beliefs" will influence "the meanings that key executives or decision-makers attribute to changes in their business environment and the linkages they draw between these changes and the development and survival of their firm", M. Casson, "Entrepreneurship and Business Culture", in J. Brown and M. B. Rose, *Entrepreneurship, Networks and Modern Business* (Manchester, 1993), p.34; Gonyea, "Business Culture a Family Affair", pp.9-10.

[48] *Edgar Allen Works and Sports Magazine*, no.60, (Sept. 1925), p.12; no.95, (Aug. 1928), p.2.

[49] *Edgar Allen News*, vol.7, no.84, (May 1929), p.374.

was that "it reduced the field of competition...as they could produce products which...bulk manufacturers could not find time to handle."[50] However, they recognised that to be successful, they must be capable of switching form one market niche to another, and they therefore remained committed to flexible specialisation. Edgar Allen's, for example, acknowledged that "Our Engineers Department...realises perfectly well that there must come a time when the productive capacity of cement plants all over the world will equal the demand...and as the market for this type of machinery approaches saturation point, it will have to...switch over to some other specialised line."[51]

Of crucial importance to this strategy however, was the development of a range of specialist steels which could be tailored to diverse needs. In particular, Firth's built upon its invention of stainless-steels, developing a bewildering variety of heat- and corrosion-resistant alloys, which were marketed under the brand-name 'staybrite'.[52] Firth's and Edgar Allen's research laboratories were therefore even more important to their business strategy after World War One than before.[53] Nevertheless, Firth's considered that research into specialist steels alone would not suffice in a hostile business environment, and it therefore sought to forge closer links with John Brown's. In 1930, their steel interests were finally amalgamated to form a new company, Thomas Firth and John Brown Ltd. [54] This amalgamation was accompanied by a rationalisation programme which resulted in the closing down of inefficient shops, and the installation of the largest electric arc furnace in Europe and the largest high-frequency induction furnace in Britain. This latter furnace, pioneered by Edgar Allen's in 1927, produced steels that were free from impurities and homogeneous throughout, and it was therefore ideally suited to the manufacture of specialist alloys. [55] Of course, Firth's and Edgar Allen's technological strategy was not unusual - product quality was a core-value of the industrial district. Most manufacturers considered that product quality was their "sheet anchor" and the one thing they must never give up. This encouraged them to install high-frequency furnaces and manufacture top quality

[50] *Edgar Allen Works and Sports Magazine*, no.95, (Aug. 1928), p.1.
[51] *Ibid.*, no.98, (November 1928), p.2.
[52] *The Development of Staybrite Steel* (Sheffield, 1930), pp.1-4. Tweedale, "Science, Innovation and the Rule-of-Thumb: the Development of British Metallurgy to 1945", in J. Liebenhau (eds.), *The Challenge of New Technology: Innovation in British Business Since 1850* (Aldershot, 1988), p.74; Edgar Allen heat- resistant steels were marketed as 'Maxhete', *Edgar Allen Trade Catalogue* (Sheffield, 1934), p.23.
[53] *The Brown-Firth Research Laboratories*, (Sheffield, 1938), p.6; *Edgar Allen Works and Sports Magazine*, no.29, (Feb. 1923), p.26.
[54] *Souvenir of a Visit to Firth-Brown Ltd., March 14th 1957* (Sheffield, 1957), p.47.
[55] *The Bombshell*, vol.15, no.4, (April 1931), p.123; *Firth-Brown Souvenir, 1957*, pp.51-54; G. Tweedale, *Steel City, Entrepreneurship, Strategy and Technology* (Cambridge, 1995), p.253; *Edgar Allen News*, vol.6, no.68, (Jan. 1928), p.99.

stainless steels.[56] However, in their continuing commitment to education and training, Firth's and Edgar Allen's were quite unique. Indeed, in what follows it will be argued that policies of education and training, were not only integral to the business strategy of these firms, but that, along with other industrial welfare measures, they were also used by the management as a tool to recapture the loyalty and trust of the workforce, which had finally broken down during World War One.

In chapter 4, it was argued that the 'social glue' which held firms such as Firth's and Edgar Allen's together was the reciprocal relationship between management and workers, based upon notions of loyalty, trust and obligation.[57] During the early 1920s, both these firms experienced unprecedented labour troubles, which suggests that this 'glue' was coming unstuck. The directors of both companies recognised that the rapid expansion of their business activities during the war had undermined their personal relationship with the workers and, in particular, it had rendered "one to one verbal communication", which chapter 4 identified as a key mechanism for the development of trust, extremely difficult.[58] Firth's chairman for example expressed his regret that: "during the war the number of employees had increased so rapidly and the duties of direction had become so much greater, that the personal relationship previously existing between the management and the employees had unavoidably suffered...."[59] Indeed, as the firm grew developing various departments and functions, it culture began to lose the homogeneity of the founder period, which was explored in chapter 4. In particular, there developed a clear sub-culture based upon a nascent shop steward's movement, known as the Firth Workers' Committee. In view of this sub- or counter-culture, the management recognised that "more and more conscious thought and direction was needed, in keeping alive confidence between employees and a more aloof management...to promote a feeling of common endeavour."[60] Thus, in terms of the metaphor of culture as 'social glue', in a larger, more functionally oriented company, the glue required more careful maintenance and repair work.

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[56]Quality was a core-value of the business culture of the industrial district, thus, the Sheffield Chamber of Commerce emphasised that "for generations, the name of our city had been associated...with production of the highest quality of material and craftsmanship on which the reputation of our industry has been built up", *Quality*, vol.1, no.1, (Oct. 1929), p.1; vol.3, no.7, (April 1932), p.16; vol.3, no.6, (March 1932), p.1.
[57]For a discussion of culture as 'social glue', see chapter 1 of this thesis and M. Alvesson, Cultural Perspectives on Organisations (Cambridge, 1993), p.19.
[58] *The Bombshell*, vol.3, no.3, (March 1919), p.91; Edgar Allen's directors claimed that during the war the works had grown so large that their personal relationship with the workers was beginning to break down, *Edgar Allen Works and Sports Magazine*, no.1, (June 1920), p.23.

[59] *The Bombshell*, vol.3, no.1, (Jan. 1919), p.11.
[60] Cited in H. Jones, "Employers' Welfare Schemes and Industrial Relations in Inter-War Britain", *Business History*, vol.25, no.1, (1983), p.62.

In order to promote the feeling of a common endeavour, and to foster a company culture based upon reciprocal loyalty, both Firth's and Edgar Allen's looked to their company journals, *The Bombshell* (established 1916) and *The Edgar Allen's Works and Sports Magazine* (established 1920) as a means by which they could communicate with their workers and maintain a personal relationship with them.[61] The case-studies lend support to Alvesson's argument, that it is possible to be, at the same time, constrained by culture and yet attempt to manage it.[62] In other words, the directors of both companies were bound by the core-value of product quality, which circumscribed the scope for strategy formulation, but nevertheless, they attempted to maintain and nurture the loyalty and trust of the workforce.

Both journals stressed the importance of the human element in industry. Edgar Allen's magazine for example, identified "skilled and educated workers" as a "definite business asset."[63] In addition, they promoted the ideology that the interests of employers and employees were identical, and that they should work together in order to combat foreign competition. We are back therefore, to the assumption discussed in chapter 4, that human relationships should be characterised by co-operation. Indeed, a typical passage in the Bombshell claimed that "All Firth's workers must pull together....Whatever our position, whether as director, clerk or workmen, we all have our part to play, and can either help or hinder the running of the industrial machine."[64]

Nevertheless, at Firth's in particular, the management were not the only ones attempting to project their ideology in order to capture the hearts and minds of the workers. The Firth Workers' Committee, for example, published its own magazine, *The Firth Worker*, expressly as "an antidote to the one issued by the firm."[65] It argued that the interests of capital and labour were diametrically opposed and characterised by conflict.[66] It sought to undermine the assumption of co-operation between workers and management, and it encouraged Firth's employees to take "a much wider outlook on industrial matters than the four walls of the firm."[67] In other words, it claimed that the

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[61] *The Bombshell*, vol.3, no.1, (Jan. 1919), p.11; *Edgar Allen Works and Sports magazine*, no.1, (June 1920), p.23; Firth's use of *The Bombshell* was identical to the use that Lever Brothers made of their magazine, which, as J. Griffiths has pointed out, "figured as an important medium to communicate with the Lever Brothers workforce", J. Griffiths, "Give My Regards to Uncle Billy: The Rites and Rituals of Company Life at Lever Brothers, c.1900-1990", *Business History*, vol.37, no.4, (Oct. 1995), p.28.

[62] Alvesson, *Cultural perspectives*, p.90.

[63] *The Bombshell,* vol.3, no.3, (March 1919), p.95; *Edgar Allen News*, vol. 11, no.126, (Nov. 1932), p.167; according to Helen Jones the emphasis on the human element in industry acted as an antidote to the growth of the firm, Jones, "Welfare Schemes", p.72.

[64] *The Bombshell*, vol.3, no.3, (March 1919), p.95; *Edgar Allen Works and Sports Magazine,* no.2, (July 1920), p.21.

[65] *The Firth Worker*, no.16, (1917), p.9.

[66] *Ibid.*, no.14, (1917), p.2.

[67] *Ibid.*, no.16, (1917), p.9.

workers' interests lay with workers at other firms and attempted to undermine the old notion of the firm as an organic and harmonious whole, and in order to drive its message home, it parodied certain of *The Bombshell's* monthly features, for example, "Is It A Fact": "Is it a fact that the firm again showed their love for workers by summoning a discharged soldier for losing time." [68]

In order to counteract the messages transmitted by *The Worker*, the directors embarked upon a concerted campaign of cultural intervention. It is, for example, no coincidence that Firth's official history was written in 1924. In terms of the metaphor of culture as 'clan', this history, excerpts of which were printed in *The Bombshell*, can be viewed as a means of "providing members with the intellectual tools and a long memory which guarantee the perception and evaluation of fair reward and which over the long-run discourage opportunistic behaviour."[69] Nevertheless, if the directors were to overcome the challenge of the Firth Workers Committee, something more than words was required.

Various studies of industrial welfare have suggested that the primary aim of welfare schemes was the development of an efficient workforce. That is, a workforce which was disciplined, healthy and trained to whatever degree of skill was required.[70] In what follows, it will be argued that both Firth's and Edgar Allen's used welfare to achieve all three ends, and a particular accent was placed on acquiring discipline through the promotion of an ideology of reciprocal loyalty and obligation, in which management acted to inspire the loyalty which they demanded. Through the medium of their works magazine for example, Edgar Allen's directors informed the workers that "We believe...that we have certain duties to our employees. One of these is to ensure they are given facilities for healthy recreation which will improve their physical constitution."[71] Workers provided with such facilities were, in turn, expected to be loyal to the goals of the firm. Thus, *The Bombshell* urged workers that "if a man pays you wages which provide your bread and butter, work for him; if besides he treats you well, speak well of him, stand by him and the firm he represents."[72] Both firms

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[68] *Ibid.*, no.8, (1917), p.2.

[69] This history contained organisational stories, which reveal and promote the managerial ideology, and role-models for the workers to follow. For a discussion of culture as 'clan', see chapter one of this thesis and Alvesson, *Cultural Perspectives*, p.18. Of course Firth's and Edgar Allen's problems were part of the general worsening of labour relations in British industry in the early 1920s, leading up to the General Strike of 1926.

[70] H. F. Gospel "Managerial Structures and Strategies: An Introduction", in H. F. Gospel and C. R. Littler (eds.), *Managerial Strategies and Industrial Relations* (London, 1983), p.14 ; J. Melling, "Employers, Industrial Welfare and the Struggle for Workplace Control in British Industry, 1880-1920", in Gospel & Littler (eds.), *Managerial Strategies*, pp.57-8 . H. Jones, "Employers Welfare Schemes", pp.61-75.

[71] *Edgar Allen Works and Sports Magazine*, no.83, (Sept. 1927), p.28.

[72] *The Bombshell*, vol.4, no.8, (Aug. 1920), p.284.

explicitly set out to use welfare to harness such loyalty. Indeed, they provided canteens, large sports grounds and pavilions and encouraged the formation of football and cricket teams, athletic clubs, fishing clubs, and choral societies. They emphasised that these actions were "not wholly inspired by the sordid motive of keeping men and boys in good condition in order that they may do their work better," rather as men, they "preferred to see their workers fit and well and were willing to do something to ensure this."[73] Nevertheless, recreation facilities, together with safety-first committees and ambulance classes, were a method by which the firms could invest in the health of their human resources and contribute to their efficiency. In addition, combined with annual sports days and works trips, they were also a method of fostering worker loyalty and co-operation. Indeed, in 1925, Firth's directors explicitly stated that "the sports club, the garden society, choral society and orchestra were all doing their educative work...developing the co-operative spirit"[74] and, in 1928, following a trip to Blackpool, they expressed the opinion that "there is no doubt that these gatherings maintain that friendly personal relationship amongst our work people"[75] Thus, in terms of the metaphor of culture as 'manager-controlled rites', the annual trips were a key mechanism for reinforcing loyalty and trust.[76] Indeed, Edgar Allen's directors considered that annual trips in particular, and welfare in general, gave each man "the feeling that he was regarded as something more than a mere cog in the industrial machine" and developed "mutual confidence and co-operation between management and employees."[77] A confidence and co-operation that was galvanised by enabling each and every employee to become a shareholder in the company.

The available evidence suggests that the firms were successful in their efforts to foster a company culture based upon reciprocal loyalty and obligation, and this lends support to J. Griffith's claim, that cultural values and symbols may be manipulated to desired ends.[78] For example, *The Worker* appears to have ceased publication in the mid-1920s, and both Firth's and Edgar Allen's were noted for the long-service of their employees and for the cordial relations between capital and labour. Indeed, in 1939 a Sheffield newspaper ran an article entitled "Firms Pride in Workers' Long Service." This article reported on a ceremony in which Firth-Brown's Managing Director personally presented certificates of long-service to 952 workers, each of whom had been employed by the firm for over twenty five years.[79] This ceremony can be analysed as a 'social

[73] *Edgar Allen Works and Sports Magazine*, no. 83, (Sept. 1927), p.28.
[74] *The Bombshell,* vol.9, no.8, (Aug. 1925), p.285.
[75] *Ibid.*, vol.12, no.8, (Aug. 1928), p.283; *Edgar Allen Works and Sports Magazine*, no.106, (July 1929), p.14.
[76] For a discussion of culture as 'manager-controlled rites', see chapter one of this thesis and Alvesson, *Cultural perspectives*, pp.20-21.
[77] *Edgar Allen News*, vol.5, no.49, (June 1926), p.809.
[78] J. Griffiths, "Give My Regards to Uncle Billy", p.42.
[79] SLSL, Newspaper Cuttings relating to Sheffield, vol.25, (Jan.27th 1940), p.39.

drama', which reveals the triumph of the directors in promoting a company culture, based upon an overarching ideology of loyalty. It was a triumph in which education, training and promotion, which were the cornerstone of Firth's welfare policy, played a pivotal role. Indeed, as Schein has argued, recruitment, training and promotion are vital mechanisms for culture embedding and reinforcement, it is therefore to a consideration of education and training that I now turn.[80]

Education and training became an increasingly important component of the business strategy at Firth's and Edgar Allen's during the inter-war period. Both firms looked to their education and training programme to deliver a number of important objectives. The education and training programmes were designed firstly to: develop, not only practical skills, but also the technical and commercial expertise required by the business strategy. Secondly, to develop an adaptable and efficient workforce whose "broad-based knowledge and judgement" would facilitate flexible specialisation.[81] Thirdly, to produce management potential by fitting employees for promotion on merit. Fourthly, to foster a loyal and willing workforce which attached itself to the goals of the firm and displayed "careful attention to duty."[82] Education and training was to achieve this by "building up character", and "instilling discipline".[83] Moreover, by fitting people for promotion, education was intended to create 'company men', who identified themselves closely with the goals of the firm. For example, Edgar Allen's directors recognised that it was "naturally encouraging to employees to know that when positions of responsibility become vacant or new ones are created they will receive first consideration"[84] Gospel has argued that certain types of employment contracts are likely to elicit more commitment than others, and these are those which offer greater job security, internal promotion and a wider-range of welfare benefits - in other words, labour management via an internal labour market - and it was towards this type of arrangement that Firth's and Edgar Allen's were moving.[85] Finally, the education and training programme was also meant to ensure that old workmen were kept up-to-date with technical developments. Education was not therefore solely related to the apprenticeship system, rather, it was emphasised that "No-one is too old to learn."[86]

The Sheffield Education Committee regarded Firth's, in particular, as a model employer, and the directors themselves acknowledged that they were leaders in human

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[80]Schein, *Organisational Culture*, pp.236-237,242.
[81] *The Bombshell* ,vol.6, no.9, (Sept. 1922), p.366.
[82] *Ibid.*, p.366.
[83] *Ibid.*, p.366; vol.5, no.6, (June 1921), p.222.
[84]*Edgar Allen News*, vol.17, no.193, (June 1938), p.191.
[85]Gospel, *Management of Labour*, p.183.
[86] *The Bombshell*, vol.3, no.8, (Aug. 1919), p.292; vol.8, no.10, (Oct. 1924), p.363; *Edgar Allen Works and Sports Magazine*, no.48, (Sept. 1921), p.23.

resource management. Indeed, they claimed that "We are bound to make mistakes, but if we can help by precept and example to develop a more highly-trained staff and secure that the reward for efficiency shall be promotion to a higher grade, then we shall have done a little towards all round national welfare."[87] As chapter 5 argued, the directors clearly believed that education and training would deliver enhanced business performance for the firm, and that this would have a positive impact upon long-run macro-economic growth.[88] Nevertheless, the firm's education programme was not only designed to improve economic performance, rather, the management emphasised that "many of the problems of the future could only be solved by a highly educated democracy."[89] Their education and training programme was therefore designed to produce "ideal citizens" for the firm and for the nation, by training workers who would grow up to become a "credit to themselves, the firm and the community."[90]

However, what form did the education and training programme take? In a context of intense foreign competition, both firms improved their recruitment and selection procedures. The directors at Firth's, for example, considered that recruitment could be "reduced to a fairly systematic procedure"[91] and their Welfare Department used a range of psychometric tests to examine a variety of skills, including "the capacity to adjust thinking to new requirements", a key aptitude required by flexible specialists.[92] The results of these tests were used to ensure that employees were placed "in positions to which their capabilities, temperaments and skill most suited them,"[93] and the Welfare Department maintained details of the training and achievements of all employees on index records, which were analysed in order to arrange "transfers and promotions on merit."[94] Similarly, Edgar Allen's welfare officers set boys to work for which they were "best suited...keeping a watchful eye on their conduct and marking out those for whom promotion was most appropriate."[95]

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[87] *The Bombshell*, vol.3, no.1, (Jan. 1919), p.15; vol.6, no.9, (Sept. 1922), p.366.
[88] *Ibid.*, vol.5, no.8, (Aug. 1921), p.283.
[89] *Ibid.*, vol.4, no.8, (Aug. 1920), p.304.
[90] *Ibid.*, vol.9, no.8, (Aug. 1925), p.284. There was, at this time in Britain, grave concern with worsening labour relations. Of course the General Strike broke out the following year.
[91] *Ibid.*, vol.9, no.3, (March 1925), p.89.
[92] *Ibid.*, vol.4, no.9, (Sept. 1920), p.325. Firth' s must have been one of the first companies to use such methods.
[93] *Ibid.*, vol.9, no.5, (May 1925), p.163. Thus Firth's further refined their recruitment procedures, which as chapter 4 argued, were already becoming more systematic and more sophisticated prior to World War One.
[94] *Ibid.*, vol.9, no.8, (Aug. 1925), p.284.
[95] *Edgar Allen Works and Sports Magazine*, no.46, (July 1924), p.32; Schein has argued that companies with strong cultures pay a lot of attention to recruitment, to ensure that they get the right type of employee. Of particular importance for Firth's and Edgar Allen's were co-operation and loyalty which were an essential prerequisite for promotion.

Once recruited Firth's sought to "develop the workers moral, mental and physical well-being through day and evening classes and recreational facilities of all kinds."[96] In 1918, it established a day continuation school, which all employees between the ages of 14 and 16 were allowed to attend on two half-days per week, whilst in receipt of full wages. Aside from Firth's, Daniel Doncaster and Sons, and Samuel Osborn's were the only Sheffield firms to establish such a school. Hendrick has cited a number of reasons for the failure of the continuation school movement, but he identifies the opposition of employers through The Federation of British Industries, and the attacks on educational spending in the House of Commons, which culminated in the Geddes axe of 1921, as the key factors.[97] Following the Geddes axe, most firms abandoned their day continuation schemes. Firth's however, persisted, indeed, attendance was made a condition of employment.[98]

Why, in direct contrast to the bulk of British manufacturers, were Firth's so committed to their continuation school? Part of the explanation may be that the continuation school rapidly became an integral part of Firth's selection procedures: the headmaster's reports on pupils attendance, punctuality, conduct and capabilities were used to assess what occupations they were best suited for, which ones would benefit from a formal apprenticeship and which ones it would be in Firth's interests to dismiss. However, the reasons for the firm's commitment ran deeper than this. Hendrick has argued that the continuation school movement was driven by three key objectives: firstly, to continue the disciplinary function of elementary schools. Secondly, to create adaptable workers "capable of mobility between different branches of trade". And thirdly, to turn working-class adolescents into ideal citizens. Hendrick claims that by the early 1900s, the adolescents role in the labour market was thought to have such serious industrial and social consequences, as to constitute a boy labour problem. Working-class adolescents were believed to be growing up into manhood inefficient for adult work and incapable of performing the elementary duties of citizenship. Continuation schools were therefore viewed as a vehicle for reviving citizenship, "a concept of social organisation which stressed harmony and duty."[99] The congruence of the general aims of the continuation movement, with the specific objectives of Firth's education programme outlined earlier in this chapter, is unmistakable, and this explains why the firm remained so committed to its continuation school. Indeed, the directors regarded

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96 *The Bombshell*, vol.9, no.8, (Aug. 1925), p.284.

97 H. Hendrick, "A Race of Intelligent, Unskilled Labourers: The Adolescent Worker and the Debate on Compulsory Part-Time Day Continuation Schools, 1900-1922", *History of Education*, vol.9, no.2, (1980), p.159-173..

98 *The Bombshell*, vol.5, no.7, (July 1921), p.247.

99 Hendrick, "Day Continuation Schools", pp.161-166.

their school as a key component of the business strategy and as "an honest attempt to deal with the boy labour problem."[100]

All Firth's day continuation students were required to study non-vocational subjects, such as English and the civics, which accounted for one third of the curriculum and they were trained in "the arts of reading, writing and speaking intelligently"[101] A record was kept of each boy's reading age and "backward boys were encouraged to read by choosing them suitable books."[102] In teaching the civics Firth's express aim was to "arouse an intelligent interest in local and national affairs"[103] However, *The Worker*, was suspicious of the directors' motives, it claimed that "Keenly alert to the necessity of training the worker to accept the present social system unquestioningly, they have fully grasped the gist of Carlisle's remark - 'the pappy infant, capable of being kneaded and baked into any social form you choose'."[104]

Whether the directors' goals were as Machiavellian as this is doubtful, but it is notable that Firth's Managing Director considered that the day continuation classes bridged the gulf between school and work, and developed good tone and atmosphere among the boys, effectively tying them to the firm.[105] The Firth's case-study would therefore appear to support Burgess' claim that employers perceived quality in education and training, not so much in technical competencies, but in the contribution it made to securing the commitment and loyalty of young workers to their employers.[106] This was clearly the aim of Doncaster's Continuation School, which lasted only two years and which "sought to give not trade instruction but broad general education", which would "produce good citizens."[107] However, Firth's School was not only designed to produce young workers embedded in the company culture of reciprocal loyalty, but also to inculcate the technical and commercial knowledge, which would support the business strategy. In other words, Firth's does not fit neatly with the received notions of Burgess. Indeed, at Firth's Continuation School vocational subjects absorbed two-thirds of the curriculum: artisans followed courses in maths, applied mechanics and

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[100] *The Bombshell,* vol.9, no.8, (Aug. 1925), p.284.
[101] *Ibid.*, vol.11, no.10, (Oct. 1927), p.377.
[102] CA 419, Sheffield Higher Education Sub-Committee Minute Book, p.108.
[103] *The Bombshell*, vol.11, no.10, (Oct. 1927), p.377.
[104] *The Worker*, no.24, (March 1920), p.3.
[105] *The Bombshell*, vol.14, no.11, (Nov. 1930), p.420; Thus as Toulson and Smith have argued, "organisations go to great lengths to socialise new members into prevailing beliefs", P. Toulson & M. Smith, "The Relationship Between Organisational Climate and Employee Perceptions of Personnel Management Practices", *Public Personnel Management*, vol.23, no.3, (Fall 1994), p.456.
[106] K. Burgess, "British Employers and Education Policy 1935-45: A Decade of Missed Opportunities?", *Business History*, vol.36, no.7, (July 1994), pp.32-33.
[107] *The Hand and Heart Magazine*, vol.1, no.2, (1919), pp.86-89.

machine drawing, whilst commercial students focused upon economic history and commercial arithmetic.[108]

When youths reached sixteen years of age, both Firth's and Edgar Allen's provided those who were selected for an apprenticeship with a practical training that was supervised by an apprentice-master, who "ensured that the boys were trained in every branch of the work so that they became skilled craftsmen."[109] A proportion of the training given to apprentices would have been firm-specific, but the sheer breadth of the training provided by these firms, meant that the degree of general skills would have been rather high. In order to ensure that they reaped the reward for their investment therefore, the firms paid apprentices on a sliding-scale, which meant that they shared the costs of their training and, in addition, they looked to welfare as a tool to buy the young employees' loyalty and ensure that they were not poached by other firms.[110]

Both sets of directors recognised that motor skills alone would not meet their human resource requirements and that their education programmes must also deliver cognitive capabilities; indeed, Firth's Managing Director emphasised that, while "the firm would continue to give apprentices a sound practical training, it was necessary for them to attend evening schools in order to learn how to read a drawing, make their own calculations and know something about the material on which they have to work if they desired to be highly skilled workmen."[111] In order to encourage apprentices to acquire this technical training, both firms maintained their pre-war policy of remitting the fees of all those who made satisfactory attendance at evening classes, and of providing wage increases as a reward for exam. success.[112]

While the 'carrot' was used to encourage employees under twenty-one years of age to attend evening classes, those over twenty-one were subject to the 'stick'. They were continually reminded that "training" was "the order of the day" and that they must keep pace with technical developments in the industry or they would be "shelved before their

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108 *The Bombshell*, vol.3, no.3, (March 1919), pp.163-167; vol.3, no.1, (Jan. 1919), p.15; vol.4, no.10, (Oct. 1920), p.363.

109 *Edgar Allen News*, no.8, (September 1920), p.120; *Edgar Allen Works and Sports Magazine*, no.49, (October 1924), p.17. Ideally one would want details of the numbers trained and the departments they worked in, but such information is simply unavailable. Nevertheless, what is known is that Firth's and Edgar Allen's did not keep apprentices on one machine as some other firms did.

110 Ideally one would want figures on labour turnover, but these are unavailable. What is known is that Firth's and Edgar Allen's were renowned for the long-service of their employees.

111 *The Bombshell*, vol.12, no.10, (Oct. 1928), p.377; *Edgar Allen News*, vol.3, no.26, (Sept-Oct. 1923), p.404.

112 *The Bombshell*, vol.3, no.8, (Aug. 1919), p.292; many firms which had such schemes in place prior to World War One, abandoned them for long periods in the hostile inter-war environment.

proper time."[113] In particular, they were advised to attend the lectures of the Sheffield Trades Technical Societies, which provided information on the most up-to-date technologies. In addition, Firth's also provided its own in-house lectures. Dr. W. H. Hatfield (Director of the Brown Firth Research Laboratories and perhaps the most eminent research metallurgist of his day), for example, provided lectures on subjects such as "the forging and pressing of alloy steel."[114] He also gave lectures to the foremen, on subjects such as work methods and industrial relations, and encouraged junior managers to use outside agencies and attend international conferences, in order to fit themselves for more senior posts.[115] Having considered the content of the education and training programme, I will now examine the outcome of the firms' dedicated investments in their human resources.

The Headmaster of Firth's Day Continuation School constantly referred to the "good tone" and "discipline" of the boys, whom he considered "*appreciated* the opportunities afforded to them by the firm".[116] He particularly praised their good attendance, their punctuality and their general commitment to learning. Similarly, Firth's directors commended the "higher spirit of educational endeavour" and the discipline among the boys which they considered to be a direct product of the school. Indeed, they argued that the Firth's Continuation School had succeeded in creating young workers who were committed to the firm.[117] Clearly, they were satisfied that the school had served one of its most important objectives. But, what about competencies? As table one in Appendix F indicates, the failure rate for first year students was rather high. However, there was a considerable improvement in the second and third years, and Her Majesty's Inspectorate could conclude that "While the attainments and ability of the boys entering the School appear to be in no way above the average, work accomplished by students in their last year indicates a great advance in intelligence, which demonstrates the value of the School..."[118]

The continuation school was clearly the kernel of Firth's graduated system of education, and at least two of the firm's continuation school students succeeded, through evening study, in achieving the Sheffield University associateship in metallurgy. The number of Firth's employees attending such evening classes invariably increased each year, and by

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[113] *Ibid.*, vol.6, no.9, (Sept. 1922), p.366.
[114] *Ibid.*, vol.4, no.2, (Feb. 1920), p.59.
[115] *Ibid.*; The concept of spill-over effects suggests that graduates in an organisation improve the productivity of other employees. By giving lectures Hatfield may have found a formal mechanism for this. For a discussion of spill-over effects, see J. R. Hough, *Education and the National Economy* (Kent, 1987), p.72.
[116] *The Bombshell*, vol.4, no.8, (Aug. 1920), p.304.
[117] *Ibid.*, vol.8, no.9, (Sept. 1924), p.323.
[118] Excerpt from Her Majesty's Inspectors Report on Firth's Day Continuation School, May 1927, in *The Bombshell*, vol.11, no.10, (Oct. 1927), pp.375-378.

1932, there were 288 in attendance, compared with approximately 100 in 1921. Table two in Appendix F suggests that the majority of Firth's evening students passed their examinations, and management reports claim that the results consistently improved. Indeed, fragmentary evidence suggests that Firth's senior youths were qualifying for the various professional associations, such as the London Association of Accountants.[119] Unfortunately, inadequacies in the sources preclude conclusions as to the extent to which this was occurring, but table three in Appendix F shows that between 1918 and 1932, some 23 Sheffield University associates (21 in metallurgy and 2 in engineering) came through the company's education and training scheme, an average of two associates per year.

The number of Edgar Allen's employees attending evening classes was considerably smaller, never exceeding 130 per annum. The Directors complained that, "with so many lads in our works, it is a matter of regret that many of them do not avail themselves of the facilities for evening instruction."[120] Moreover, they emphasised that many of those who began courses left after a few months, and a large proportion failed their examinations. Nevertheless, Edgar Allen's education and training scheme still succeeded in producing 9 associates and 3 bachelors in metallurgy and engineering. The smaller number of Edgar Allen's apprentices attending evening classes, may be attributed to the fact that the scope for promotion at this firm was more circumscribed than at Firth's. Indeed, the directors who took control of Edgar Allen's, following its conversion to limited liability status in 1891, continued to regard the business as a family legacy, and priority was given to the education and training of their sons, who were groomed for managerial and directorial succession.[121] There was therefore, less incentive for employees to follow evening classes and this may have also contributed to the higher student wastage rate. However, this may also have been related to the failure to provide a preparatory day continuation school. In chapter 6 it was argued that in the 1920s the quality of education in the city's elementary schools was in decline, and this had a detrimental impact upon the apprentices' ability to benefit from higher technical and commercial studies. Clearly, in terms of students attending classes and the overall output of qualifications, Firth's education and training programme was the more successful, but I now turn to the key question: did Firth's and Edgar Allen's training programmes support their business strategies? This will be considered under three headings, research, production and sales.

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[119] *Ibid.*, vol.8, no.9, (Sept. 1924), p.337.

[120] *Edgar Allen Works and Sports Magazine*, no.9, (February 1921), p.16.

[121] L. K. Everitt, son of Edgar Allen's director C. K. Everitt, qualified as BMet in 1924. This mirrored the training provided in family firms prior to World War One, see chapter 4 of this thesis.

Research

Martell, and Carrott Junior have argued that, since "the R & D function is crucial to innovation", it warrants "special attention wherever a strategy based upon innovation is pursued."[122] The Brown-Firth Research Laboratories were a central component of Firth's business strategy. They pioneered the nitriding process in Britain and developed an impressive range of stainless-, heat- and acid-resistant alloys. The directors were acutely aware of the importance of research to their business, and their education and training programme was therefore primarily targeted at this function. Of the 23 associates produced between 1918 and 1932, at least 17 acquired positions in the Brown Firth-Research Laboratories. Recruited as laboratory apprentices, they were provided with training in various analytical laboratories, before progressing to the research laboratories proper, learning every aspect of analysis and research .[123] Research was also important to the business strategy at Edgar Allen's and its education and training scheme did not neglect this function, indeed 5 laboratory apprentices, worked their way through the analytical and research Laboratories before graduating as associates in metallurgy [124]

During the inter-war period, as chapter 5 argued, the market for graduate metallurgists was highly competitive, therefore, there was an obvious danger that Firth's and Edgar Allen's research staff may be poached by other firms.[125] It was here that their welfare policies became important, for they created workers that were deeply embedded in the culture of the firm, loyal to its goals and therefore highly reluctant to leave. Moreover, Firth's made a point of promoting researchers who had given the firm long and loyal service, to the Board of Directors. Thus, as Schein argues, promotion is a key mechanism for culture embedding and reinforcement.[126] The promotion of researchers such as Dr. W. H. Hatfield gave a clear cultural message, regarding how highly the management valued product quality, innovation, and employee loyalty. In consequence, Firth's was not only notable for its retention of home grown technical expertise, but also able to attract metallurgists and engineers from elsewhere. Thus, the staff of the Brown-Firth laboratories, as table four in Appendix F shows were augmented by graduates from the Royal College of Mines, The Royal School of

[122] K. D. Martell & S. J. Carrott Jnr., "The role of Human Resource Management in Supporting Innovation Strategies: Recommendations on how R & D Managers should be treated from a Human Resource Management Perspective", *Research and Development Management*, vol.25, no.1, (1995), pp.91-94.

[123]The experience at the firm was crucial for, as chapter 6 argued, the University equipment had fallen behind best-practice techniques. Firth's apprentices had access to better and more up-to-date technology.

[124]*Edgar Allen News*, vol.4, no.44, (January 1926), p.720.

[125] Martell and Carrot Junior have argued that companies pursuing an innovation strategy will "often face a competitive labour market for the technical talent that these types of strategy require" Martell & Carrott Jnr., "Human Resource Management", p.92.

[126]Schein, Organisational Culture, pp.236-237, 242.

Science, and the Oxford, London, Birmingham, Edinburgh and Manchester Universities.[127] The firm's education, training and promotion policies clearly delivered the personnel required to develop new specialist steels tailored to particular end uses; indeed, Firth's established a considerable lead in the field of corrosion-resistant alloys, and for a time, as the ESC recognised, it had a virtual monopoly of the market.[128] A good record of product innovation was also a feature of Edgar Allen's business operations, its research staff enabled the firm to establish a technological superiority in the manufacture of many new products, such as carbide-tipped tools.[129] But what about product quality?

Production

The production of quality steel was central to the business strategy of both firms. Quality steel was reliant upon metallurgically-controlled melting and processing, and Firth's directors recognised that it was the focused efforts of their scientific staff and highly skilled workmen, which ensured the correct manufacture of their steels, and that their ET programme delivered the extra quality which characterised their products. Many of the workers possessed a high level of metallurgical knowledge, and a number of graduates occupied positions, not only in middle, but also in top management. Indeed, as table five in Appendix F shows, Firth's adopted the policy of promoting graduates who had proved themselves in the position of works manager, to the Board of Directors. The promotion of production specialists, such as Edward Dixon, who had over 25 years in the service of the firm, emphasised how highly the company valued product quality and employee loyalty, and together with the other welfare measures discussed earlier in this chapter, it ensured that the firm retained a staff which possessed the highest skill and metallurgical knowledge, and which was therefore, able to manufacture "a final product...capable of super-service."[130] Firth's name was in fact synonymous with quality. Robert Hadfield for example, attributed the firm's trade with Rolls Royce to Firth's "high quality of product",[131] and a report, written by technical representatives of the English Steel Corporation, concluded that "the lighter and special quality section of manufacture was one which Firth's had developed to a very high degree of perfection."[132] Edgar Allen's training programme was also geared towards

[127]Brown-Firth Research Laboratories, p.6.
[128]SCA, records of Firth-Brown Ltd, Firth-Brown Box 177, William & Anderson (ESC Technical Representatives) Report on Firth-Brown Ltd., 16th March 1931.
[129]*Edgar Allen News*, vol. 17, no.195, (August 1938), p.221; *Edgar Allen News* New Series, no.50, (June 1957), pp.160-61.
[130] *Firth-Brown Small Tool Products*, (1935), pp.8-15.
[131] SLSL Report of Chairman's Speech at the Annual General Meeting of Hadfield's Ltd, 17th March 1930, p.28.
[132] SCA, records of Firth Brown Ltd., Firth Brown Box no.177, Williamson & Anderson (ESC'S Technical Representatives) Report on The Possibilities of Co-ordination between the ESC and Thomas Firth and John Brown Ltd., dated the 16th March 1931, p.9.

the careful supervision of the production process, in particular, the university and works training of directors sons, such as L. K. Everitt (Bmet), enabled them to supervise every operation in the departments which they managed, and encouraged process innovation. Thus, it was Everitt who pioneered the use of the high-frequency induction process in the manufacture of the highest quality tool steels. Indeed, Edgar Allen's had a long tradition of process innovation.[133] But what of sales?

Sales

Edgar Allen's were clearly more committed to the sales function than Firth's. In what follows, it will be argued that Firth's neglected the training of its salesmen and this undermined the efficient functioning of its business strategy. An examination of the occupations of employees who won Firth's top education prizes is instructive. Out of 415 prizes awarded between 1919 and 1929, only 7 were won by salesmen.[134] This figure was dwarfed by awards in production, analysis and research, and it is suggestive of an imbalance in the firm's education and training programme. For much of my period, the training of Firth's salesmen was based upon practical experience at the works, followed by a stint as a junior sales representative under the supervision of an area sales manager, and, in a very small minority of cases, commercial instruction at evening school. The fundamental problem with this training programme was that salesmen failed to acquire a scientific understanding of their industry and to keep abreast of the product and process innovations, for which Firth's was renowned. Given the strategy of producing a wide range of steels tailored to particular uses, the deficiencies in the salesmen training were a major problem. How could salesmen assess if the firm could meet a technical specification, and make an informed recommendation to customers, if they lacked knowledge and scientific understanding of the company's products? The inadequacies in their training meant that Firth's representatives were heavily reliant upon communication with the appropriate technical expert in Sheffield, but they found it extremely difficult to contact the individual they required. [135] By 1930, the directors were beginning to recognise that this was producing considerable delays in answering queries, submitting quotations and executing deliveries, and that in a buyers' market, it ultimately resulted in a loss of business.[136] They also recognised that, in a context of severe competition and depression, the transaction costs were one which the company could ill-afford to bear,

[133]Edgar Allen's was the first company in Britain to use the tropenas and electric arc furnaces and the first in the world to use the high-frequency induction process.
[134]See *The Bombshell* (1918-1930)
[135] SCA, records of Firth-Brown Ltd., , Firth Brown Box 97, memo to switch-board attendant, 16th Nov. 1928.
[136] *The Bombshell*, vol.13, no.2, (Feb. 1929), p.50; *Firth-Vickers Newsletter*, (Nov. 1934), p.100; SCA, records of Firth-Browns Ltd, Firth Brown Box 97, Thomas Firth and John Brown Ltd., Meeting held at the Atlas Works, 28th April 1939; Board Meeting, Nov. 23rd 1928.

the directors therefore urged the area sales managers to inform the salesmen that: "unless there was an urgent need for immediate communication matters should be dealt with by letter rather than by telephone."[137] Of course, dealing with matters by letter could only exacerbate the problem of late deliveries, for which, Firth's was getting "a very bad reputation."[138] The directors were therefore forced to acknowledge that the education and training of salesmen had failed to support the business strategy, and they came to the conclusion that if business performance was to improve, there was "a vital necessity for salesmen to acquire a thorough and up-to-date knowledge of the goods which they had to sell."[139]

Chapter 5 argued that many Sheffield firms experienced similar problems with their salesmen, but one firm to whom these problems clearly did not apply was Edgar Allen's. Edgar Allen's Directors emphasised that their representatives were able to give "direct practical help and advice in connection with the application of the company's products to the many purposes for which they may be useful."[140] Indeed, they informed customers that "if you are uncertain what quality of steel is the best for a particular part or purpose, an Edgar Allen's salesmen will readily give you this information. He will describe the best way of grinding a particular material and the machine most suitable for the work... (moreover)...when necessary, he can take off his coat and actually with his own hands properly demonstrate how to harden a tool, run a test, or operate a tube or bar mill."[141] They considered that their salesmen provided the firm with a significant competitive advantage, as "The time and correspondence saved by consulting them, instead of having to refer the matter to the imperial steel works (was) by no means unappreciable and business (was) in consequence facilitated."[142]

Why were Edgar Allen's salesmen so superior? In order to answer this question one must examine Edgar Allen's recruitment and training practices. All of Edgar Allen's general salesmen were works trained, as at Firth's, but, as the profiles in table six of Appendix F show, many of them were also university-educated engineers and metallurgists, and they were kept in constant touch with product and process developments by periodical sales meetings.[143] Moreover, in addition to its general salesmen, as table seven in Appendix F indicates, Edgar Allen's also recruited, or trained, technical representatives to push particular specialities such as quarry plant.[144]

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[137] SCA, records of Firth Brown Ltd., Firth Brown Box 114, Board Minutes 13th January 1932.
[138] SCA, records of Firth-Brown Ltd., Firth Brown Box 97, Board Report 19th Sept. 1928.
[139] *The Bombshell*, vol.15, no.12, (Dec. 1931), p.464.
[140] *Edgar Allen News*, no.12, (May-June 1921), p.181.
[141] *Edgar Allen News*, vol.8, no.91, (Dec. 1929), pp.509-510.
[142] *Edgar Allen News*, vol.1, no.7, (July 1920), p.31.
[143] *Edgar Allen News*, vol.8, no.91, (Dec. 1929), p.509.
[144] *Edgar Allen News*, vol. 10, no.118, (March 1932), p.49; vol. 12, no.144, (May 1934), p.439.

In the early 1930's, perhaps not unsurprisingly, Firth's introduced a near replica of the Edgar Allen training scheme. Those trainees who were to become general salesmen, were provided with a broad practical training within the firm and were enrolled on technical courses which were especially designed for salesmen. Meanwhile, those trainees who were required to push particular specialities, were given a detailed, but narrow, training in one specific department. Nevertheless, despite the introduction of this new training programme, the desired results failed to materialise, and, in 1935, a memo warned sales representatives that "it is not advisable for you to specify any steel in place of a competitors without reference to Sheffield"[145] Indeed, as late as 1944, the directors were still complaining that "a knowledge of technical developments was a lack too common among sales staff...."[146]

Why did the firm's new education and training programme for salesmen fail to deliver the anticipated outcome? Earlier in this chapter it was argued that the directors were successful in promoting their ideology and fostering a company culture, based upon reciprocal loyalty and obligation, by using a range of culture embedding and reinforcing mechanisms, such as rituals, welfare provision and particularly promotion. However, as L. A. Krefting and P. J. Frost have argued, "because some of the consequences of managing culture are often unanticipated, the process of working with organisational culture involves risk."[147] In what follows, it will be argued that the focus upon the education and training of production and research staff during the 1920's, and the promotion of such staff to the Board of Directors, spawned a sub-culture in the area sales offices, which undermined the new training programme.

No marketing or sales specialists were promoted to the Board and they had little contact with the management. This created ideal conditions for the development of an identifiable sub-culture, for, as Maanen and Barley point out, an organisation's members who meet regularly together, but who have little contact with other members in the organisation, may easily come to identify themselves as a distinct group and develop their own ideas and values. [148] In particular, the area sales officers valued the all-round man, the personality of the salesmen and the art of selling, rather than

[145] *Firth-Vickers Newsletter*, (Sept. 1935), p.246.
[146] SCA, records of Firth-Brown Ltd., Firth Brown Box 104, memo on training 11th November 1944.
[147] L. A. Krefting & P. J. Frost, "Untangling Webs, Surfing Waves and Wildcatting: A Multiple-Metaphor Perspective on Managing Organisational Culture", in P. J. Frost et al (eds.), *Organisational Culture* (London, 1985), p.156.
[148] J. Maanen & S. R. Barley, "Cultural Organisation: Fragments of a Theory", in Frost et al (eds.), Organisational Culture, p.40; Brown and Starkey remind us that "while some values may be pervasive within an organisation others are likely to be held only by certain groups which thus constitute identifiable sub-cultures", A. D. Brown & K. D. Starkey, "The Effect of Organisational Culture on Communication and Information", *Journal of Management Studies*, vol.31, no.6, (Nov. 1944), p.808.

technical expertise. Therefore, when the directors attempted to integrate technical talent into the sales offices, they met with resistance from the area sales managers, who, regarded this as an attack upon their autonomy and their values, and feared for their jobs. For example, Mr. Hutchinson, the Area Manager for Lancashire, informed the Board of Directors that instead of focusing on technical talent "great attention should be devoted to selecting the right man who could develop selling as a career" and that there was "just as much technique in the art of selling as there is in the art of steel-making."[149] Similarly, Mr. Wostenholme, Area Manager for the North Midlands, informed the Board that, in any increase in his sales staff he would prefer "to have an all-round man capable of dealing with the whole of the products of the company."[150] Clearly, the attempt to colonise the area sales officers with technical talent, invested the cultural rhetoric of the organisation with considerable tension. Indeed, Maanen and Barley have emphasised that such colonisation often strengthens the notion of a separate identity amongst the colonised, as it gives them something to react against, and it appears that this was a key factor in the failure of the new training programme.[151] That is, established sales staff were disinclined to acquire technical knowledge, and new technically-educated salesmen were forced to work under the leadership of men whose core-values were antithetical to those of the directors. Therefore, while in its founding years Firth's was characterised by a relatively stable and homogenous culture, during the inter-war years, as the company grew in size and became more functionally oriented, this homogeneity began to break down. Indeed, the company can be analysed in terms of the metaphor of culture as 'non-order', which claims that modern organisations are characterised by ambiguity, uncertainty, contradiction and tension.[152]

The most damaging effects of this tension occurred in Firth's American subsidiary, the Firth-Sterling Steel Company. From 1922 onwards, there was a pitched battle between Lewis J. Firth (The Chairman) and his son, Gerald Firth (The Works Manager), as to who should control this company. The Sheffield directors visited the American subsidiary to investigate the source of these disputes on several occasions during the 1920s, but they only resolved the issue in 1934, when they decided in favour of Gerald Firth. In that year, they informed Lewis Firth that "We realise all that you have done

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149 SCA, records of Firth-Brown Ltd, Firth-Brown Box 97, Thomas Firth and John Brown Ltd., meeting 28th April 1939.
150 *Ibid.*
151 Maanen & Barley, "Cultural Organisation", p.41.
152 For a discussion of the metaphor of culture as 'non-order' see chapter 1 of this thesis and Alvesson, Cultural Perspectives, pp.21-22; many authors have stressed ambiguity , contradiction and tension in large functionally oriented organisations, Maanen & Barley, Meryl Louis, Martin, Sim, Bithin and Boehm, and Siehl, all in Frost et al (eds.), *Organisational Culture.*

for the firm for so many years, but the time must come when the work is handed over to younger men"[153]

From this quote, the business historian could easily mistake the problems in America, as simply, another example of a family member holding on to power for too long, but, the battle between father and son, was more a microcosm of the competing cultures in the parent company. Lewis J. Firth was a sales specialist, but, Gerald Firth, who had visited the Brown-Firth research laboratories during World War One, was a research and production specialist, who possessed a high degree of technical expertise. Lewis Firth recognised that the Sheffield directors "valued very highly Gerald Firth's knowledge and experience of manufacturing and technical steel questions." But, he emphasised that in his opinion, his "knowledge and experience of sales, commercial and financial matters was narrow and limited". Indeed, he considered him "no match for the management of other companies in connection with this latter class of business."[154] This, however, held no sway with the directors, who concurred with Gerald Firth's view that research had been seriously neglected in the United States. It was therefore, to give greater prominence to research and to end the disputes, which together with the effects of the 'Great Depression', were undermining the performance of the subsidiary (see table eight in Appendix F), that they decided to remove Lewis J. Firth from office. As Schein has argued therefore, "who gets promoted, and who gets retired or 'ex-communicated', are powerful mechanisms for culture embedding and reinforcement."[155] The decision to promote Gerald Firth was intended to reinforce the importance of product innovation and product quality, but, by retiring Lewis Firth, it also served to heighten the fears and suspicions of the salesmen who felt increasingly marginalised and under threat, for, here was a man, a family member even, who had given a long and loyal service, but whose skills were clearly no longer valued highly by the directorate. However, I now turn to focus upon the relationship between education training and business performance.

IV

Business Performance: A conclusion

What is patently clear, is that the education and training schemes, devised by Firth's and Edgar Allen's, supported the company culture and delivered the human resource requirements of the research and production functions. Indeed, both firms were noted for their product and process innovations and for the good relations between management and employees. On both these non-financial indicators, their performance

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[153] SCA, records of Firth-Brown Ltd., Firth-Brown Box 160 (A), Letter from Lord Aberconway to Lewis J. Firth, 6th July 1934.

[154] SCA, records of Firth-Brown Ltd, Firth-Brown Box 160 (A), Letter from Lewis J. Firth to H. McLaren, 14th June 1933; Letter from Lewis J. Firth to D. McCloskey, dated 14th June 1933.

[155]Schein, *Organisational Culture*, p.242.

was unusually good. However, as Gospel has argued, labour unrest and labour turnover during the inter-war period amongst those in work was low, for, in a context of high unemployment, they were wary of causing trouble or leaving a secure job.[156] This raises questions therefore, over whether Firth's and Edgar Allen's investment in welfare, at least for skilled workers, was worthwhile. Of course, since the graduate labour market was tight, investment in welfare for this group of workers was important in retaining staff and supporting product and process innovation. Nevertheless, a good record of product and process innovation did not translate into superior financial performance. Indeed, Firth's financial performance closely mirrored that of other Sheffield firms (see tables nine and ten in Appendix F). Good profits were made between 1918 and 1921, from 1922 to 1924 profits declined and some firms made small losses, before a short lived recovery in 1925. Profits declined sharply once more in 1926, due to the General Strike and particularly the Coal Strike, which left Sheffield firms short of vital raw materials, before recovering up until the Wall Street Crash of 1929. Almost every Sheffield firm, Firth's included, appears to have made a net loss in the years between 1930 and 1933, but from 1933 onwards, business performance improved, gaining significant momentum from 1936, and, aside from a cyclical downturn in 1938, net profits (before allowance for war taxes), continued to increase to the end of our period.[157]

Clearly, Firth's dedicated investment in human resources had not brought the financial rewards that management anticipated. However, one could possibly argue that this was due to failings in the education and training of its salesmen. Indeed, the directors considered that this had undermined their performance, nevertheless, Edgar Allen's profit and loss data indicates that such arguments have limited explanatory power. This firm had an excellent education and training scheme for its salesmen, but its financial performance conformed to the general pattern identified above. What this suggests, is that factors other than education and training were far more important in determining business performance. These factors were largely exogenous to the firm and were related to Britain's macro-economic policy. Unilateral free trade in the 1920s, deflationary policies designed to facilitate the return to the gold standard and the overvaluation of the pound, which placed exports at a cost disadvantage, combined with the spread of protectionism in foreign markets and import substitution in the empire were the key factors which constrained Sheffield's business performance in the 1920s.[158] Equally, the introduction of protectionism for the British steel industry, the abandonment of the gold standard, devaluation and the introduction of a policy of

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[156]Gospel, *Management of Labour*, pp.63-65.
[157]This conforms to the general pattern identified by Pollard, S. Pollard, *Three Centuries of Sheffield Steel: Marsh Brothers, The Story of a Family Business* (Sheffield, 1954), p.57.
[158]S. Pollard, *The Development of the British Economy, 1914-1990*, (London, 1992), p.52.

cheap money, together with re-armament, closer imperial ties, and cyclical forces of recovery, were the key factors underpinning improved business performance in the 1930s.[159] Although many firms, which neglected to invest in education and training during the 1920s, suffered human resource constraints on production in the 1930s, this did not prevent them from enjoying good profits. Indeed, during the late 1930s, Sheffield's output of steel reached a record level and most firms experienced a revival in their business fortunes, despite their under-investment in education and training.[160] Thus, protectionism and devaluation, helped both the dynamic firms, which rationalised production and invested in education and training, and slothful firms, which did little of either. I may, at this stage, however, ask a more fundamental question: was the strategy of producing high-quality specialist goods appropriate for the city? If the Vickers organisation, with the huge manufacturing resources available to it and its experience of mass production, could not develop economies of sufficient scale and scope to meet foreign competition in the cheaper steels, without the benefit of protection, what hope was there for the more typical Sheffield firms? I would argue very little, indeed, Firth-Brown emphasised that the ESC had not given consideration to the fact that there were other bigger plants engaged in producing this cheaper material and at a much better price than the ESC could ever hope to attain. It appears therefore, that the development of specialist alloys produced by the high-frequency induction process was the most appropriate strategy for Sheffield firms, and most firms moved in this direction, though some at a slower pace than others. Indeed, it is significant that the directors of the ESC frequently attributed their improved performance to the formation of Firth-Vickers Stainless Steels.[161] Thus, it appears that, as *The Metallurgist* argued, given its product and factor markets, Britain "should seek to produce steel better than the best, rather than cheaper than the cheapest."[162] Indeed, moving down-market would have required a transformation in the culture of the district. Such a transformation would have been extremely difficult, if not impossible. Indeed, as we have seen, Vickers found that an old culture based upon product quality frustrated its strategy of going down-market, and this lends support to Scholz claim that, if a culture is a strong one, rather than change it, it is best, at least, over the short-run, to stick with strategies which fit the culture.[163] Of course, manufacturing specialist alloys brought with it advantages and disadvantages.

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[159]Businessmen clearly felt that changes in macro-economic policy had contributed to improved business performance, see FBI Survey of British Commercial Policy, 1934, in *Quality,* vol.6, no.11, (August 1935), p.409; Speech by A. J. Grant (M.D. of Firth-Brown), in *Quality*, vol.8, no.7, (April 1937), pp.264-65; Pollard, *The British Economy*, p.53; K. Warren, "Iron and Steel", in N. K. Buxton & D. H. Aldcroft (eds.), *British Industry Between the Wars* (London, 1979), p.116; M. Kitson & S. Solomou, *Protectionism and Economic Revival, The British Inter-War Economy* (Cambridge, 1990), p.6.

[160]*Quality*, vol.8, no.3, (Dec. 1936), p.98; vol.8, no.4, (Jan. 1937), p.137; *The British Steel Maker*, vol.1, (June 1935), p.32.

[161]*Vickers News*, vol.13, no.155, (May 1937), p.444.

[162]*The Metallurgist*, vol.7, (May 1931), p.65.

[163]C. Scholz, "Corporate Culture and Strategy: The Problem of strategic Fit", *Long range Planning*, vol.20, no.4, (1987), p.86.

On the credit side, as table eleven in Appendix F indicates they had numerous uses, feeding a number of domestic growth industries, such as chemicals and motor vehicles, and they provided a strategic weapon in the fight against import substitution, as the colonies lacked the necessary skills and knowledge to produce these goods. In South Africa, for example, where Firth's had traditionally done a good trade in forgings and castings, import substitution in these products was counteracted by exports of staybrite steel. Indeed, staybrite became a key feature of the company's export accounts. In addition, by holding a broad product range, manufacturers such as Edgar Allen's, always had something that was selling well. However, on the debit side, holding stocks of various steels incurred high overheads and a willingness to manufacture specially to customer requirements, impaired overall efficiency. Thus, good performance in one dimension, may run counter to good performance in another.[164] In addition, it should be added that there were simply too many firms developing specialist steels, so that research became subject to diminishing returns. Indeed, Hadfield's complained that they spent time and money developing new steels, only to find them quickly copied by other firms, who drove prices downwards.[165] Quite simply therefore, the inter-war steel industry needed more rationalisation, but this was never likely given the tenacity of family control. On one level therefore, we may claim that education and training was 'small potatoes', but it is noticeable that Firth's, who did invest in education and training, was a leader in product innovation, and the general slowing of innovation may well have been causally related to the inadequate supply of scientific personnel. Moreover, of more fundamental significance for Sheffield over the long-run, was the shortage of skilled labour. In his recent study of *Steel City*, Tweedale identified skilled labour as a major source of Sheffield's early competitive advantage, and it is significant that the inter-war years marked the beginning of the unravelling of this advantage. Throughout the period 1930-1960, shortages of skilled labour prevented Sheffield firms from meeting delivery deadlines, and after World War Two, there were even suggestions that shortages of skilled labour were beginning to undermine product quality.[166] Thus, over the longer run, it may be argued that the district paid a heavy price for its under-investment in human resources in the 1920's. Indeed, during the 'Long Boom', the failure to meet delivery deadlines and weakening product quality allowed a window of opportunity for competitors to exploit and this perhaps explains the central paradox of the 1950s, that is, why British growth rates were good, but not as good as those of her key competitors. Significantly, two firms which do not appear to have suffered from such human resource constraints, and who remained renowned for

[164]"...variety of manufactures...great advantage...tends to minimise the effect of local or sectional depressions in trade", *Edgar Allen News*, vol. 18, no.207, (August 1939), p.423; vol.17, no.195, (August 1938), p.221.
[165]*Hadfield Bulletin*, no.5, (1939), p.6.
[166]See the last two chapters of Tweedale, *Steel City*

product quality and product innovation, were Firth-Brown's and Edgar Allen's, and it may be that their investment in education and training paid dividends over the long run.[167]

[167]Content analysis of the business records of Firth-Brown, 1950-1970 reveals no mention of labour constraints on production, nor does the Edgar Allen News.

According to the theory of business strategy, changes in human and physical resources are causally-related. In other words, product and process innovations will demand complementary changes in the human resources which comprise the firm.[1] This chapter therefore, explores how cutlery manufacturers used education and training to manage the skills and knowledge of their human resources in line with the needs of the workplace, during a period of unprecedented technical change. The chapter is divided in to four parts. Part one, focuses upon the technical and organisational innovations introduced during World War One, the establishment of the Cutlery Research Association and new training initiatives such as the pre-apprenticeship programme, developed by the Technical School of Art. Part two then focuses upon Sheffield's response to the collapse of the brief post-war boom. This collapse and ensuing depression hastened the contraction of the luxury cutlery market in which the city had traditionally specialised, and placed a premium upon the development of cheaper products. It will be argued that cutlery manufacturers were not unaware of the need for increased mechanisation, which would facilitate the development of less expensive product lines, but process innovation continued to be constrained by the structural and cultural factors which were first identified in chapter 2. Nevertheless, by 1940, the degree of mechanisation within the industry was far greater than in 1914 and part three therefore examines the extent to which new technology was supported by changes in human resources. In particular, it focuses upon the re-training or re-skilling of adult workmen through the cutlery trades technical lectures, which were provided by the University of Sheffield. The issue of re-skilling has received little attention in the literature, part three of this chapter therefore explores an important but somewhat neglected aspect of human capital formation. Finally, part four considers the question of business performance and its relationship to education and training. Here it is argued that, despite investing in more machinery and developing a more technically-educated workforce, Sheffield cutlery firms failed to enjoy good business performance. Indeed, in several years prior to 1935, industry leaders such as Wostenholm's and Rodgers incurred significant losses.

I

War and Change

According to Geoffrey Tweedale, "the First World War presented Sheffield's cutlery manufacturers with unprecedented opportunities to meet the challenge of overseas competition." Firstly, the war "made...industrialists more aware of the advantages of co-operation in the task of reforming the industry", secondly, "it forced them to provide

[1] Scot Moss, *An Economic Theory of Business Strategy* (Oxford, 1981), pp.16-18.

many of the products such as razors (and) scissors...that had previously come from abroad", and thirdly "...it kept German cutlery producers out of international markets for almost half a decade."[2] Nevertheless, Tweedale claims that to a large extent, Sheffield manufacturers failed to exploit these opportunities because "although German competition had vanished overnight...its spectre continued to haunt the... industry, and...while money could be earned on war contracts by muddling along with the old ways, calls for reform fell on deaf ears."[3] In particular, he argues that the industry's tradition of individualism and the pressures of war prevented large-scale reorganisation.[4] Here, it will be argued that although more could have been done, more was achieved than Tweedale allows.

Cutlery manufacturers soon discovered that traditional methods of production were not adequate to meet the sheer volume of the military demand for their products. In other words, the pressure of war precluded the possibility of simply muddling along with the old ways, and placed a premium upon technical and organisational change. For example, as chapter 2 argued, Sheffield had a huge reputation for the high quality of its specialist pocket-knives, which were hand-made by men who were "masters of their craft", but the military need was for large quantities of standard knives.[5] Although the city's craftsmen could make these knives "right enough", they made them "in their own time and by methods that were wasteful and out-of-date."[6] In consequence, Sheffield's output was dwarfed by that of the enemy, and military demands quickly outstripped the ability to supply, with traditional technology and works practices. The manufacturers were therefore forced to introduce jigs and repetition machinery, enabling all parts of a knife to be duplicated with accuracy in as great a quantity as required.[7] Large firms such as Wostenholm's developed new departments which incorporated power shears, power flies, drop hammers, boring, grinding and riveting machines, all of which were organised in a logical time-saving lay-out.[8] Such developments were unprecedented in the history of the cutlery industry, and they ensured that military demands for large quantities of standard knives were satisfied.[9]

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[2] G. Tweedale, *Steel City, Entrepreneurship, Strategy and Technology, 1743-1993* (Oxford, 1995), p.268; Owen also stressed the opportunity that war offered for modernisation, A. D. K. Owen, *A Report on Unemployment in Sheffield* (Sheffield, 1932), p.26.
[3] Tweedale, *Steel city*, p.269.
[4] *Ibid.*, p.269.
[5] *The Engineer*, vol.125 (March 22nd 1918), p.261.
[6] *Ibid.*, p.261.
[7] *Ibid.*, p.261.
[8] SCA records of Wostenholm's, Wos R7, Papers relating to machinery for new Pocket-Knife Department, 1918.
[9] How widely diffused such mechanisation was, we simply do not know.

The war also forced the industry to establish links with Sheffield University, which appointed an engineer to investigate how machinery may be applied to the production of cutlery. This engineer collaborated with local manufacturers, developing new razor and scissors grinding machines. Out of these modest beginnings grew the British Cutlery Research Association, which aimed to hasten the rate of technical change within the industry and develop new methods which would enable Sheffield to compete with the world's foremost cutlery producers.[10] Significantly, manufacturers recognised that, although the degree of mechanisation prior to World War One had been limited, changes in physical resources had nevertheless out-paced changes in human resources, and the efficient functioning of the new technology required improvements in the technical attributes of the workforce. Indeed, it was claimed that machinery had been damaged by workmen who lacked the technical knowledge required to operate them effectively.[11] The university therefore provided a forum in which manufacturers workers, and scientists could meet in order to discuss technical change, and it also provided technical lectures which were specifically designed for the re-training of old craftsmen. Moreover, whilst the university catered for the needs of adults, the Technical School of Art developed a pre-apprenticeship programme, which intended to supply the industry with more technically-educated recruits who, as chapter 5 argued, would be better suited to mechanised production. These research and training initiatives will be considered in detail later in this chapter but, for now, it is important to recognise that whilst in Tweedale's formulation the war constrained technical developments within the industry, in mine it had a catalytic effect hastening much needed change in plant, equipment and industrial training. Of course, the extent of these changes can be exaggerated, but, as *The Engineer* pointed out, by adopting machine-methods, Sheffield cutlery firms had succeeded, during the war, in "turning out articles by the million, where previously they were produced only in 1000's."[12] Production and productivity were improved through the use of new technology, such as spot-welding machines.[13] Moreover, the introduction of machinery was supported by changes in human resources and works organisation. In 1915, for example, Needham, Veal and Tyzack appointed an American systematist to the position of Works Manager, his remit being to develop 'economies in manufacture' through the intensification of working hours; the development of bonus schemes and the introduction and scientific organisation of the latest American machinery.[14] Similarly, Wostenholm's appointed

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[10]SUA VIII/1/3, Sheffield University Department of Applied Science Minute Book, no.3, p.108; SUA 5/1/2 (ii), Chapman Collection, papers relating to the history of Sheffield Technical school, vol.2, pp.206-07.
[11]SUA 5/1/2 (ii), pp.207, 211.
[12]*The Engineer*, vol.125, (May 17th 1918), p.429.
[13]SCA, records of Wostenholm's, Wos R7, papers relating to machinery for new Pocket-Knife Department, 1918.
[14]SCA, records of Needham, Veal and Tyzack, NVT 12, H. Senior (USA Agent) to NVT, 15th Jan. 1915; 10th Feb. 1916.

James Neil, an American consulting engineer, to redesign the plant and install and maintain new machines.[15] In addition, although Tweedale is correct to point out that these two firms quickly abandoned their plans to merge once the war was over, they did, nevertheless, enter into a joint purchasing agreement for Firth's stainless-steel. This agreement demonstrates an increased willingness to co-operate, and allowed the firms to obtain an essential raw material at an unusually low price.[16] However, the industry generally retained a highly atomistic business structure and the degree of co-operation was clearly circumscribed.. Moreover, despite the introduction of new technology during the war, Sheffield continued to lag behind best-practice techniques. Indeed, those Sheffield manufacturers who visited Solingen in 1918 found that machinery was used to a greater extent, the processes of manufacture were more sub-divided, and the German industry was generally better organised. They concluded, therefore, that "a greater application of machinery in Sheffield would help considerably in meeting German competition both in respect of prices and output."[17] Nevertheless, the immediate post-war years witnessed many firms moving in the opposite direction. As chapter 2 argued, product quality was a 'sacred cow' of the business culture. In other words, product quality and the skilled workmen who made product quality possible were what particularly mattered and, in consequence, skilled men returning from the armed forces quickly displaced semi-skilled female labour, reinstating old works practices which held back increases in productivity and high volume output.[18] A valuable opportunity for further modernisation was, therefore, lost. However, in what follows, it will be argued that the collapse of the brief and somewhat speculative post-war boom in 1921 led to a reappraisal of Sheffield's traditional strategy and to further changes in both the industry's human and physical resources.

II

The post-war boom collapsed in 1921, and, as depression set in and protectionism spread, the demand for the quality cutlery in which Sheffield had traditionally excelled sharply declined.[19] Firms such as Wostenholm's may have deplored the state of affairs where "price appears to be the only thing buyers look at,"[20] but, as their American agents informed them: "...whilst your fine knives are all that could be desired...and will always command their price...the bulk of the cutlery trade in this country is done in the

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[15] Wos R7, G. Quirk (US Agent) to Wostenholm's, 4th Dec. 1918.
[16] M. J. Lewis, "The Growth and Development of Sheffield's Industrial Structure, 1880-1930" (Unpublished PhD, Sheffield City Polytechnic, 1989), p.224.
[17] H. Willey, *Sheffield Cutlery Manufacturers Association, Report of the Sheffield Cutlery Mission to Solingen*, pp.2-6, in SCA records of Needham Veal and Tyzack, NVT 22
[18] For a discussion of culture as "sacred cow", see chapter one of this thesis and M. Alvesson, *Cultural Perspectives on Organisations* (Cambridge, 1993), p.20.
[19] S. Pollard, *A History of Labour in Sheffield* (Liverpool, 1959), pp.289-90.
[20] Cited in Tweedale, *Steel City*, p.273.

more moderately priced goods."[21] Unfortunately, this was a pattern that was replicated throughout the world; indeed, the Sheffield Chamber of Commerce emphasised that, due to financial stringency and protectionism, the global demand for cutlery was mainly for the cheaper qualities.[22] However, the growing demand for cheap products was not simply a consequence of the depression or the spread of tariff barriers; rather, depression and protectionism simply hastened trends already apparent before World War One. Indeed, as Williamson points out, by the end of the late nineteenth century it was already evident that the aspects of American development which had created a demand for Sheffield's high-quality products were coming to a close. California's gold had been exhausted, the buffalo herds decimated, and the Indians relegated to their reservations.[23] Throughout the world, societies were becoming more urban, and as Tweedale has argued "more focused and cost-conscious" in their demands for cutlery and, as a result, many of the cutlery items such as pocket-knives, Bowie knives and cut-throat razors, in which Sheffield had traditionally specialised, were "becoming obsolescent or were no longer needed in such large quantities."[24]

Another factor which also acted to undermine the demand for Sheffield's high-quality crucible and shear steel cutlery, was the development of stainless-steels. As Walton has pointed out, stainless alloys damaged Sheffield's traditional industry in at least three ways: firstly, by considerably lengthening the life of the average knife, it made it much easier to disguise shoddy workmanship. In a context of depression, this made the customer even more inclined to purchase the cheaper foreign knife.[25] Secondly, because of its unique physical and chemical properties, which were discussed in chapter 5, stainless-steel did not lend itself to Sheffield's traditional handicraft methods. And thirdly, by increasing the length of the life of a knife, stainless-steel also "robbed the cutler of uncounted orders for renewals."[26] Sheffield's luxury market was therefore being squeezed by a whole array of demand- and supply-side factors, and this raised important questions concerning the future development of the industry. War-time experience had suggested a more mechanised route, but, as we have seen, the

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[21] SCA, records of Wostenholm's, Wos R8, statement by Mr. Bunting (American Agent), May 6th 1919.
[22] *Quality*, vol.1, no.7, (April 1930), p.10; (October 1930), p.22; vol.3, no.6, (March 1932), p.1.
[23] William R. Williams, *I*XL Means I Excel*, no publication details. Stored at SLSL, p.5.
[24] As early as 1903, as Callis argued, Sheffield's "most expensive and elaborately worked scissors" had fell from favour, the demand was for "a useful, rather than an ornamental article, at a moderate price.", F. Callis, "The Cutlery Trades in Sheffield" (1903), in M. Berg, *Technology and Toil in Nineteenth Century Britain* (London, 1979); G. Tweedale, *Steel City*, p.273; See also S. Taylor, "Tradition and Change: The Sheffield Cutlery Trades 1870-1914" (Unpublished PhD, Sheffield University, 1988), p.320.
[25] M. Walton, *Sheffield: Its Story and its Achievements* (Sheffield, 1968), p.245.
[26] *Ibid.*, p.245; Wostenholm's emphasised that the development of stainless-steel made it difficult for customers to distinguish between what Wostenholm's considered to be a good knife and a bad one. Of course, from the consumers point of view, a stainless-knife which lasts a life-time can hardly be considered bad, see H. Bexfield, *A Short History of Sheffield Cutlery and the House of Wostenholm* (Sheffield, 1945), p.39.

immediate post-war years witnessed a reaction to this with a reinstatement of traditional practices and traditional strategies. Nevertheless, manufacturers simply could not ignore the logic of the situation, which demanded increased mechanisation and forays into cheaper mass markets through the development of stainless-cutlery. In consequence, the inter-war years were characterised by progress in this direction. However, there remained important constraints upon technological innovation which I will now explore.

Chapter 2 argued that prior to World War One, the small-scale structure of the industry placed severe constraints upon mechanisation. Here it will be argued that the structure of the industry continued to constrain the pace of technical change throughout the inter-war years and, in particular, it contributed to the early demise of the Cutlery Research Association (CRA) in 1932. This association, which was formed in 1918, had its headquarters in the Department of Applied Science at Sheffield University. It was financed by an annual contribution of £1,500 from the city's cutlery firms and by a corresponding grant from the government-sponsored Department of Scientific and Industrial Research (DSIR).[27] The first director of the association was drawn from the ranks of the university staff, but from 1922 until 1928, the CRA came under the directorship of a Peterborough-based machine-tool manufacturer. He focused his attention upon the development of "radical changes in the methods of manufacturing cutlery" and, in particular, his interests lay " in the development of machines."[28] Significantly, a report written in 1957 concluded that, "this type of research may not have been the best" because "the majority of the income of the association was spent in developing machines which few of the subscribing members could afford to purchase."[29] It was the development of machines that manufacturers simply could not afford, which led to "disillusionment in the programme" and a "general lack of interest", manifested in a "considerably reduced membership."[30] This reduction in membership, and consequent fall in revenue, prevented the CRA from repaying a loan to the DSIR, who, in 1930, therefore terminated their financial support for this organisation.[31] Although the CRA struggled on for another 2 years, the DSIR had dealt it a mortal blow.[32] Significantly, DSIR officials explained their decision to end grant-aid for this association by reference to the inability of manufacturers to purchase the machines which it developed, which, in turn, they attributed to the small-scale structure of the industry. Indeed, they explicitly stated that:

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[27] H. C. Baker, *Human Factors: A Survey of Management Opinion* (Sheffield, 1957), p.9; for a discussion of the DSIR, see S. Pollard, *The Development of the British Economy*, 1914-1990 (London, 1992), p.93.
[28] Baker, *Human Factors*, p.9.
[29] *Ibid.*, p.9.
[30] *Ibid.*, p.10.
[31] Excerpt from the annual report of the DSIR for 1930, in *Quality*, vol.1, no.6, (March 1930), p.8.
[32] Baker, *Human Factors*, p.10.

When a machine apparently quite successful from a technical point of view, is objected to by the cutlery manufacturers because it will cost a few hundred pounds, one begins to realise how great are the difficulties of bringing about the introduction of improved methods in this old established industry...so long as the industry is organised in small units, scientific research is not going to assist it much, except by the provision of better steel and materials, and these are continuously being improved as the result of the work of the chief research laboratories of the steel industry.[33]

Clearly, therefore, we should not overestimate the ability of Sheffield's small-scale manufacturers to purchase machinery, even relatively cheap machinery, particularly in the depressed conditions of the 1920s.[34] Moreover, the problem of industrial structure was not only significant in the cutlery trades, rather it permeated the city's light trades. In saw manufacture, for example, the management of Spear and Jackson, an atypically large firm which grew during the inter-war period through the acquisition of E. W. Lucas Ltd, emphasised that "the development of specialist steel saws" is an expensive matter which can "only be undertaken by those firms which are large enough to sustain the increased all round expenditure entailed by the employment of metallurgists, up-to-date research departments and large furnaces fitted with pyrometers".[35] Significantly, they considered that, within the whole of Britain, theirs was the only saw firm large enough to make the necessary investment.[36]

Labour resistance to new products and processes also remained a significant, if diminishing factor, in delaying technical change following World War One. For example, because stainless-steel was difficult to work by hand and temper using the traditional method described in chapter 5, workers regarded this new alloy as a threat to their handicraft status and their piece rates, and resisted managerial attempts to incorporate it into their product lines.[37] Such resistance was instrumental in delaying the introduction of this alloy, but, by 1925, 12 years after its discovery, most cutlery firms were manufacturing stainless-products. Nevertheless, although worker resistance was generally not as active, nor as successful as prior to 1914, the city's manufacturers continued to bemoan its effects. As late as 1930, the Sheffield Chamber of Commerce, for example, was still citing "the attitude of one or 2 small trade unions as a serious

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[33] *Ibid.*, p.8.

[34] Pollard and Lewis may have over-estimated the ability of small firms to purchase cutlery, Pollard *History of Labour*, p.294-295; Lewis, "Industrial Structure", p.224.

[35] *The Mermaid*, vol.2, no.6, (Winter 1926), pp.47-9; SCA records of Spear and Jackson, SJC 8, Spear and Jackson Ltd., Director's Minute Book, 31st October 1922, Director's Meeting, p.112. The purchase of Lucas Ltd. enabled the firm to extend its business in 'Never bend' spades and other garden tools.

[36] The technical press also emphasised that the small-scale structure of the file trades spawned out-dated works methods and technologies, see *The Engineer*, vol.125, (1918), p.437, 544; vol.126, p.358.

[37] S. Taylor, "Tradition and Change", pp.42, 61.

problem."[38] In particular, it criticised labour's "passive resistance and organised restriction of output", which resulted in the cutlery manufacturer gaining "no advantage whatever from his expenditure"[39] It claimed that such resistance delayed the introduction of new techniques, and ensured that the costs of production remained higher than those of foreign competitors."[40] That this influential local body took labour constraints seriously cannot be doubted; indeed, its concern was such that it asked the government to "undertake active propaganda to convince the working man that increased output and acceptance of new methods and improved machinery are in the true interests of labour."[41] In addition, it advised the city's cutlery firms to establish foreign subsidiaries in order to escape domestic labour constraints. Thus, Wostenholm's established a manufacturing subsidiary in New York in order to make use of a labour force that was more amenable to machine-methods, and satisfy the demand for a cheap line of jack knives, thereby circumventing American import duties.[42]

However, Wostenholm's decision to invest overseas and develop a cheaper machine-produced knife, was not arrived at easily. Chapter 2 argued that product quality was a core-value of the business culture, and this ensured that Wostenholm's decision to produce a cheaper knife caused a great deal of soul-searching amongst the directorate. Nixon, for example, questioned whether it was wise to associate the good-name of the company with an inferior product.[43] Thus, a cultural commitment to the old values of high product quality and handicraft techniques, was only slowly undermined by the realisation that quality cutlery was no longer in such great demand.[44] Indeed, as

[38]"Unemployment in Sheffield", statement prepared by a committee of manufacturers representative of the Sheffield industries, January 1930, in LD 1986/14, Sheffield Chamber of Commerce Minute Book, no.14, p.N9.
[39]*Ibid.*, p.N9.
[40]*Ibid.*, p.N9; Hayter has stressed the negative effects of passive resistance upon productivity in the cutlery trades, M. Hayter, "Technical Change and Labour in the Sheffield Staple Trades, 1850-1914" (Unpublished thesis, Sheffield City Polytechnic, 1983), pp.61-2. For a more general discussion of passive resistance see R. Samuel, "The Workshop of the World", *History Workshop Journal*, vol.3, (1977), p.10; according to Pollard passive resistance also involved the attachment of impossible wage claims to the introduction of new machinery, S. Pollard, *Britain's Prime and Britain's Decline: The British Economy 1870-1914* (London, 1989), p.53.
[41]"Unemployment in Sheffield", statement prepared by a committee of manufacturers representative of the Sheffield Industries, January 1930, in LD 1986/14, Sheffield Chamber of Commerce Minute Book, no.14, p.N9.

[42]SCA, records of Wostenholm's, WOS R8, Correspondence on a proposed factory in the United States of America, 1919, esp. letter from George Quirk (American Agent) to F. B. Colver, May 21st 1919; Letter from Colver to Mr. J. Lewis Schrade (MD of Schrade Cutlery Co.), 8th Aug. 1919, see also statement by Mr. Bunting, 1919.
[43]Cited in Tweedale, *Steel city*, p.277.
[44]According to Schein, the success of a strategy leads to it becoming established as a sacred cow of the business culture. The realisation that a past strategy is no longer appropriate leads to the slow unravelling of this sacred cow. It is slow because businessmen become so committed to the old values that change is unthinkable or at least extremely painful, E. Schein, *Organisational Culture and*

Tweedale has phrased it, "although logic dictated the introduction of machine methods, emotion lay with the old craft skills and traditional quality", and this continued to constrain the extent to which companies were prepared to mechanise and go down-market.[45] Thus, as late as 1945, Wostenholm's customers were being told that "price should never be their main consideration."[46] Indeed, they were informed that "There is hardly anything in the world that some man cannot make a little worse and a little cheaper, and the people who consider price only are the man's lawful prey."[47] In consequence, whilst Wostenholm's were prepared to make special machine-made lines, they paid a great deal of attention to their high-quality, hand-crafted pocket knives, and they were not alone in this. Joseph Rodgers, for example, informed their customers that they were "jealously maintaining their high standard of quality", and George Ibberson and Co., emphasised that the "fame of Sheffield cutlery was based upon craftsmanship", and that the majority of their knives were hand-made, with "that attention to detail which discerning buyers associated with their fiddle trade mark."[48] Thus, although many larger Sheffield firms showed an increased willingness to mechanise and produce certain lines of cutlery for cheaper mass markets, an exhibition of the city's cutlery in 1928, emphasised that the old time tradition of Sheffield for quality, both of material and workmanship, continues to be the aim and watch-word.[49] Therefore, a range of cultural, structural and labour constraints which were identified in chapter 2, continued to restrict the degree of mechanisation within the industry, and it is important to realise that though these constraints have been dealt with separately here, they were clearly inter-linked. In other words, a manufacturer's view of whether he could afford a new machine would have turned, not only upon the money available to him, but also the likely degree of labour resistance and the strength of his own commitment to the old techniques.

Nevertheless, whilst cultural, structural and labour factors continued to constrain mechanisation after World War One: they were not able to do this to anything like the extent that they had done prior to 1914. During the 1930s, in particular, as trade improved, machine methods which supported the development of new products, such as safety razors and stainless-steel knives, became more common. Indeed, by 1939 only the highest quality pocket-knives were manufactured from crucible steel, whilst all other cutlery articles were manufactured from stainless-steel.[50]

Leadership (Oxford, 1989), pp.30, 55; Taylor has stressed the cultural commitment to quality prior to World War One, S. Taylor, "Tradition and Change".
[45]Tweedale, *Steel City*, p.275.
[46]Bexfield, *The House of Wostenholm*, p.39.
[47]*Ibid*, p.39.
[48]*Ibid.*, pp.5, 35, 37, 38; Advert for George Ibberson and Co. in *Sheffield University Magazine*, vol.1, no.2, (1938), p.1.
[49]*Exhibition of Sheffield Workmanship* (Sheffield, 1928), p.6.
[50]Tweedale, *Steel City*, p.272.

The development of the stainless-knife provided a major stimulus to changes in plant and equipment, because its physical properties made it extremely difficult to forge and grind by hand, and its chemical composition as chapter 5 argued, was such that its temperature and therefore its temper, could not be confidently inferred from the colour of its heated surface.[51] Stainless-cutlery therefore, required the instalment of furnaces fitted with pyrometers, and, in consequence, the period after World War One was characterised by the abandonment of the traditional coke-hearth and its replacement, particularly at the larger firms, with gas and later electric furnaces fitted with automatic temperature control.[52] Indeed, industry leaders, such as Rodgers and Wostenholm's, established analytical laboratories equipped with the latest scientific appliances, which brought the heat-treatment of their blades under "special control" and secured "uniformity of hardness and a lasting cutting edge."[53] The advent of stainless-steel also accelerated the pre-war development of machine-forging, whilst stimulating the development of machine-grinding, which became increasingly common. As early as 1925, the Ministry of Labour could report that, in the larger establishments machine methods had made rapid progress, and that power-driven machinery was common in the making of the cheaper grades of razors, scissors and forks, particularly in the processes of forging and grinding. Many of these articles were either drop-stamped or simply flied out of the sheet steel using trip hammers, presses and boring machines.[54] Wostenholm's, for example, installed a completely new scissors plant that embodied all the latest methods of manufacturing, whilst Rodgers new plant facilitated the production of a special range of machine-made scissors, which were available at a lower price than that of any other Sheffield firm.[55] Nevertheless, the Ministry of Labour concluded that handicraft methods still prevailed in many of the smaller workshops, and, in both large and small establishments, the highest quality pocket-knives continued to be made solely by hand.[56] Clearly, therefore, although Sheffield manufacturers undertook to provide more fully than in the past for "the type of purchaser who cannot afford the artistic work of craftsmen" by developing "machine-made cutlery which could be sold at a competitive price", they continued to pay considerable attention to the manufacture of the highest class of hand-made cutlery, particularly pocket-knives.[57] As late as 1946, for example, Wostenholm's were still

[51] Baker, *Human Factors*, p.2.
[52] *Ibid.*, p.2.
[53] *A Royal Record: The Brief History of a Famous Sheffield House, Joseph Rodgers and Sons Ltd.* (Sheffield, 1930), p.12; Bexfield, *The House of Wostenholm*, p.35.
[54] *Ministry of Labour Report of an Enquiry into Apprenticeship and Training for the Skilled Occupations in Britain and Northern Ireland* (London, 1926), p.103.
[55] Bexfield, *The House of Wostenholm*, pp.37-8; *The Brief History of Joseph Rodgers and Sons Ltd*, p.9.
[56] *Ministry of Labour Report into Apprenticeships*, p.103; SUA 5/1/2 (iii), Chapman Collection, papers relating to the history of the Technical School, vol.3, pp.409, 414.
[57] *Exhibition of Sheffield Workmanship* (Sheffield, 1928), p.14.

emphasising that "skill and craftsmanship were essential" to the manufacture of their best pocket knives, which was carried out "in exactly the same way as centuries ago."[58] However, this is not to dismiss the progress that was made throughout the industry, particularly in the 6 years after 1933. Indeed, in 1935, the Sheffield Chamber of Commerce could claim that: "A feature of recent years has been the extensive installation of modern machines, and Sheffield cutlery firms are now in a position to supply the vast quantities of cheap goods formerly supplied by the Germans."[59] Although this was almost certainly an exaggeration, it neatly captures the general feeling of transformation that pervaded the industry at this time. Moreover, the changes were not only technological. More sophisticated methods of works organisation and labour control also began to emerge. The larger firms for example, began to require all their workers, including youths who were now employed directly by the firm, to fill in time sheets to enable their productivity to be assessed.[60] Nevertheless, again, the extent of these changes can be exaggerated; out work remained common, and the *Encyclopaedia Brittanica* claimed that there were still many small tenement factories in Sheffield where workers were free to come and go as they pleased.[61] Indeed, in 1935 there were 476 cutlery firms in Sheffield, the majority of which employed less than 20 workers.[62] However, this should not blind us to the progress made, particularly in the larger firms, with regard to product and process innovation, and I now turn to consider the impact of this upon their human resource requirements.

III

Education, Training and Re-skilling.

Since a firm's plant and equipment require to be operated by labour, it follows that the firm must possess workers with the appropriate knowledge, skills and temperaments.[63] An issue to explore, therefore, is to what extent were product and process innovations in the cutlery industry supported by changes in its human resources? In order to answer this question, it is necessary to be clear about the skills and knowledge that the new product and processes required. As chapter 5 argued, the development of stainless-steel rendered the traditional form of tempering redundant, as its chemical composition was such that it was extremely difficult to infer the temperature of an article, and therefore its temper, from the colour of its heated surface. The development of stainless-steel cutlery therefore demanded not only the introduction of furnaces which could be controlled with pyrometers, but also workers who were capable of reading scientific instruments, and who had some metallurgical knowledge of the various stainless alloys

58 Bexfield, *The House of Wostenholm*, pp.35, 39.
59 *Quality*, vol.6, no.4, (January 1935), p.138.
60 SCA, records of Wostenholm's, Wos R9, esp. letter to W. Nixon 3rd August 1920.
61 Excerpt from the *Encyclopaedia Britannica* 1928 in SUA 5/1/2 (iii), p.532.
62 See *White's Trade Directory For Sheffield* (1919).
63 Moss, *Business Strategy*, p.17.

with which they had to work.[64] Thus, just as high-speed alloys had undermined the sway of 'rule-of-thumb' in steel and armaments firms prior to World War One, so now in cutlery, stainless-steel finally sounded a death-knell for old techniques.[65] In addition, whilst the introduction of new products demanded an improved metallurgical education, the introduction of machinery demanded enhanced engineering education. Indeed, as chapter five argued, manufacturers recognised that "the use of machines would necessitate, not only the employment of a skilled engineer, but also operators who possessed some knowledge of engineering", as increased mechanisation meant that production was "no longer a cutler's problem", but an "engineering problem", which "needed to be solved by engineering methods."[66] Having outlined these developments in human resource requirements, it is necessary to examine the key question of how, and to what extent, these needs were met?

During the First World War the Sheffield Technical School of Art inaugurated a pre-apprenticeship training programme, which was supposed to provide the cutlery and allied trades with more technically-educated recruits. On joining the pre-apprenticeship programme at the age of 13, boys were required to enter into an agreement which bound them to a career in the cutlery trades.[67] Their training programme consisted of a two-year course which was highly relevant to the needs of local manufacturers. For example, more than half the timetable was devoted to technical and design education, and students were required to study science, workshop arithmetic and geometrical drawing. In addition, they also received manual instruction in well-equipped workshops, under the expert tutelage of craftsmen who were recruited from local industry.[68] Nevertheless, by 1923, this promising programme had been scrapped.

How may the demise of this training initiative be explained? On one level, the decision to terminate this programme can be explained by reference to the economy campaigns of local and national government, discussed in chapter 6. It was, for example, officially reported that the programme had been shelved due to "severe financial stress."[69] However, the reasons ran deeper than this, in particular, the programme was ear-marked for redundancy, because of its inability to attract students following the collapse of the post-war boom in 1921.[70] The fall in the number of students joining the pre-

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64 *Sheffield Workmanship*, p.14.
65 SUA 5/1/2 (iii), p.497.
66 SUA 5/1/2 (ii), p.207.
67 B. J. Carr, "Sheffield Technical School of Art", in C. Holme (eds.), *Arts and Crafts a Review of the Work Executed by Students in the Leading Art Schools of Britain and Ireland* (London, 1924), pp.116-118.
68 *Ibid*, pp.116-118; CA 329, Managers of the Technical School of Art Minute Book, no.3, p.217.
69 CA 681/9/19, Sheffield Education Committee Report for Year ended 31st March 1930 and Survey from 1st April 1921, p.19.
70 CA 329, p.126.

apprenticeship programme, simply mirrored the decline in the number of apprentices entering the cutlery industry, and can be explained by the same factors. In the depressed conditions of the 1920s, many firms were unwilling to take on apprentices, and those that were, found that very few boys wanted to enter an industry where unemployment rates averaged between 15 to 40 per cent, and where working conditions were unhealthy and wages relatively low.[71] In consequence, not only was the pre-apprenticeship programme starved of recruits, but by 1925, as a Ministry of Labour report pointed out, there were less than 50 apprentices in the whole of the city's cutlery firms. Not surprisingly this report drew the conclusion that, "It is to be feared that apprenticeship as a means of training is fast disappearing"[72] However, the problem was not only quantitative, but also qualitative. In other words, increased mechanisation demanded the recruitment of better educated youths who were capable of benefiting from technical training. Indeed, some of the city's manufacturers emphasised that, with the advent of mechanisation, "it was necessary to supply the industry with boys of good type", and the Sheffield Trades Technical Societies held special meetings to discuss how they might attract such youths in to the city's firms.[73] However, despite their best endeavours they found that, because of the conditions prevailing in their industry, only the least able boys were willing to enter their firms, whilst the more intelligent sought opportunities elsewhere; a process that was encouraged by the academic ethos of the city's secondary schools, discussed in chapters 3 and 6.[74] In consequence, it was reported that, despite managerial encouragement, very few youths in the cutlery industry were taking evening technical classes because firms were the recipients of boys with minimal intelligence who lacked initiative.[75] However, another reason why cutlery firms received the least able boys, as chapter 2 argued, was that very few firms employed apprentices directly, instead they were employed by the workmen. Manufacturers therefore, had little say in who was recruited, and workers preferred to take on relatives at the age of 13, rather than well-qualified secondary school students.[76] Indeed, local headmasters complained that some of their brightest pupils found that they were prevented from entering the cutlery industry due to the old practices and prejudices of the workmen. Therefore, even though the Technical School of Art

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[71] H. Townsend, "The Cutlery Trade", in D. Burn (eds.), Structure of British Industry: a Symposium, vol.2 (Cambridge, 1958), p.406; Pollard, *History of Labour*, pp.212-13; Taylor, "Tradition and Change", p.320.

[72] *Ministry of Labour Report into Apprenticeships*, p.104.

[73] LD 1803, Sheffield Cutlery Trades Technical society Minute Book, Oct. 29th 1919, May 1st 1924, Dec. 8th 1924; LD 1815, Sheffield Spring Trades Technical Society Minute Book, November 25th 1925.

[74] Statement by Manufacturers in the Cutlery, File and Tool Trades, in LD 1807, Sheffield Tool Trades Technical Society Minute Book, May 11th 1925.

[75] LD 1795, Sheffield Trades Technical Society Handbook, June 15th 1937, p.147.

[76] Mr F. Charles and R. S. Fry (manufacturers) pointed out that in most cutlery firms, except the largest ones, boys were appointed by the workmen and this made schemes of technical education difficult, LD 1807, Sheffield Tool Trades Technical Society Minute Book, Advisory Council Meeting 11th may 1925; *Ministry of Labour Report into Apprenticeships*, p.104.

introduced a new pre-apprenticeship programme in 1929, the number of youths attending remained very low, in the region of 12 per annum.[77] In conclusion, therefore, it appears that firms were recruiting neither the quantity nor the quality of apprentices required for the future prosperity of the industry. A more modern apprenticeship training programme, which integrated paid day-release at technical college with practical training in the firm, was finally introduced in 1955.[78] However, this lies outside my period, and it is significant that during the inter-war years Sheffield developed nothing to compare with Solingen's Fachschulen; which provided apprentices, not only with theoretical instruction, but also with practical instruction on friction-presses and stamps.[79]

The decline in the number of youths entering the trade, and the failure to up-date their industrial training, meant that if the larger firms, in particular, were to maintain their human resources in line with the changing needs of the workplace, they must either recruit workers from other industries, or else re-train their existing staff. Given the conditions of the industry described earlier in this chapter, it was unlikely that manufacturers would be able to attract large numbers of workers into their firms, therefore it was crucial that the skills of existing staff were brought up-to-date. The issue of re-skilling or re-training has received little attention. Indeed, an article written by Charles More in 1996, was explicitly designed to establish a research agenda for an analysis of re-skilling.[80] More's pioneering article provides a useful framework for an exploration of re-skilling in the inter-war cutlery industry. He has identified several methods by which skills may have been up-dated, including de-skilling, the one-off impact of World War One, the transferability of existing skills, and technical education, each one of which will now be considered in turn.[81]

More first poses the question: did the process innovations introduced into manufacturing industry require less skill, thus enabling them to be learned very quickly?[82] De-skilling theses have a long academic tradition, stretching back from the more recent research undertaken by Harry Braverman, to the work of Karl Marx, but, as More points out, there now appears to be "a general consensus that simplistic de-

[77]CA 681/9/19, p.20. For a general discussion of the Sheffield School of Art, which in 1926 became the College of Arts and Crafts, an antecedent of Sheffield City Polytechnic, see J. Kirby, *The Sheffield School of Art, 1843-1940* (Sheffield 1987), esp. p.25; *Sheffield College of Arts and Crafts Prospectus, 1928*, p.1; *Prospectus, 1930-31*, pp.1-9.
[78]*Quality*, New Series, vol.2, no.4, (April 1955), p.22.
[79]*Report of the Sheffield Cutlery Mission to Solingen, July 1919*, p.22.
[80]C. More, "Re-skilling and Labour Markets in Britain, c.1890-1940: Questions and Hypotheses", *Historical Studies in Industrial Relations*, vol.2, (September 1996), pp.93-110.
[81]*Ibid.*, p.95.
[82]*Ibid.*, p.100.

skilling theses...are unconvincing."[83] Historians who have analysed the engineering industry, for example, have argued that some technical changes required skilled workers to act as supervisors and tool-setters, and that this demanded more skill than such workers previously exercised not less.[84] However, what can we say about mechanisation in the cutlery industry and its impact upon labour? Some of the machines introduced during our period clearly reduced the labour requirement by more than half, but were there also qualitative changes in the demand for labour?[85] In particular, did mechanisation lead to de-skilling? Sheffield cutlery manufacturers were quick to dismiss such notions. At the Exhibition of Sheffield Workmanship in 1928, for example, it was argued that:

> The idea that the coming of the machine-tool age means the disappearance of the skilled craftsmen is a mistaken one, there will always be need of the highly skilled craftsmen. Today's craftsmen must set up new machinery, tune it up to its efficient working speed, and keep it in such a condition of efficiency as will secure from it maximum service.[86]

Historians have tended to agree. Pollard, for example, has argued that although the introduction of machinery led to de-skilling in some branches of the industry, such as the preparation of cutlery material and the grinding of knives, many new machines often required as much skill and training as the old, if not more.[87] Moreover, as I have already argued, the development of machine-methods and new products demanded an enhanced level of engineering and metallurgical education. De-skilling theses therefore clearly have limited applicability to the cutlery industry.

To what extent, then, did World War One act as a mechanism for re-skilling? More claims that the war was a "great discontinuity" which offered ample opportunities for re-training the workforce. In particular, he considers that the development of mass production techniques during 1914 to 1918, constituted a steep learning curve for both workers and management. However, he acknowledges that, on the cessation of hostilities, pre-war production methods were quickly re-instated in most industries.[88] Cutlery, as we have seen, was no exception. Whilst the unions acquiesced in the development of mass production and the use of female labour during the war, once the hostilities were over they were instrumental in removing women from the workplace, and, as the old craftsmen were de-mobilised, production methods within the industry

[83] *Ibid.*, p.100; see H. Braverman, *Labour and Monopoly Capital: The Degradation of Work in the Twentieth Century* (London, 1974).
[84] More, "Re-skilling", p.100.
[85] Pollard, *History of Labour*, p.295.
[86] *Sheffield Workmanship*, p.30.
[87] Pollard, *History of Labour*, p.295.
[88] More, "Re-skilling", p.103.

returned to their pre-war norm.[89] The impact of the war upon re-skilling in the cutlery industry can therefore easily be exaggerated.

To what extent, however, did workers needed to be re-trained, in other words, how transferable were their existing skills? More argues that some workers were able to adapt their existing skills to new products or new processes, without incurring extensive re-training. In particular, he considers that the old apprentice-trained workers would have had enough experience to adapt easily, and could have developed and honed their skills on the job. Nevertheless, he emphasises that the ability of workers to adjust in this way was likely to have varied with the breadth of their original training, and that semi-skilled workers, whose training was more narrow and specialised, would have required more extensive re-training. Thus, on-the-job learning would have required a period of sub-optimal working, which would have varied in length according to the individuals prior experience. Nevertheless, More considers that this was how most workers were re-skilled.[90] A key concern for him, therefore, is how firms ensured that they reaped the benefit of this retraining. He considers two options: first that workers undergoing re-training were paid lower wages until they became productive, and, second that, there was a high degree of reciprocal loyalty between manufacturers and workers, or, in his terminology, an implicit contract which discouraged workers from taking their new skills elsewhere. The first option More dismisses due to a lack of empirical evidence, but he finds the second more persuasive.[91] Nevertheless, how do More's claims stand up against empirical evidence garnered from the cutlery trades? As far as cutlery is concerned, More's preoccupation with how firms captured the benefits of retraining is somewhat misplaced. In an industry characterised by high unemployment, those who were lucky enough to be in work were reluctant to move; indeed, as Gospel argues, labour mobility amongst the employed during the inter-war years was restricted.[92] This means that firms were, over the short-run at least, unlikely to lose their investment. In addition, the working of short-time, due to weak demand, provided ample opportunity for workers to re-skill themselves on new machinery, and many employees, who were working a three-day week, up-dated their skills in this way. Nevertheless, as More admits, on-the-job training alone was not always sufficient because, although the best apprenticeship training gave workers good manual skills and an understanding of a range of processes or techniques, the theoretical knowledge acquired in most apprenticeships was very limited. "Whilst time served workers might be flexible and adaptable over a range of existing processes and products", therefore,

[89]LD 1986/9, Sheffield Chamber of Commerce Minute Book, no.9, p.97; H. F. Gospel, *Markets, Firms and the Management of Labour in Modern Britain* (Cambridge, 1992), p.53.
[90]More, "Re-skilling", pp.100-03.
[91]*Ibid.*, pp.95-6, 104, 107.
[92]Gospel, *The Management of Labour in Modern Britain*, pp.63-65.

"they were unlikely to have the theoretical understanding that would help them to come to terms with new products and processes if these were at all complex."[93] For example, although cutlers had adapted their skills to different varieties of crucible and shear steel, manufacturers recognised that, in coming to terms with new stainless-steels, they would require the "advice and assistance of the metallurgist."[94] I now therefore turn to consider the question of technical education.

More has argued that technical education provided an obvious medium for re-skilling in the classic fashion prescribed by human capital theory. In other words, adult trainees paid for their own re-training by forgoing leisure opportunities and by paying their own fees. However, although he considers that technical education would have provided a theoretical background which would have given workers an enhanced capacity for dealing with change, he claims that "It would not usually have provided them with an up-to-date training on the latest machinery and processes since much technical education was theoretical rather than practical."[95] In More's opinion, therefore, even if we take a maximising view of the importance of technical education, it could, at most, have provided only part of the skills which workers required, and this throws into sharp relief, the importance of on-the-job-learning within the firm. Indeed, he claims that the importance of technical education in re-skilling adult workers can easily be overstated, as the vast majority of students attending evening classes were under 21 years of age. Thus, in More's opinion, on-the-job learning was the most significant mode of re-skilling.[96] Nevertheless, in what follows it will be argued that while on-the-job training was important in the cutlery industry, technical education was of far more importance in re-skilling the workers than More allows, even in his maximising view. Indeed, the Sheffield Cutlery Trades Technical Society, and in particular, the cutlery trades technical lectures, which I now turn to discuss, were central to the re-training of adult workers.

No economic or business historian has undertaken a detailed examination of the Sheffield trades technical societies. Pollard makes a reference to them in his *History of Labour in Sheffield*, but neither Tweedale, Lewis or Taylor have explored this medium of re-skilling. The only sustained analysis of the societies is to be found in A. W. Chapman's monumental history of the Sheffield University, but this work is fundamentally institutional in its orientation and draws few conclusions as to the links

93 More, "Re-skilling", p.104.
94 *Exhibition of Sheffield Workmanship,* p.14.
95 More, "Re-skilling", pp.105-06.
96 More, "Re-skilling", pp.106-07.

between education and industry.[97] There are therefore clear interstices in the received knowledge of industrial training during the inter-war years which need to be addressed.

The first trades technical society to be formed in Sheffield was for the cutlery industry in 1918. However, this was rapidly followed by societies for the other light trades, and, later, by societies for the heavier trades, so that, by 1937, Sheffield had a total of 14 trades technical societies.[98] All of these societies were composed of manufacturers, managers, workmen and university staff, each of whom paid a two-shilling annual subscription, and had the right to stand for election as chairman. Thus, the societies could claim to be truly democratic in their constitution..[99] The Cutlery Trades Technical Society grew out of the industry's collaboration with the university during World War One, and was explicitly founded on the basis of a "feeling that methods of organisation and machinery would have to be thoroughly revised and brought up-to-date."[100] Under the chairmanship of Walter Tyzack, of Needham, Veal and Tyzack, therefore, the society aimed: firstly, to provide a forum where manufacturers, managers, foremen and workmen could meet to discuss the latest product and process innovations in the industry, both at home and abroad. Secondly, to provide a medium through which manufacturers could meet with the university staff, and thereby bring "the workshop in to close touch with the newest and most helpful discoveries." Thirdly, to provide an opportunity for works visits, in order to examine new technology at work. Fourthly, to provide special lectures which would enable all members of the society, and particularly workers who were not students of technical institutions and whose education was limited, to learn the scientific principles that informed their industry. Fifthly, to enable all members to deliver papers on different aspects of the industry's technical development. And finally, to use the university staff and equipment to carry out research[101]. The university continued to undertake such research on behalf of local firms, even after the demise of the Cutlery Research Association in 1932. There therefore remained an avenue through which the products and processes of the industry could continue to be improved throughout the inter-war years.[102] Nevertheless, my attention is focused upon human resources. In what follows, it will be argued that the Cutlery Trades Technical Society provided ample opportunities for re-training the workers, both formal and informal.

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[97] A. W. Chapman, *The Story of a Modern University* (Oxford, 1955), esp. pp.287, 291.
[98] *Sheffield University Magazine*, vol.1, no.1, (December 1937), p.25.
[99] See, *Science in Industry: Opportunity for Further Education, National Trades Technical Societies, Sheffield Section* (Sheffield, 1944), pp.5, 9 and foreword.
[100] *Science in Industry, Trades Technical Societies*, p.3; SUA 5/1/2 (ii), p.211.
[101] *Science in Industry, Trades Technical Societies*, pp.4-49; LD 1803, Sheffield Cutlery Trades Technical Society Minute Book, December 13th 1918.
[102] *Sheffield University Magazine*, vol.1, no.1, (December 1937), p.25.

Regular works visits were an integral feature of the society's activities. Visits to leading firms, such as Needham, Veal and Tyzack, provided an opportunity for workers and managers to observe the operation of the latest machinery, and, on occasion, even to use them. Thus, a combination of observation and, to a lesser extent, hands on experience, created a clear medium for re-skilling.[103] In addition, by encouraging the workers to read papers before the society, it was claimed that workers improved, not only their technical knowledge, but also their literary and communication skills, and became more co-operative and receptive to new techniques.[104] Discussions amongst manufacturers, managers and university staff were also alleged to have enhanced workers' acceptance of the need for technical change and their willingness to co-operate with management, whilst providing a valuable means of improving their knowledge of best-practice techniques.[105] Of course, the extent of the effect of all this is extremely difficult to gauge, taken individually, the various components of the society's activities may not have been all that impressive, but, considered as a whole, they provided a important avenue for re-skilling, particularly when the trade technical lectures, which I now turn to examine, are taken into account.

The cutlery trades technical lectures were central to the society's activities. Indeed, they were the main method by which the university aimed to transform old craftsmen into new craftsmen, who were able to understand and apply scientific principles.[106] From the outset, the trades technical lectures were divided into two sections: metallurgical and engineering. The first studied the properties of the various materials used in cutlery manufacture and their effect upon treatment and processing, whilst the second focused upon the methods of manufacture. In particular, the two sections concentrated upon product and process innovations.[107] Before examining the content and development of the cutlery lectures in more detail, however, I will briefly consider the qualifications of the lecturers, and the method by which lectures were delivered.

The lectures were given in a simple language which could be more readily understood by the workmen, and supported by visual aids, such as slides, and opportunities for discussion. The university clearly recognised that the success of the lectures would depend very much upon the qualities of the lecturer. They acknowledged that lecturers would have to be able not only to "impart an idea of the scientific background of the craft", but also to "hold their own in discussions on the mysteries of the shop-floor", if

[103] *Science in Industry, Trades Technical Societies*, pp.11, 15, 32.
[104] *Ibid.*, p.14.
[105] *Ibid.*, pp.9-12.
[106] *Ibid.*, p.3.
[107] LD 1803, Sheffield Cutlery Trades Technical Society Minute Book, April 29, 1929; *Science in Industry, Trades Technical Societies*, pp.4, 5, 10, 40-1.

they were to win the respect and trust of the workmen.[108] Therefore, in addition to their academic qualifications, the majority of the lecturers had substantial industrial experience, indeed, many of them had positions in local industry. One of Joseph Rodgers' engineers, for example, provided numerous lectures on subjects such as modern works management. Such lecturers were sensitive to the workmen's fears and prejudices, and took pains to show how the traditional rule-of-thumb could be supplemented, and, in some cases, supplanted by the application of scientific principles. However, how did the special lecture courses develop during our period?

Initially, the lectures were provided in an *ad hoc* manner, as a need for them was perceived by the industry, but, by 1926, both the metallurgical and engineering sections offered a graduated two-year course, which was administered by a separate Trades Technical Department of the University.[109] The metallurgical section focused upon the treatment of stainless-steel in all its stages of production, including melting, forging, grinding, hardening and tempering.[110] Much of the work was theoretical, but the lecturers carried out demonstrations using the university's pyrometers and furnaces, and the students were allowed to use the laboratory equipment to test the properties of the steel for themselves. This training was of fundamental importance, for the heat-treatment of stainless-steel was so complex that it required an in-depth scientific understanding, and not merely the rudiments of empirical knowledge, contained in the rule-of-thumb. Indeed, manufacturers early attempts to temper this steel in the traditional manner resulted in knives which would not retain a cutting edge.[111]

In the engineering section attention was focused upon the changing conditions of manufacture, in particular, the application of electricity, the construction and use of abrasive wheels, the use of machine-tools and grinding machines, machine-drawing and the principles of measurement and inspection.[112] Again, much of this instruction was theoretical, but the workers were allowed to run tests in the laboratories, and, on occasion, they had access to the machines devised by the CRA. Moreover, in 1932, following the re-equipment of the university, discussed in chapter 6, a new four-year course was established, and the practical dimension of the education was significantly increased.[113] On the metallurgical side, for example, students were now allowed, not only to use the laboratories testing equipment, but also to heat-treat and temper various steels using the university's new annealing furnaces and pyrometers. Indeed, from 1932

[108]Chapman, *Modern University*, pp.291-92; SUA VIII/1/3, Sheffield University Applied Science Dept. Minute Book, no.3, p.365.
[109]LD 1803, Sheffield Cutlery Trades Technical Society Minute Book, April 1929; SUA VIII/1/3, p.365.
[110]Sheffield Cutlery Trades Technical Society Minute Book, LD 1803, April 1929.
[111]W. H. Hatfield, *The Application of Science to the Steel Industry* (Ohio, 1928), pp.146-153.
[112]LD 1803, December 8th 1924.
[113]*Science in Industry, Trades Technical Societies,* pp.7, 40-1.

onwards, they were allowed to heat, cool, forge, roll, harden and temper a variety of steels, including stainless.[114] On the engineering side, they constructed abrasive wheels, and used those grinding and polishing machines which were most suitable for the working of stainless, whilst learning how to read drawings and blue-prints, and how to use the most up-to-date micrometers and slide-rules.[115] By 1932, therefore, the Sheffield Cutlery Trades Technical Society offered a technical education which was directly aimed at old craftsmen, and which combined theoretical instruction with practical workshop and laboratory experience.[116] For the cutlery and allied trades, therefore, More's conclusion as to the limited impact of technical education upon re-skilling, appears premature. However, as late as 1932, the Sheffield trades technical lectures were unique, there was nothing like them anywhere else in Britain, or it appears abroad, moreover, the question of the effect of these lectures needs to be explored in greater detail, and, in particular, the level of attendance.[117]

What is clear is that membership of the trades technical societies increased almost every year, and by 1939, the 14 societies could boast a combined membership of over 3,500. Moreover, the numbers enrolled for the cutlery trades technical lectures in both the metallurgy and engineering sections increased from around 200 in 1919, to about 400 by 1939.[118] This suggests that a considerable number of workers would have been re-trained prior to World War Two, in order to enable them to cope with the new products and processes with which they had to work. Indeed, I would estimate that a minimum of around 6,000 workers and a maximum of 10,000 would have been re-trained. Given that the three largest firms, Rodgers, Wostenholm's and Needham Veal and Tyzack, together employed no more than 2,500 workers, it appears that workers in some of the city's smaller firms must have been involved in this re-training programme. Indeed, as they were manufacturing stainless-steel products, they particularly required forgers with the metallurgical knowledge needed to temper these steels. Some local businessmen and educationalists considered that the movement was successful both in terms of the number of students enrolled, and in terms of its impact upon the workers' cognitive understanding and their ability to cope with new techniques. The Sheffield University, for example, argued that the lectures rendered the working man more amenable to the scientific point of view, whilst the Sheffield Chamber of Commerce considered that there was no doubt that the lectures were providing an invaluable service to the industries of Sheffield.[119] In particular, it was claimed that they provided a ready means

[114] *Sheffield University Magazine*, vol.1, no.1, (December 1937), p.25.
[115] *Ibid*, p.25; *Science in Industry, Trades Technical Societies*, p.10.
[116] SUA VIII/1/4, Sheffield University Applied Science Dept. Minute Book, no.4, p.255.
[117] *Sheffield University Magazine*, vol.1, no.1, (December 1937), p.25.
[118] SUA 5/1/2 (ii), p.211; SUA VIII/1/3, p.365; *Sheffield University Magazine*, vol.1, no.1,(1936) p.26.
[119] SUA 5/1/2 (ii) p.334; SUA 5/1/2 (iii), p.450; LD 1986/17, Sheffield Chamber of Commerce Minute Book, no.17, May 1932, p.E7.

for the thinkers of the industry to bring out their ideas and this encouraged the adoption of a more scientific approach to cutlery manufacture. This sanguine view of the effect of the lectures has been reinforced by Chapman in his history of the Sheffield University, and I too would argue that the trades technical lectures were of fundamental importance in re-skilling the workforce. However, Chapman tended to gloss over some of the weaknesses of the trades technical movement, which I now turn to discuss. Firstly, it is important to note that we cannot confidently infer the number of workers re-trained from the enrolment figures, for reports suggest that actual attendance at the lectures was subject to wild fluctuations. Hence, the wide variation in the maximum and minimum estimates which I have provided for the numbers re-trained. Professor Ripper, for example, pointed out that during the depths of depression, attendance was significantly reduced, as unemployed workmen were either unable to afford the fees, or simply lost the inclination to attend, many of them hoping to find jobs elsewhere.[120] Paradoxically, boom conditions also had a deleterious effect upon attendance, as firms required their employees to work over-time, which many of them were only too keen to accept.[121] Thus, the quantity of students following the whole of the trades technical programme can be exaggerated by an analysis of enrolment figures. This means that the quality of the students' learning experience can also be over-stated, for although the lectures provided a comprehensive education programme in metallurgy and engineering, the evidence suggests that workers only attended those lectures which they considered to be most directly relevant to them. In other words, if their firm did not employ automatic grinding machines, then they did not attend lectures on such technology. This was a pattern that was replicated throughout the trades technical societies: workers whose rolling mills were powered by steam or gas were reluctant to attend technical classes on electric rolling, while crucible melters could see little point in studying open-hearth and electric technology.[122] Such selective attendance, would have undermined the aim of broadening the students' horizons and increasing their flexibility and receptiveness to new techniques.

Attendance was also affected by the diverse make-up of the student body, which consisted of workmen, foremen, managers and manufacturers. In attempting to cater for such an eclectic audience, the lecturer confronted a serious problem. Indeed, as Professor Andrew pointed out, it was an impossibility to meet "the requirements...of ...every member of the class." The lecturer was therefore forced to select as his standard, a mean-average based upon the abilities of his audience, and this was "apt to eliminate those who were either very much below or very much above the standard".[123]

[120]SUA VIII/1/4, p.148.
[121]*Ibid.*, p149.
[122]SUA VIII/1/4, p.54.
[123]SUA VIII/1/4, p.392.

Students finding the lectures either too advanced or too elementary, ceased to attend or gained very little from their attendance.[124] However, this was more of a problem in the early years of the movement than in the 1930s, when cutlery workers could either take an elementary course consisting of 20 introductory lectures, or more advanced two- and four-year courses. Unfortunately, no records have survived of the number of students completing these courses, so their effectiveness in this respect simply cannot be assessed, but nevertheless the advent of more practical work in 1932 and the increased differentiation between courses was a major boon, and we may conclude that the trades technical movement provided a useful avenue through which workers could re-train to cope with the new products and processes, which were being installed particularly at the larger firms.[125] In addition, as table one in Appendix G shows, a small number of cutlery firms (invariably the larger ones) enhanced their ability to deal with new technology, through the appointment of university-trained metallurgists and engineers. For example, Needham, Veal and Tyzack informed their grinders that if they experienced any difficulties with their machinery they should consult their works engineer, Albert Wright, who would be able to explain the problem to them and undertake any necessary repairs.[126] Nevertheless, many firms could not afford to employ such staff, and this throws into sharp relief the importance of the re-training of workers through the trades technical lectures. However, I now turn to explore the relationship between education, training and business performance.

IV

Industrial Performance and ET Provision.

Assessment of the performance of the cutlery industry during the inter-war years is made extremely difficult by the lack of business records. However, available data for two of Sheffield's largest firms: Wostenholm's and Rodgers indicates that from 1922 to 1934, Wostenholm's paid no dividends, and by 1925, Rodgers in particular was suffering heavy losses.[127] However, what can be said about the city's smaller firms? Analysis of the city's trade directories reveals that in 1919 there were 519 cutlery firms in Sheffield, but by 1935 this figure had dwindled to 470. Of the 470 firms, 227 were survivors from 1919 and 243 were new entrants.[128] The survival rate from 1919 to 1935 was therefore 44 per cent. In a hostile business environment, characterised, as chapter 7 argued, by unfavourable domestic macro-economic policies, foreign protectionism and import substitution in the colonies, this was no mean achievement. Many cutlery firms were able to weather the difficulties of the 1920s and, as Moss has

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[124] *Ibid.*

[125] The university staff considered that the introduction of practical work had made the courses an unqualified success, SUA VIII/1/5, p.170.

[126] SCA, records of Needham Veal and Tyzack, NVT 12, Job Advertisement, May 1915.

[127] Tweedale, *Steel City*, pp.278-279.

[128] See *White's Trade Directories for Sheffield* (1919, 1935)

argued, the first objective of any business is to survive. Unfortunately, the lack of financial data makes it infuriatingly difficult to explore whether the firms were doing anything more than simply hanging on. Nevertheless, trade reports suggest that conditions throughout the cutlery sector were poor. Indeed, Tweedale has argued that the 1920s and 1930s were black decades for the Sheffield cutlery trades. While Sheffield's steel and engineering firms enjoyed some minor recoveries during the 1920s, for cutlery firms, the years from 1921 to 1934 were ones of almost complete depression, the only difference being that some years were worse than others.[129] Thus, as Pollard has argued, conditions only really began to improve after 1935, with the re-armament campaign.[130] However, what does this tell us about the relationship between education, training and business performance?

Fifty two per cent of the total number of cutlery firms based in Sheffield in 1935 did not exist in 1919 and this suggests that barriers to entry into the trade were low. In particular, large-size and investment in technical education were not prerequisites for cutlery manufacture. Many small firms were able to set up business using traditional methods and survive for long periods. Indeed, during the 1950s, as the economy recovered, Sheffield's cutlery industry grew to incorporate 600 firms, many of them small-scale concerns pursuing traditional strategies using traditional technologies and skills.[131] Because small firms were able to enter the industry and survive for long periods and because large firms, such as Wostenholm's and Rodgers which invested in machinery and technical education, made significant losses, it may appear tempting to dismiss technical education as a key factor in business performance. However, such a conclusion may be premature. Trade reports suggest that the development of machinery and technical education during the 1920s and 1930s enabled Sheffield's larger firms to compete more effectively with foreign producers in the cheaper mass markets. The most significant advances came in the manufacture of razors and scissors. In 1929, for example, it was reported that Sheffield manufacturers were "competing with German scissors, with increasing success both in home and colonial markets", and a year later it was claimed that: "The scissors branch in Sheffield continues to progress and an increasing amount of trade is being captured from Germany, as the installation of machinery has enabled Sheffield prices for the cheaper qualities of scissors to be brought down approximately to those of Germany."[132] The development of a "cheap bazaar trade in safety razors", through the introduction of machine-methods, was also

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[129] *Ibid.*, p.268.
[130] *Quality*, vol.10, no.9, (July 1939), p.554.
[131] As late as 1958 there were about 700 cutlery firms over 600 of which were in Sheffield, and over 500 of which employed fewer than 11 people, H. Townsend, "The Cutlery Trade" in D. Burn (eds.), *Structure of British Industry: A Symposium* (Cambridge, 1958), pp.379-80.
[132] *Quality*, vol.1, no.2, (November 1929), p.14; Quality (April 1930), p.10.

commented on.[133] Indeed, it was claimed that in their scissors and safety razor sections, some Sheffield firms were beginning to make significant profits.[134] Wostenholm's and Rodgers, for example, considered that the profitability of their scissors department more than justified the expense involved in laying down modern machinery. In addition, it was recognised that Sheffield was leading the world in the manufacture of stainless-steel gramophone needles, and even exporting large numbers of such products to Germany.[135] Indeed, Sheffield manufacturers quickly came to terms with stainless-steel. Firms such as Atkinson Brothers, for example, which manufactured and treated their own stainless alloys, could boast of knives that were guaranteed to cut.[136] The success in developing stainless and cheaper scissors would not have been possible without mechanisation and the development of a more technically-educated manpower, indeed the re-training of craftsmen was integral to the tempering of stainless-steel.

Why, however, if the larger firms were making profits in their mechanised scissors departments did they not make profits overall? Large firms such as Wostenholm's simply did not respond rationally to market signals. Although they emphasised the profitability of their mechanised scissors departments they nevertheless continued to place many resources behind the manufacture of the highest quality hand-crafted pocket-knives. The explanation of this must, in the final analysis, be cultural: the core-values of product quality and craft skills continued throughout the inter-war years to act as a 'defective compass', discouraging large-scale manufacturers from making a more complete switch into cheaper mass markets. Thus, as Garlick has argued, Sheffield retained its fame as a producer of high-class cutlery, but the demand for these products accounted for only 5 to 10 per cent of the market. He considers, therefore, that "Sheffield proved unwilling or unable to cater properly for the huge demand for the cheaper and middle quality cutlery."[137] I believe that the emphasis should be placed upon unwilling. Had large firms placed more resources behind cheaper machine-made products, the new methods of industrial training may have had a much greater impact upon business performance. However, cultural constraints and the depressed conditions of the inter-war years made large-scale reorganisation of the industry unlikely.[138] Chapter 7 argued that it is extremely difficult to change business culture and that over the short-run manufacturers should perhaps stick with strategies that suit the culture, however, I believe that with regards to the cutlery sector such a prescription is invalid.

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[133] *Quality*, vol.1, no.3,(December 1929), p.6.

[134] *Ibid.*, p.10; John Nowill and Sons Ltd. was an important manufacturer of safety blades for Gillette type razors, *Sheffield Workmanship*, p.89.

[135] *Sheffield Workmanship*, p.15.

[136] *Ibid.*, p.89.

[137] P. C. Garlick, "The Sheffield Cutlery and Allied Trades and Their Markets in the Eighteenth and Nineteenth Centuries" (Unpublished thesis, Sheffield University, 1951), pp.62-63.

[138] Pollard, *History of Labour*, p.291.

Whilst specialist steel producers, as chapters 4 and 7 argued, found a growing market for their products with customers drawn from important new industries such as motor-vehicles, aeroplanes and chemicals, the demand for quality cutlery was a declining one from the late nineteenth century onwards. By sticking with a strategy of quality production manufacturers ensured firstly that new training initiatives would have limited impact upon their performance and secondly that they would be bound to a long-drawn out process of industrial decline. Whilst booms such as that of the 1950s were able to disguise the problems in the cutlery sector, on each down-swing firms suffered more and more and by the 1980s little was left of Sheffield's most characteristic industry. Thus, over the twentieth century, the strategy of quality production for niche cutlery markets become subject to rapidly diminishing returns. Had manufacturers made a more effective response to the challenge of changed conditions in the late nineteenth century the fortunes of this sector may have been distinctly different. By the inter-war years, however, the window for opportunity had more or less closed, as foreign competitors had been allowed to acquire such a substantial lead in the manufacture of the cheaper classes of cutlery that they were able to import into Britain despite of a 33.3 per cent tariff.. Thus, whilst I accept that small firms pursuing traditional strategies did survive for long periods by exploiting the advantages of low overheads and skilled human resources which allowed for flexible specialisation, over the long-run the writing was on the wall for Sheffield firms as early as the 1890s. The profitability of firms mechanised scissors departments is an indicator of what perhaps could have been achieved if manufacturers had invested more in machinery and used the new-science based skills provided by the trades technical lectures more effectively. Indeed, the failure to move more rapidly into machine-based production meant that the seeds of more formal technical education fell on relatively barren ground.

Education, Training and Business Performance: A Conclusion

This thesis has contributed to two important debates: the historical debate on the role of education and training in Britain's relative economic decline, and the debate on the relationship between education, training and business performance. This conclusion provides a brief summary of the major findings of the thesis and identifies areas for further research. The conclusion is divided into two parts. Part one challenges the received wisdom which has identified alleged inadequacies in education and training as a major factor in the nation's relative economic decline prior to World War One, whilst part two emphasises the complex nature of the relationship between education, training and the economy. In particular, it rejects the popular notion that simply more or 'better' education will necessarily improve long-run business performance. It is emphasised that whilst education and training can provide firms with an important weapon in competitive markets, the impact upon their performance will be influenced by the appropriateness of the training to the business strategy and by the institutional and cultural context in which the education and training system operates. Indeed, as chapter seven argued, inappropriate macro-economic policies may severely dilute the contribution which investment in education and training can make to an organisation's competitive success.

I

Education, Training and Economic Decline

1870-1914

Many economic historians have alleged that, prior to World War One, Britain neglected technical and commercial education, and this contributed to her decline as a manufacturing nation. Some have blamed British business for being uninterested in technical education, whilst others have argued that the education system was unable or unwilling to provide industry with the technical and commercial personnel that it required. These demand- and supply-side failure arguments are not mutually exclusive: both are predicated upon the assumption of a 'second industrial revolution' which rendered rule-of-thumb methods redundant and which required a more science-based approach to manufacturing. In addition, many historians have argued that there was both a failure of demand and a failure to supply, and the two were self-reinforcing. The evidence which I have garnered from a sectoral analysis of Sheffield's steel and engineering trades, however, suggests that the role of education and training in Britain's relative economic decline prior to World War One may have been over-stated. Indeed, the question of decline in the steel industry is itself problematic as Sheffield firms became world leaders in the manufacture of alloy steels which were key products of the 'second industrial revolution.'

During the late nineteenth century, as chapter two emphasised, Sheffield's steel and engineering manufacturers became more and more vociferous in their demands for technical education. This demand was informed by increasing competition and the spread of protectionism, and manufacturers came to regard technical education as a strategic weapon in the battle for world markets. Initially the business demand was not broad-based, but following the development of specialist alloys, manufactures became more united in their demands for improved technical education. They clearly recognised that the development of these alloys had fundamentally altered the technological context in which they operated, and that this required important modifications in the traditional form of industrial training. In other words, they were acutely aware of the need to support the apprenticeship system with more formal education. By 1918, therefore, as chapter 4 argued, many steel manufacturers provided financial incentives to encourage their employees to attend evening classes, and a significant number of them also contributed to the endowment of the Sheffield University College. These contributions were stimulated by the growing need for scientific graduates who were capable of staffing research laboratories and of managing works departments. Moreover, some of Sheffield's family firms looked to the university to provide their sons with the scientific knowledge that would fit them for managerial succession, whilst technical education generally was viewed as a means of hastening product and process innovation, improving product quality, which was a core-value of the culture of the industry in Sheffield, and reducing the costs of production. The notion of a demand-side failure with regard to the steel industry can therefore be easily overdone. Indeed, as foreign competition intensified, the city's steel manufacturers also became major advocates of commercial education. During the 1850s they had had little interest in such matters, but they recognised that their market configuration had altered and that, if they were to extend or even maintain their trade, more attention would have to be paid to marketing, sales and distribution. In particular, they recognised that their goods would no longer sell themselves no matter how good their quality, and they therefore demanded more facilities for the teaching of modern languages. The evidence garnered from the steel and engineering sector of the city thus questions the received wisdom of an entrepreneurial complacency or unwillingness to respond to the challenge of changed conditions. Manufacturers recognised the changes in their business environment and demanded an appropriate shift in the methods of industrial and commercial training.

However, businessmen in the cutlery sector conform more closely with the stereotypical businessman who often appears in the work of historians such as D. H. Aldcroft and who valued traditional methods and plied traditional skills.[1] Whilst a culture based upon quality led to a series of product and process innovations in steel and engineering, in the cutlery sector the concern with product quality constrained technical change. As chapter 2 argued, mechanisation during the Edwardian period was limited. The city's firms continued to manufacture their products in much the same way as they had for centuries and industrial training continued to revolve around the apprenticeship system Apprenticeships were designed to provide workers with the broad skills that were required to support a strategy based upon flexible specialisation. Firms focused upon the manufacture of high-quality products, such as pocket knives, which were hand-crafted and turned out in thousands of patterns for specialist niche markets. Under these circumstances, manufacturers had little interest in technical education and the majority were dismissive of it. Moreover, they believed that quality cutlery *should* sell itself and they could therefore discern no need for commercial studies.[2]

Can cutlery manufacturers be criticised for this attitude? On this question there is scope for a variety of opinion. More, for example, has argued that as long as firms used technology that was intensive in manual skills such training was good enough. Indeed, he has claimed that, "...technical training failed to overtake apprenticeship...not because employers did not realise what their real requirements were, but because their requirements were met adequately by older methods."[3] This argument appears perfectly logical and it dovetails with the work of neo-classical economists who have suggested that so long as firms made profits they were perfectly rational to stick with existing methods of production and industrial training, particularly given the constraints under which they were forced to operate. That mechanisation was subject to numerous constraints is beyond doubt. Cutlery manufacturers experienced a range of market, structural, cultural and labour constraints, the latter two of which were particularly problematic. Cultural constraints derived from the historical development of the industry whose success had been built upon product quality and handicraft techniques. Thus, by the late nineteenth century, product quality had become firmly established as a 'sacred cow' of the business culture, and because machine-methods were believed to deliver an inferior product, manufacturers were reluctant to mechanise as they felt that this would damage their good-name. In addition, skilled workers not only shared the ideological commitment to quality, but they had invested in a long apprenticeship and they saw machines as a threat to their craft status. They therefore resisted managerial attempts to incorporate machines into the production process. Moreover, because boys

[1] D. H. Aldcroft, "Investment in and Utilisation of Manpower: Britain and Her Rivals, 1870-1914", in B. M. Ratcliffe (eds.), *Britain and Her World, 1750 - 1914* (Manchester, 1975).
[2] However, there were exceptions, Wostenholm's, for example, reorganised its office and business methods and encouraged its employees to acquire more commercial education
[3] C. More, *Skill and the English Working Class, 1870-1914* (London, 1980), pp.219-220.

were usually apprenticed to a journeyman rather than directly to the firm, workers were in a strong position to oppose schemes of technical education which increased mechanisation would have required.[4] Thus, as Gospel has argued, "Where and how a worker acquires his skill is of fundamental importance, it effects his attitude towards these skills, his control over them and his attitude to technical change"[5] Indeed, More admits that learning by doing may foster an exaggerated respect for established methods and a reluctance to adapt new ones."[6] In this respect various factors may have reinforced one another: "...old fashioned plant and equipment furnishes a most hospitable environment for the perpetuation of old fashioned working habits and institutional arrangements (for example education and training), just as the hardiness of the latter might constitute an effective obstacle to more ambitious investment projects."[7] This was admittedly a difficult cycle to break, however, many manufacturers were not unaware of the activities of competitors in Germany and America who were mechanising production and supporting this with more formal technical education. Nor were they unaware that the demand for the cheaper machine-made cutlery was large and growing whilst the demand for quality cutlery, unlike that for quality steel, was small and declining. Thus, as Coleman and Macleod have argued, "Whatever its value as a short-run analysis...the neo-classical line raises some misgivings when considered in the long-term context....It assumes...deliberate choice on economic grounds to stick with the status quo. Consequently it does not distinguish rationality from inertia, ignorance or complacency."[8] Moreover, "It takes no heed of one essential element in business decision-making: the willingness to take risks on the new rather than staying safely with the old. "Rationality" in this sense may keep businessmen in business but it also means that they will never take a chance on moving ahead of their competitors."[9] Taking a neo-Schumpeterian perspective, therefore, it could be argued that "In failing to confront institutional constraints innovatively businessmen can justifiably be accused of entrepreneurial failure."[10] Indeed, I consider that the failure to mechanise prior to World War One, and to support this with policies of technical education, set the industry on a protracted process of decline. Although more efforts were made to mechanise and develop a more technically educated workforce during the inter-war years, it came as too little too late. By then the window

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[4]For a discussion of labour resistance to technical education, see S. Pollard, *A History of Labour in Sheffield* (Liverpool, 1959).
[5]H. F. Gospel, *Markets, Firms and the Management of Labour in Modern Britain* (Cambridge, 1992), p.8.
[6]More, *Skill*, p.84.
[7]Gospel, *Management of Labour*, p.182.
[8]D. C. Coleman & C. Macleod, "Attitudes to New Techniques: British Businessmen, 1800-1950", *Economic History Review*, vol.XXXIX, no.4 (1986), p.598.
[9]Ibid.
[10]B. Elbaum & W. Lazonick, "An Institutional Perspective on Decline", in B. Elbaum & W. Lazonick (eds.), *The Decline of the British Economy* (Oxford, 1986), p.2.

of opportunity had almost closed because foreign competitors had acquired such a large technological lead that they were able to penetrate the British market despite its being protected by a 33.3 per cent tariff. We therefore have ambivalent outcomes in the two broad sectors of the Sheffield metal trades and there is consequently a need to turn our attention to the development of the local education system.

Evidence can be garnered from the Sheffield case-study to support the argument that the education system developed with little connection to the needs of manufacturing industry. For example, by 1914 there were only two secondary schools in the whole of Sheffield, and the education provided by one of these schools (King Edward VII) was overwhelmingly classicist. The governors showed a complete disregard for business demands for commercial and technical education, and they consistently resisted the Board of Education's requests that the curriculum become more industrially oriented. The school's culture was set firmly within the liberal classicist tradition and it provides an ideal example of the Weiner thesis that England's education system was imbued with an anti-industrial spirit.[11] Indeed, King Edward's governors viewed technical education both as socially and intellectually second class. However, there are dangers in pushing the Weiner thesis too far, for not all of the education system conformed to this pattern. The Central Secondary School devised a scientific and technical curriculum and the city's extensive network of evening schools, which provided an education from the 3 "R"'s upwards of degree level, largely compensated for the inadequacies in the day system. There was an extensive provision of technical and commercial subjects and combined with the excellent apprenticeship training provided by many local firms this ensured that industry got the recruits that it needed: workers with a combination of practical skills and cognitive capabilities who would be able to fit themselves for promotion. In addition, the Sheffield University provided an excellent training in metallurgy and engineering. Its equipment and curriculum were praised throughout Europe. Although it did not produce many graduates, prior to World War One manufacturing industry was able to procure a large proportion of the available talent. Indeed, my database shows that, between 1900 and 1910, Sheffield firms provided employment for 60 per cent of the total cumulative population of metallurgy and engineering graduates from the Sheffield University, whilst manufacturing industry outside of Sheffield accounted for a further 14 per cent. Graduates became integral to research into specialist steel and, as departmental managers, they ensured the quality control necessary for the manufacture of the highest class of alloy steels. By 1919 approximately 70 Sheffield steel and engineering firms had recruited graduates from the local university and the Sheffield case-study thus challenges the received wisdom which claims that, prior to 1919, the majority of science graduates either went abroad or

[11]M. J. Wiener, *The Decline of the Industrial Spirit* (Cambridge, 1981)

entered the teaching profession because they were unable to find remunerative posts in British industry, which simply used graduates as analysts.[12] The case-study also raises important questions concerning the traditional caricature of education and training in Britain: the gentleman / player divide. Briefly stated, this caricature claims that top management was dominated by gentleman amateurs educated in the classics, whilst middle and lower management were composed of practical men who possessed little or no formal education, and who had simply worked their way up from the shop-floor. The result of this, it is argued, was an unholy alliance against technical education. Like all caricatures it has some explanatory power but the dichotomy between gentleman and players, and the homogeneity ascribed to top and middle management is far from convincing. As chapter 4 argued, technical education became an integral aspect of the training system in Sheffield's steel firms and it became a pre-requisite for promotion to positions of responsibility. In addition, scientific and technical graduates were not only to be found in middle but also in top management, at both large and small firms. Admittedly, as Edgerton points out, our historical picture of scientists and engineers working in industry remains sketchy, but my research and the recent research undertaken by Divall and Donnelly suggests that historians may have underestimated not only the number of science graduates working in industry but also the variety of the roles that they assumed.[13] Clearly much more empirical research needs to be done using sources such as alumni lists before we can reject or accept the argument of limited graduate recruitment, but at last questions are beginning to be asked of the empirical base upon which the gentleman / player divide has been based.

Having explored the question of business demands and educational provision, there is a need to explore the broader question of education, training and industrial decline. What is clear is that by investing in the technical education of their apprentices and by recruiting graduates, particularly from the local university, Sheffield firms were able to obtain a commanding lead over Germany and America in the manufacture of specialist

[12]G. W. Roderick & M. D. Stephens, *Science and Technical Education in Nineteenth Century England* (Plymouth, 1972); G. W. Roderick & M. D. Stephens, *Education and Industry in the Nineteenth Century: The English Disease* (London, 1978); J. P. Hull, "From Rostow to Chandler to You: How Revolutionary was the Second Industrial Revolution", *Journal of European Economic History*, vol.25, no.1 (Spring 1996).

[13]D. E. H. Edgerton, *Science, Technology and British Industrial 'Decline', 1870-1970* (Cambridge, 1996), p.25; J. F. Donnelly, "Industrial Recruitment of Chemistry Students from English Universities: A Reevaluation of its Early Importance", *British Journal of the History of Science,* vol.24 (1991); J. F. Donnelly, "Representatives of Applied Science, Academics and the Chemical Industry in Late Nineteenth Century England", *Social Studies of Science*, vol.6 (1986); C. Divall, "A Measure of Agreement: Employers and Engineering Studies in the Universities of England and Wales, 1897-1939", *Social Studies of Science,* vol.20 (1990); C. Divall, "Education for Design and Production: Professional Organisation, Employers and the Study of Chemical Engineering in British Universities", *Technology and Culture*, vol.35 (April 1994)

alloys, which they exported throughout the world in spite of increasing tariff barriers.[14] Indeed, it is significant that customers throughout the United States continued to purchase Sheffield alloy steels on account of their superior quality despite customs duties which made them four times as expensive as the nearest American equivalents. This makes the whole notion of decline in steel problematic. Although Britain was rapidly superseded by America and Germany in terms of the tonnage of the steel that it produced, in terms of its value per ton and high quality she remained pre-eminent. The evidence for Sheffield therefore suggests that we may have to qualify the emphasis that has been placed upon 1870 to 1914 as marking a fundamental climacteric in British industrial development. Britain clearly fell behind Germany and America in terms of the quantitative output of steel and in this sense it is meaningful to discuss relative decline, but relative decline should not be conflated with failure.[15] By and large Sheffield steel manufacturers did not fail, they followed a high-quality high-skills approach, and in a key industry of the 'second industrial revolution' they acquired a significant technological lead. This begs questions of the argument that "from the last decades of the nineteenth century Germany and America became the main source of innovation in science-based industries", and that "the paucity of technical manpower may have retarded innovation and impeded performance in Britain."[16] In addition, it casts doubt upon Chandler's assertion that success in the science-based industries of the 'second industrial revolution' depended upon a three-pronged investment in large-scale plant and distribution facilities and an extensive managerial hierarchy.[17] Although some specialist steel firms were large-scale concerns, many were small, and even the larger firms retained the characteristics of personal management. Nevertheless, they survived for long periods and enjoyed a good degree of business success by batch producing quality goods for niche markets using skilled and technically-educated labour. There is, as Sabel and Piore have argued, a craft alternative to the large-scale corporation which rejects mass production and yet is a model of technical advance.[18] Taylorism was not a central feature of the 'second industrial revolution' in Sheffield, as chapter 4 argued Taylorism was anathema to the business culture. Firms were more concerned with the quality of their output than the quantity, and they used the local education system to develop the technical expertise that their business strategy required. The case-study of Sheffield therefore serves as a salutary corrective to Aldcroft's

[14]These alloy steels could not be graded in the usual way - by the fractured surface of an ingot - because their properties were no longer solely determined by their carbon content. Technical education was therefore essential to the successful manufacture of these steels.

[15]Edgerton, *British Industrial 'Decline'*, p.4.

[16]H. F. Gospel, "Industrial Training and Technological Innovation: An Introduction", in H. F. Gospel (eds.), *Industrial Training and Technological Innovation: A Comparative and Historical Study* (London 1991), pp.7, 18.

[17]A. D. Chandler, *Scale and Scope: The Dynamics of industrial Capitalism* (Cambridge, Mass. 1990)

[18]M. J. Piore and C. F. Sabel, *The Second Industrial Divide: Possibilities for Prosperity* (New York, 1984)

extraordinary claim that "educational provision in Britain has never by any stretch of the imagination been geared to the world of work and industry."[19] The concept of decline and educational failure in cutlery is, however, much easier to substantiate, but nevertheless would more technical education alone have solved the industry's problems? Whilst it is clear that technical education was a prerequisite for the manufacture of alloy steels, it had little relevance to the production of hand-made cutlery in which Sheffield specialised. However, it was important to the manufacture of machine-made cutlery in which Germany and America excelled. Thus, we may return to the theory of business strategy which has stressed the importance of the inter-play of human and physical resources. An investment in technical education may have enhanced the worker's receptivity to new techniques, but without substantial mechanisation technical education was unlikely to have a major impact upon business performance. In any case, as was argued earlier, workers generally resisted managerial attempts to introduce new equipment and new training initiatives.[20] Moreover, the manufacturers cultural commitment to quality made them complacent in the face of environmental change. Thus whilst the special steel sector embarked upon a virtuous cycle of investment in new technology, such as the electric arc furnace, new products, such as high-speed steel, and new training initiatives, such as technical education; the cutlery industry was locked into a cycle of complacency characterised by traditional methods and traditional skills which were coming increasingly out of line with market demands and which contributed to its long-run decline. Indeed, cutlery manufacturers only really began to respond to the growing demand for cheap machine-made cutlery during the inter-war years, which period I now turn to discuss.

Inter-War Years

As Edgerton has argued, "most of the criticisms of British education cover the years before 1914, much less attention has been given to later decades even though we would expect the significance of technical education to have increased."[21] Nevertheless, the general consensus is that during the inter-war years business demands for technical, commercial and managerial education remained weak and businessmen generally neglected education and training as an essential investment in human resources. As chapter 5 argued, the Sheffield case-study provides some evidence to support these claims, however, the thrust of this chapter was that there were many positive aspects of

[19] D. H. Aldcroft, "Education and Britain's Growth Failure, 1950-1980", in G. Tortella (eds.), *Education and Economic Development Since the Industrial Revolution* (Valencia, 1990), p.226.
[20] There was clearly an acute need for management to break worker control over the work-process, but this was not easy in cutlery or in any other industry, see J. Melling, "Employers, Industrial Welfare and the Struggle for Workplace Control in British Industry, 1880-1920", in H. F. Gospel & C. R. Littler (eds.), *Managerial Strategies and Industrial Relations* (London, 1983); J. Lovell, "Employers and Craft Unionism: A Programme of Action for British Shipbuilding, 1902-25", *Business History*, vol.34, no.4, (1992).
[21] Edgerton, *British Industrial 'Decline'*, p22.

business demands which have been largely over-looked in the literature. For example, business requests that management subjects be integrated into science degrees in order to support the policy of promoting graduates to senior positions, and the demand for a special course of technical lectures which would improve the salesman's knowledge of the products he sold. This was symptomatic of business's need for a fuller integration of the key functional activities of production and distribution. Moreover, even cutlery manufacturers became more vociferous in their demands for technical education, in order to support the machine-based manufacture of stainless-steel knives, whose unusual chemical properties demanded a more scientific approach to manufacture.

Unfortunately, however, whilst business demands were becoming more sophisticated, the Sheffield case-study suggests that it was in this period that the education system began to fail manufacturing industry. As chapter 6 argued, economic depressions in the 1920s led to cuts in educational expenditure which culminated in a general deterioration in the standard of education provided at all levels of the system. In particular, it delayed the development of more vocational secondary schools and resulted in Sheffield University's curricula and equipment falling behind industrial needs. Moreover, although the university produced more metallurgy and engineering graduates during the inter-war period than prior to World War One, the numbers remained relatively small (no more than 60 per annum) and Sheffield firms were only able to procure 38 per cent of the cumulative graduate population, compared with 60 per cent prior to 1914. Thus, firms were unable to obtain either the quantity or quality of graduates that they required because the university failed to comply with their requests that managerial subjects be integrated into the metallurgy and engineering degree programmes and because more and more graduates turned to careers outside of manufacturing.

Management education generally was slow to evolve, and the two largest units of the inter-war steel industry, Vickers and United Steels, failed to develop their own management training programmes quickly enough to support the expansion of their business activities. The failure to train apprentices and to develop management training programmes, combined with inadequacies in the education system, led to acute human resource constraints when the economy recovered in the 1930s. The shortages of skilled labour constrained output and the lack of high-quality graduates was considered to be a factor in the slowing pace of innovation. This challenges the received view, articulated most recently by leading authorities such as Howard Gospel, that "with the exception of the two world wars there was usually an excess supply of labour including skilled craft labour and firms were able to recruit the scientific graduates that they required without difficulty."[22] More significantly, in spite of the building of a new technical school, the re-equipment of the university and an increased apprentice intake during the 1930s, Sheffield could not make up for a decade of neglect. As business needs for technical and managerial personnel burgeoned during the 1950s, the legacy of this neglect was a shortage of all classes of workers, ranging from operatives to technologists. These shortages were emphasised by numerous official reports including the white paper on technical education in 1956, the Crowther report of 1958 and the Robbin's report of 1963.[23] In Sheffield these human resource constraints manifested themselves in late deliveries and failing product quality, which allowed a window of opportunity for competitors to exploit. This may partly explain the central paradox of the 1950s: why Britain's growth rates were good but not as good as those of her competitors. Thus in terms of education, training and Britain's economic decline, the major finding of this thesis is that the period 1870 to 1914 did not preclude a high-skills route; rather, what made this route increasingly difficult were the cuts in educational expenditure during the 1920s, which as chapters 6 and 7 demonstrated, ensured that Sheffield, and probably Britain as a whole, entered the second half of the nineteenth century with insufficient skilled human resources and without the necessary educational infrastructure to quickly remedy this problem. However, what can this historical case-study tell us about the relationship between education, training and business performance?

II

Education, Training and Business Performance

Worswick has argued that:

> Education and the economy interact with one another. The state of the economy influences the volume of resources which will be made available for education and training. In the other direction the volume...of education and... training are likely to have effects favourable or otherwise on future economic performance.[24]

The Sheffield case-study clearly suggests that causation is, over the long-run, reciprocal, but the causal links from economic performance to educational provision are the easier to trace. During the period 1870 to 1914, a relatively successful local economy was able to generate the capital to finance a rapid expansion of elementary and higher education, but, as we have seen, failing performance in the 1920s led to retrenchment. National and local government placed severe constraints upon

[22] Gospel, Management of Labour, p.176; H. F. Gospel and R. Okayama, "Industrial Training in Britain and Japan an Overview", in Gospel (eds.) *Industrial Training*, p22.
[23] Sir G. Crowther, *Education: 15 to 18, A Report of the Central Advisory Council For Education* (London, 1959); *White Paper on Technical Education* (London, 1956)
[24] G. D. N. Worswick, "Introduction", in G. D. N. Worswick (eds.), *Education and Economic Performance* (Aldershot, 1985), p.1.

educational expenditure, and the Geddes Axe alone cut educational spending by a massive £6.5 million. This had a severe impact upon the quantity and quality of provision not only in Sheffield but throughout the nation. Equipment and syllabuses became antiquated and classes grew increasingly overcrowded. One can, therefore, easily see how economic performance may have important consequences for educational provision. Falling profits also undermined industrial training as the majority of employers reduced their apprentice intake and devalued the quality of their learning experience. However, the links are not direct: poor economic performance need not necessarily have such a profoundly negative impact upon the education and training system. The volume of resources made available to education and training is, to a large extent, influenced by the socio-institutional factors which shape the context in which choices are made. The decisions taken by statesmen and businessmen during the 1920s suggest that education and training were generally perceived as expediencies. It was this perception which ensured that failing performance would manifest itself in an acute weakening of the education and training system. Moreover, the form that this weakening took was also about choices: which sectors of the education system should bear the brunt of retrenchment, elementary, secondary, higher or vocational? Sheffield businessmen wanted a reduction in expenditure upon classicist secondary education for they believed that such education had little relevance to their needs. This is important for it suggests that there was an underlying tension between education and training and simply more education will not necessarily lead to long-run competitive success: the form and content, or in other words the appropriateness of the education and training provision, is also of vital importance.

To explore the importance of the appropriateness of education and training I focused upon the case-study of Thomas Firth and Sons. Thomas Firth and Sons was unusual in that, during the inter-war years, it continued to place a high priority on education and training. The management viewed human resource development as an essential factor in long-run performance and devoted substantial resources to education, training and general welfare work. The firm pursued a conservative prospector-type strategy, focusing upon sub- or improvement-innovations which would allow it to diversify into related markets and product lines. In order to support this strategy, it developed an excellent education and training system for its research and production staff, who were essential to the development of high-quality corrosion- and heat-resistant alloys. In consequence, the firm developed an international reputation for the quality of its products and for its innovatory capacity. Nevertheless, this did not enable the firm to enjoy an unusually good business performance, as chapter 7 argued it suffered in much the same way as other firms throughout the 1920s. A number of factors may explain this, but part of Firth's problems were related to the education and training of its salesmen which was inappropriate to the needs of the business strategy. Raghuram has argued that firms which pursue a prospector strategy should focus upon the training of sales and research staff, whilst Firth's did the latter it certainly did not do the former. Research staff were given an in-depth training which combined laboratory experience with a university education in metallurgy or engineering. Salesmen, on the other hand, simply underwent a tour of the firm, whilst some of them also obtained formal commercial education. They did not receive the technical instruction that they needed if they were to make an informed recommendation to customers, and understand the product and process innovations for which the firm became renowned. In order to identify and satisfy customer needs, therefore, they were forced into extensive communication with their research and production staff. This led to excessive transaction costs, delays in answering customer queries and ultimately culminated in lost business, which allowed a window of opportunity for less innovative companies to exploit. Clearly, therefore, there is a need for firms manufacturing and marketing technically sophisticated products to ensure that education and training not only acquires its fair share of the annual budget but that the resources are used most effectively. In other words, the education and training programme should be geared to deliver the expertise that the strategy requires. The Firth's case study emphasises that firms should think more carefully not only about their education and training programme but also their wider personnel policies. In particular, Firth's focus upon the education and training of their research and production staff during the 1920s, and particularly their policy of promoting such staff to the Board of Directors, led to suspicion and disillusionment in the sales function where staff had more limited scope for promotion. Indeed, Firth's personnel policies helped to breed a sub-culture in the area sales offices that was antithetical to the managerial ethos. This culture undermined Firth's attempts to develop a more technically-educated sales force later in the 1930s, as old salesmen, who valued the art of selling and the personality of the salesman, fought to resist the colonisation of their function by technical experts. Thus, earlier education, training and promotion polices were instrumental in forging a particular sub-culture which reinforced rigidities within the organisation and impaired its ability to change.

That education and training policies may create barriers to change is not often emphasised in the literature. Rather, education, training and economic change have been frequently linked. Indeed, it is often argued that education and training are vital to economic change and that economic change is in turn the motor of economic growth. The Sheffield case-study would appear to have a direct bearing upon this particular aspect of the education and training debate. In particular, it has revealed some of the rigidities that may arise from the development of internal labour markets (ILMs). It has, of course, been argued that British firms neglected education and training, and, in particular, education and training for promotion which would facilitate the development of ILMs. Gospel has been a major advocate of internal labour management, he considers that Britain's relative failure to develop ILMs may have been a factor in the nation's long-run competitive problems. For Gospel, ILMs are characterised by greater employee satisfaction and, in turn, greater productivity and profitability. However, he concedes that ILMs may bring disadvantages in terms of an inability to respond rapidly to environmental change. Nevertheless, he considers that, on the whole, strategies of internalisation will bring more advantages than disadvantages.[25] The Sheffield case-study questions this conclusion, indeed it suggests that the advantages of ILMs may have been over-stated and the disadvantages under-emphasised. Firth's dedicated investment in its human resources and its development of an ILM, at least for its production and research staff, for example, appears to have been a factor in its industrial equipoise, employee satisfaction and its excellent product quality, but during the inter-war years this did not translate easily into financial success. Another important company that was examined in chapters 4 and 7 was Vickers. Whilst its late nineteenth century policy of education, training and internal promotion may have supported its defender strategy, which was based upon the almost exclusive production of armaments, it created major problems for the firm in the inter-war years. Shifts in the business environment after 1918 required Vickers to diversify rapidly out of armaments and assume a prospector-type strategy. However, its old education, training and promotion policies inhibited such radical change. Internal promotion had led the firm to develop a particular type of human resource which found it extremely difficult to manufacture new peace products efficiently. In particular, internal promotion and the long involvement with armaments had fostered a culture based upon the core-values of exceptional product quality and reciprocal loyalty. Thus, the way things were traditionally done at Vickers frustrated the managerial attempts to produce for civilian markets, such as cuddly toys, which demanded less of a focus upon quality and more attention to price. Moreover, reciprocal loyalty discouraged management from dismissing long-service employees and recruiting new workers who would have been more suited to civilian work. Another leading armaments firm, Hadfield's, experienced similar problems. Hadfield's had a long tradition of educating and training its workforce for promotion, and the Board of Directors was dominated by company men, many of whom had over 30 years experience in the employ of the firm. In consequence, Hadfield's not only lacked the human resources to diversify into new product lines, such as motor vehicles, but also knowledge of where to find the human resources that diversification required. As a result, during the inter-war years, the firm appointed a series of incompetent managers to run its Bean car subsidiary which

[25] Gospel, *Management of Labour*, pp.179-183.

quickly ran into financial difficulties.[26] This is not to argue that ILMs are inappropriate, or that education and training for internal promotion cannot lead to higher business performance, but it reminds us that the risks of such strategies must be taken seriously, particularly in today's rapidly changing markets. ILMs may improve employee satisfaction and productivity, but firms may need to recruit from time to time from external sources in order to ensure that they retain more flexibility in the face of environmental change. A point which Gospel somewhat reluctantly accepts when he identifies a need for a combination of arrangements in labour management, which include internalisation, market forces, inter-firm co-ordination and government action."[27]

The issue of who should provide education and training will be considered later but for now it is important to stress that education and training for change is a more complex issue than contemporary debate on the subject allows. The trades technical movement, for example, which was explored in chapter 8 of this thesis, was designed to improve workers receptivity to new techniques and create a more flexible workforce which would facilitate industrial change and in turn it was hoped improve business performance. However, it was soon discovered that workers from crucible steel firms would not usually attend lectures on Siemens or electric technology, whilst workers whose firms employed Siemens furnaces were reluctant to follow lectures on other methods of steel-making. Rather, they attended lectures that appeared to be most relevant to their immediate needs: it is likely that this reinforced rigidities in the labour market rather than reduced them. Of course, the trades technical movement was a major vehicle for re-training in the cutlery industry where it was intended to support mechanisation but the culture of the industry, as chapter 8 argued, and, in particular, the core-value of product quality, continued to constrain the extent to which firms were prepared to mechanise, and this undermined the benefits that could have accrued from an increased investment in technical education. Thus, the Sheffield case-study suggests that education and training for change may be a noble but somewhat elusive goal.

Let us now consider education, training and business performance more generally. It would appear that the combination of on-the-job training and evening technical study was a major factor in Sheffield's competitive success prior to World War One. This is important for two reasons. Firstly, many historians have tended to dismiss evening education, simply assuming that more day education was what was required. Secondly,

[26]See SLSL, Hadfield's Chairman's Speech and Annual Report, 1920-1930; SCA, Hadfield's 8, Hadfield's Ltd, Shareholders Minute Book; for a detailed analysis of Hadfield's in the inter-war years, see G. Tweedale, "Business and Investment Strategies in the Inter-War Steel Industry: A Case-Study of Hadfield's Ltd and Bean Cars", *Business History*, vol.29, no.1, (1987).
[27]Gospel, *Management of Labour*, p.181.

recent studies of India and other developing nations have suggested that a combination of on-the-job learning and formal education is more effective in improving productivity than formal education alone.[28] However, here we run up against a problem for the relationship between education, training and business performance is likely to vary over time and space. The blend of evening study and on-the-job learning may have been particularly well adapted to Sheffield's needs in the late nineteenth century, and to the needs of modern-day India, but questions remain as to whether it is sufficient to meet the needs of today's advanced capitalist economies. Indeed, it may be that by the inter-war years the industrial demand for more formally qualified technicians and technologists was already beginning to make evening study less and less appropriate. Moreover, the experience of Sheffield during the inter-war years clearly indicates the contingent nature of the relationship between education, training and business performance. As chapter seven argued, the potential benefits accruing from education and training are strongly influenced by the business environment in which firms operate. Macro-economic policies play a major role in shaping this environment and if these polices are inappropriate, investment in education and training is unlikely to have a significant impact upon business performance. For example, during the inter-war years, Edgar Allen's and Firth's invested heavily in their human resources but this investment was undermined by unreciprocated free trade, deflation and the return to gold which severely overvalued the pound. These macro-economic policies effectively tied manufacturers hands, constraining business opportunities in both the domestic and foreign markets. Thus, both Firth's and Edgar Allen's found that their performance was not considerably better than that of other firms who neglected to invest in their workforce, and education and training did not pay anything like the dividends that it had done prior to World War One.

Nevertheless, how precisely may education and training impact upon business performance? The literature on human capital formation has suggested that education and training may improve economic performance by increasing employee satisfaction, productivity, product quality and the organisational capacity for innovation. The latter has figured highly in the work of Howard Gospel. He has explicitly stated that education and training will have a significant influence on the capacity for technological and other types of innovation, which, in turn, have greatly affected the business performance of firms and the international competitiveness of national economies.[29] Thus, in its simplest form Gospel's model may be stated as follows:

[28] J. B. De Long, "Productivity Growth and Machinery Investment: A Long-Run Look, 1870-1980", *Journal of Economic History*, vol.52, no.2, (1992); D. Ashton & F. Green, *Education, Training and the Global Economy* (Cheltenham, 1996).
[29] Gospel, "Industrial Training", p.1.

Increased investment in E & T-->More Innovation-->Improved Business Performance at the micro level of the firm-->Improved macro-economic performance.

This model appears plausible but the links between education training and long-run macro-economic performance are unlikely to be as straight forward as it implies. Whilst neo-Schumpeterians grant innovation a major role in economic growth, others have been more sceptical. Indeed, Edgerton has questioned whether investment in innovation is a major determinant of growth. He points out that innovation is a cost to the economy which only begins to pay off at the point of widespread diffusion.[30] What this suggests is a tension between micro- and macro-level concerns with innovation: for the individual firm, of course, the pay off is greater when the innovation remains for a long period poorly diffused, but for the economy widespread and rapid diffusion appears preferable. The Sheffield case-study may tell us something more about this debate. Firstly, prior to World War One, investment in the education and training of an expert research staff was integral to the development of specialist alloys which enabled some of the city's firms to achieve a high level of sales in protected world markets. Thus, investment in education and training appears to have been instrumental in facilitating routinised innovation and, in turn, sales and profitability. However, during the inter-war years, as the specialist steel industry became more mature, there was less scope for major innovation and also more firms working in the field. Investment in education and training for research, from the point of view of the firm, became subject to rapidly diminishing returns as innovations were invariably costly to develop, of a relatively minor nature and quickly copied by other manufacturers, who, in a context of depression, were desperate to procure the few orders that were available and therefore willing to push prices downwards, undermining profitability. If investment in education and training for research was to pay the dividends that it had done prior to World War One there was a need for rationalisation. Unfortunately, given the tenacity of personal capitalism, this was never likely. However, the major rationalised unit of inter-war specialist steel production was Firth-Vickers, and it is significant that its huge capital base enabled it to sustain an investment in education and training, particularly for the research function, which during the 1950s consolidated its position as a innovative organisation and won it a large proportion of the domestic market for stainless and heat-resistant alloys.[31] This again stresses the contingent nature of the effect that education and training may have upon business performance. Indeed, Fox and Guagnini have gone as far as to argue that "the economic, political and cultural context is crucial to the fostering, not just of educational development, but also of industry" and therefore "it is difficult to conceive of education and training as having in

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[30] Edgerton, *British Industrial 'Decline'*, pp.7, 9,12.
[31] *Enchridion*, vol.25, no.14 (Nov. 1959), pp.3-4.

any significant sense a direct causal effect on industrial performance."[32] This may be a little strong but I take their general point that "educational provision should not be conceived as anything but a part of a much broader mosaic of interrelated factors."[33] Thus, politicians and educationalists have frequently over-estimated the impact of education and training upon business performance, and have consistently over-simplified the nature of the relationship.

However, what about education, training and productivity? It is extremely difficult to explore this issue through an historical case-study due to the lack of data. Moreover, Sheffield manufacturers were generally less concerned with the effects of education and training on productivity than with their input into product quality. It would appear that the reputation of firms such as Firth's for product quality was influenced by education, training, internal promotion and welfare work which secured worker loyalty and enabled the firm to build and retain a stock of skilled human resources that emphatically identified themselves with the basic goal of product quality. However, whilst quality won firms important orders during the epoch prior to 1914, during the depressed conditions of the inter-war years many customers had to be cajoled into buying Sheffield's high-quality and therefore expensive steels. When more buoyant times returned in the 1950s, quality products were once again in demand but unfortunately the city's under-investment in education and training during the 1920s resulted in shortages of skilled labour which manifested themselves in failing product quality and an inability to meet orders and deadlines. Failing product quality in the 1950s is interesting, for, as Landymore has argued, very long lags are probably involved in any real throughput from investment in education and training to economic performance.[34] The Sheffield case-study would suggest that the same applies to educational retrenchment. Although human resource constraints emerged almost immediately upon economic recovery in the 1930s, the real problems emerged in the 1950s, when skilled labour shortages prevented firms from taking the fullest advantage of the 'golden age of capitalism'. Of course, it is impossible to be certain of the extent of the impact of these human resource constraints upon business performance. One would require at the very least a counterfactual model of the industry's likely development had sufficient skilled labour been available, and such models are not only notoriously difficult to construct but also notoriously easy to attack. Ultimately in this respect, as Aldcroft has argued, "the relationship between education training and economic performance is nebulous but this has not stopped (nor should it stop) much

[32] R. Fox & A. Guagnini, "Introduction", in R. Fox & A. Guagnini (eds.), *Education, Technology and Industrial Performance in Europe* (Cambridge, 1993), p.5.
[33] *Ibid.*, p.9.
[34] P. J. A. Landymore, "Education and Industry Since the War", in D. Morris, *Economic System in the United Kingdom* (Oxford, 1983), p.714

effort being devoted to trying to demonstrate that the two are positively associated."[35] Indeed, the Sheffield case-study clearly suggests that causation is ultimately reciprocal: the under investment in education and training in the 1920s was clearly a factor in the human resource constraints which undermined business performance some 30 years later. Thus, whilst investment in education and training may not guarantee success in the short-run, an inadequate investment in education and training may in the long-run spell failure.

However, who should provide education and training? The management of Firth's and Edgar Allen's clearly believed that investment in education and training would serve the interests of their companies and the national economy. Their ET programmes brought these firms some important advantages, they secured worker loyalty and they won them reputations as model employers and leading innovators. However, the financial success that the managements anticipated did not materialise, at least not over the short and medium-run. Thus, would Firth's and Edgar Allen's long term interests have been better served by leaving education and training to the state? This is not an easy question to answer. The firms bought the human resource gospel uncritically and this may have blinkered them to the reality that education and training does not take place in a vacuum. As has already been argued, adverse macro-economic policies during the 1920s and growing foreign competition all conspired to dilute the benefits of the human resource strategy. However, if they had relied upon state provision alone, they would have been unable to procure the graduates that were essential to product innovation. Vickers, for example, recognised how important Firth's education and training scheme had been in establishing the company as a leading supplier of corrosion-resistant alloys and in a context of a tight graduate labour market it therefore sort to join forces with this firm. This amalgamation enabled Firth-Vickers to retain its position as Europe's leading stainless-steel producer throughout the 1950s.[36] Thus, over the long-run, Firth's investment in education and training was clearly of fundamental importance. Moreover, the Sheffield case-study highlights more generally the dangers of relying too much upon state initiative. As chapter 3 argued, educational provision in Sheffield was in fact more closely aligned with business needs prior to concerted state action than before. In particular, the 1902 Education Act severely damaged local attempts to provide a more industrially-oriented secondary school curriculum. Nevertheless, state funding was crucial to the overall expansion of the education system. What this thesis suggests therefore is a need for a variety of arrangements ranging from in-house firm provision to state initiative. Of course central to the development of an effective ET system is better communication between education, business and the state. However,

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[35]Aldcroft, "Britain's Growth Failure", p.224.
[36]*Enchridion*, vol.25, no.14, (Nov. 1959), pp.3-4.

here we confront a major problem for, historically, industry in Britain has been small-scale and atomistic and this has made concerted action extremely difficult, moreover manufacturing industry in the provinces has been noticeably divorced from the corridors of power. Before education and training provision can become more useful, however, channels of communication must be opened up, for, as this thesis has argued, the relationship between education, training and business performance is highly complex and contingent and this makes a nonsense of the quick-fix approach to education and training policy which, as Burgess has argued, has dominated the 1980s and 1990s.[37]

To conclude, the focus at the level of the firm and the industry has offered a means of asking different questions of the relationship between education, training and economic growth. The theories of business strategy and company culture have proved useful analytical tools, which have clearly shown the limits of what investment in education and training may achieve. However, the lack of detailed historical records has made it difficult to examine education and training for every occupational level. This is one reason why I suggest that further research should focus upon the post World War Two era. Another is the importance that this thesis has attached to human resource constraints which undermined business performance in the 'Long-Boom'. Furthermore, such a study would afford an excellent opportunity to examine the development of the service economy as Britain entered a post-industrial era. By using the theories of business strategy and organisational culture, any future study might focus upon education and training policy in one or two firms in the service and manufacturing sectors of the economy. This would enable us to reveal more clearly the level of detail which, lurks behind aggregate generalisations thereby contributing to a more informed debate. In particular, as this thesis has shown, there is no unilinear development; provision between 1880 and 1919 was adequate and there was an emergence of a reciprocal relationship between local industry and local education. The long-run development of such a relationship, however, was damaged by external (macro-economic) factors which impacted both on the providers and receivers in different ways. In other words, investment in human resources operates at a variety of levels: the firm, the local authority and the state, and is vulnerable to radical shifts, for example the 1902 Education Act which impaired local efforts to provide an industrially-oriented curriculum and the return to Gold in the inter-war years which placed British exports at a cost-disadvantage. Moreover, superimposed upon these radical shifts are industry specific outcomes, in particular this thesis has stressed the stark differences in the

[37]Of course, in the late nineteenth century a lot of education was developed locally, and local business could influence local provision but today with the national curriculum there is a need for more nation-wide business organisations which can communicate business needs outside of narrow provincial interests.

technological paths of the Sheffield specialist steel and cutlery sectors and the role of education and training in navigating these paths.

Appendices

Appendix A: Database Design: Methodology, Problems and Issues.

It is not my intention here to go into the intricate detail of database design. Rather, I will provide a brief outline of the 3 basic stages in the life-cycle of a database: conceptual design, physical design and querying. For those who want to explore these stages in detail, I recommend the following texts: C. Harvey and J. Press "The Business Elite of Bristol: A Case-study in Database Design", *History and Computing* vol.3, no.1, (1991); C. Harvey & J. Press, "Structured Query Language and History and Computing", *History and Computing*, vol.5, no.3, (1993); C. Harvey, "Relational Data analysis: Values concepts and Methods", *History and Computing*, vol.4, no.2, (1992); J. Bradley, "Relational Database Design and the Reconstruction of the British Medical Profession", *History and Computing*, vol.6, no.2, (1994); J. Champion, "Relational Databases and the Great Plague in London 1665", *History and Computing* vol.5, no.1, (1993).
Those with an interest in database design should especially consult the work of Harvey and Press, from which much of the following is derived.

Glossary of Technical terms:

Entities
The objects which we are interested in and about which we hold data (in my database for example, students)

Attributes
Properties of entities, in other words, a set of data which describe an entity (for example student name, sex etc.)

Database
An organised list of data that provides a way of finding information quickly and easily, based upon a chosen reference point. The most common databases are tables containing rows and columns filled with data. In the jargon, columns are referred to as fields, and rows as records.

Relational Database Management System
A complex piece of software, such as 'Access' or 'Oracle', which maintains and controls the database.

Structured Query Language
A non-procedural language, the user specifies what is to be done, rather than telling the system how to do it.

Query By Example
A novel user-friendly feature of Access which allows the user to insert search criteria into the desired fields, via the query window. Behind the scenes, however, Access is actually constructing the equivalent SQL statement, which may subsequently be viewed or edited.

Methodology:

There are 2 main approaches to database design: model-driven and source-driven. The latter approach simply results in a collection of data, but the former produces a collection of data that is organised in a pre-determined way, according to a set of logical rules. The approach which I adopted was model-driven, in particular, the blue-print for the database was constructed by a process known as 'Entity Relationship Modelling' (ERM). ERM is a top-down method of database design. In other words, the designer begins by taking a wide view of the subject and progressively adds further levels of detail. Thus, in designing my database I followed the 6 point programme outlined below:

1. Identify the main object of interest: the career profiles of applied science bachelors, doctors, masters, associates and work's pupils from Sheffield University and its antecedent the Sheffield Technical School.
2. Select criteria for inclusion in the database: a, all students who qualified as bachelors, doctors, masters, associates, or work's pupils in engineering or metallurgy at the Sheffield University between

1890 and 1942. b, all organisations that students worked in subsequent to their university training between 1890 and 1929.

3. List the principal entities: student, qualification, organisation.
4. Identify relationships between entities.
5. Draw initial ERM diagram.
6. Investigate problems with ERM diagram and revise model: the aim of entity relationship modelling is to structure data in its simplest and most effective form. This requires that relationships between entities be one to many. The aim of entity relationship modelling is thus to remove many to many relationships. Many to many relationships exist when many occurrences of entity A can be associated with many occurrences of entity B, for example, a graduate may, during his career, work in many organisations and an organisation may employ many graduates. I solved this problem by creating a new link entity which I called membership.
7. List attributes associated with each entity (for example Student, - student name, sex; Organisation - organisation name, type, location etc.
8. Construct final ERM diagram.

Physical Design:

I used Access, a relational database management system to store the data in related tables. For example:

Student

Student_No	Student_Name	Sex
121	Joe Bloggs	m
(Primary Key)		

Qualification

Student_No	Qualification	Subject	Year of Award
121	Bachelor	Metallurgy	1920
121	Master	Metallurgy	1922
(Foreign Key Link)			

Membership

Student No	Organisation_Name	Organisation Type	Year of Alumni
121	Vickers	Armaments firm	1923
(Foreign Key link)			

In the student table, the student number is a primary key that uniquely identifies a particular student, in this example Joe Bloggs. In a relational database, tables are linked by a common field, in this example the student number is a foreign key link in the qualification and membership tables. This link enables us to use structured query language, or Access' user friendly query by example facilities, to retrieve data from many tables using a single query. Thus, a powerful feature of RDMS is the ability to join multiple tables and retrieve the combined information as a single list.

For example, how many metallurgy graduates were employed by Vickers in 1903:

Query 1: Metallurgy Graduates Employed By Vickers in 1903

Student No	Student Name
121	Joe Bloggs
289	Fred Elms
357	George Stevens

Problems and Issues:

As usual, the main problem for historians interested in pursuing a particular topic is one of sources:

1. Although we have full lists of the graduates and associates turned out by Sheffield University, the alumni records which chart the employments of graduates are usually incomplete, in that some students are listed without any indication of the organisation they are working in. Nevertheless, we invariably have good details for between 65 per cent to 100 per cent of the cumulative graduate population and this is sufficient for us to make conclusions as to student careers. (For example, the 1905 alumni lists will give details of where graduates and associates, who qualified between 1897 and 1905, were employed in 1905; the 1910 alumni lists will give details of where graduates and associates, who qualified between 1897 and 1910, were employed in 1910)

2. When students appear in the alumni lists without any details of the organisations they are in, we simply do not know if they are unemployed, if the university has lost touch with them, or even if they have died. The lists are most comprehensive in the early years, 1900 to 1910, when the cumulative graduate population was smaller and most graduates worked in local firms. (In these years we usually have good details on over 80 per cent of the cumulative graduate population). In the 1920s many graduates (sometimes about 30 per cent of the cumulative graduate population) are listed without any details of the organisation they worked in. This was symptomatic of the fact that more students were leaving Sheffield and finding jobs elsewhere. (It was of course, more difficult for the university to keep in touch with more and more graduates - many of whom left the locality.)

3. Unfortunately, there were no alumni lists available for the period 1930 to 1940. Ideally, one would have wanted these lists, for the period after 1933 was significant in that it marked Sheffield's revival following the trade depressions of the 1920s and 1930s. In the absence of such lists the historian is forced to rely upon the testimony of contemporaries. This testimony, as chapters 5 and 6 will argue, consistently referred to industrial demands for graduates outstripping the supply, and this may have been related to the trend identified in the 1920s for more and more graduates to embark upon careers outside of Sheffield industries and outside of British manufacturing in general.

Key to Organisation Type in the Organisation Table of the Database:

BAS	British Armed Services
BE	British Education
BMFS	British Manufacturing Foreign Subsidiary
BM	British manufacturing
BMI	British Mining Industry
BPU	British Public Utilities
BRA	British Research Association
BSI	British Service Industry
CS	Consular services
FAS	Foreign Armed Services
FE	Foreign Education
FM	Foreign Manufacturing
FMI	Foreign Mining industry
FMSIB	Foreign Manufacturing Subsidiary in Britain
FPU	Foreign Public Utilities
SAD	Sheffield Automobile Distributor
SB	Sheffield Basic (Producers of iron and steel including foundries)
SC	Sheffield Cutlery (including pure fabricators and integrated concerns producing both cutlery and basic steel)
SCE	Sheffield Consulting Engineers (these firms invariably provided not only advice and assistance to tool and engineering firms but also manufactured their own products, therefore, this thesis regards them as an integral part of the manufacturing community)
SCM	Sheffield Consulting Metallurgists (these firms invariably provided not only advice and assistance to tool and engineering firms but also manufactured their own alloy steels, therefore, this thesis regards them as an integral part of the manufacturing community)
SCS	Sheffield Consular Services
SCT	Sheffield Cutlery and Tool Producers (Cutlery and tool producers combined, including pure fabricators and integrated concerns
SE	Sheffield Education

Key to Organisation Type in the Organisation Table of the Database (Continued)

SM	Sheffield Manufacturing (a miscellaneous category for those firms that do not fit easily into the STE, SB, SC classifications, for example electrical goods producers and automobile accessory manufacturers)
SMFS	Sheffield Manufacturing Foreign Subsidiary
SMI	Sheffield Mining Industry
SPU	Sheffield Public Utilities
ST	Sheffield Tourist Site
STE	Sheffield Tool and Engineering Firms (tool and engineering goods producers, including pure fabricators and integrated concerns producing both tools, engineering goods and basic steel .)
Z	Unknown.

(Source: Eason Database (Alumni MDB) 1997, constructed from Sheffield University Applied Science Department Alumni Lists in *Sheffield University Applied Science Prospectus, 1905-1931*, *Sheffield Technical School Prospectus, 1897-1904*)

Key to Organisation Size in the Organisation Table of the Database

Size	Rateable Value (£)
Small	1 - 150
Medium	151 - 500
Large	501 - 1500
Giant	1,501 +

(Source: M. J. Lewis, "The Growth and Development of Sheffield's Industrial Structure, 1880-1930" (Unpublished PhD, Sheffield City Polytechnic, 1989). For a discussion of using rateable value as a proxy for size, see esp. chapter 1 of Lewis' thesis.)

Appendix B:

Table One: List of Promised Donations to the Sheffield University College Building Fund (1902) and the Sheffield University New Buildings and Endowment Fund (1903)

Firm / Manufacturer	1902 Fund (£)	1903 Fund (£)	Total (£)
Sir Frederick Mappin	2,000	5,000	7,000
Vickers Sons & Maxim Ltd.	2,000		2,000
John Brown & Co. Ltd.	1,000		1,000
C. Cammell & Co. Ltd.	1,000		1,000
Edward Firth	1,000		1,000
Thomas Firth & Sons Ltd.	1,000		1,000
Jonas & Colver Ltd.	500	500	1,000
C. W. Kayser	500	500	1,000
F. Mappin	500	500	1,000
Further 10 Firms each gave -	500		500
Further 10 manufacturers each gave -	500		500
8 firms each gave -	300		300
31 manufacturers each gave -	300		300
45 Firms each gave -	105 - 125		105 - 125
E. Willoughby Firth	100	500	600
64 Firms each gave -	25		25

(Source: List of promised Donations to the Sheffield University College (Sheffield 1903), in SCA, records of Firth-Brown Ltd., Firth-Brown Box 261.)

Table Two: List of Sheffield Firms which Recruited Graduates / Associates in Metallurgy and or Engineering From the Sheffield University and Its Antecedent the Sheffield Technical School, 1900 - 1919.

Org_Name	Org_Type	Org-Size 1901
Cupola Works	SB	M
J. Shipman & Co.	SB	L
J.J. Habershon & Sons	SB	L
R. Hyde & Sons Ltd.	SB	S
Rotherham Forge & Rolling Mills Co. Ltd.	SB	L
Sheffield Annealing Works	SB	S
Sybry Searles & Co. Ltd.	SB	M
Vernadium Steel Co. Ltd.	SB	U
W. Smith & Co Ltd.	SB	S
W.T.Beesley & Co. Ltd.	SB	M
Joseph Rodgers & Sons Ltd.	SC	G
P. Asjbury & Sons	SC	M
J. & P. Hill Engineers	SCE	S
Longmuir & Swinden	SCM	S
Boswell Son & Naylor	SCT	S
Thomas W. Ward & Sons Ltd.	SCT	M
J.T. Dobb & Sons Ltd.	SM	S
Jessop & Co. Ltd.	SMFS / STE	U
Salamander Stahlwerke	SMFS / STE	U
Maltby Main Colliery	SMI	U
Amalgmas Co.	STE	M
Arthur Balfour & Co. Ltd.	STE	U
Bohler Bros. & Co Ltd.	STE	S
Brown Bayley's Steel Works	STE	G
Brown Firth Research Labs	STE	G
Cammell Laird & Co. Ltd.	STE	G
Cravens Ltd.	STE	G
Davy Bros. Ltd.	STE	G
Edgar Allen Ltd.	STE	L
Flockton, Tompkins & Co.	STE	S
George Senior & Sons	STE	L
H. Rossell & Co. Ltd.	STE	M
Hadfields Ltd.	STE	G
Hallamshire Steel & File Co. Ltd.	STE	G
Hattersley & Davidson	STE	M
Henry Bessemer Ltd.	STE	G
Howell & Co. Ltd.	STE	L
Ibbotson Bros. & Co. Ltd.	STE	G
J. & Riley Carr	STE	M
J. Beardshaw & Sons Ltd.	STE	L
J.J. Saville & Co.	STE	M
Jas Chesterman & Sons Ltd.	STE	S
Jno. Crowley & Co. Ltd.	STE	L
John Baker & Sons	STE	L
John Brown & Co.	STE	G
Jonas & Colver Ltd.	STE	L
Kayser Ellison & Co. Ltd.	STE	G
Marshall Sons & Co. Ltd.	STE	S
Mining Engineering Co. Ltd.	STE	S
Muxlow & Knott	STE	S
Newton Chambers & Co. Ltd.	STE	L
Parkgate Iron & Steel Co. Ltd.	STE	L
Peace & Sons Wellmeadow Steel Works	STE	S
Princepes & Co.	STE	U
S.S. Brittain & Co.	STE	S
Samuel Fox & Co. Ltd.	STE	G
Samuel Osbourne & Co. Ltd.	STE	G
Sanderson Bros. & Newbould Ltd.	STE	G
Seebohm & Dieckstahl	STE	L
Spear & Jackson Ltd.	STE	L
Steel Peech & Tozer Ltd.	STE	L
Taylor & Co.	STE	S
Thomas Andrews & Co.	STE	S
Thomas Firth & Sons	STE	G
Thomas Garfitt & Sons	STE	S
Vickers Ltd.	STE	G
Vickers Sons & Maxim Ltd.	STE	G
W.S. Laycock Ltd.	STE	M

Wilford & Co. Ltd	STE	S
William Jessop & Sons	STE	G
William Turner & Son	STE	S
Worrall Bros. Ltd.	STE	S
Yorkshire Engine Co. Ltd.	STE	S

Key Org-Type:

SB	Sheffield Basic Producers of Iron and Steel
SC	Sheffield Cutlery
SCE	Sheffield Consulting Engineers (Provide advice and manufacture their own products)
SCM	Sheffield Consulting Metallurgists (Provide advice and manufacture their own products)
SCT	Sheffield Cutlery and Tool
STE	Sheffield Tool and Engineering
SM	Sheffield Manufacturing (A miscellaneous category covering electrical goods producers and automobile parts producers)
SMI	Sheffield Mining Industry
SMFS	Sheffield Manufacturing Foreign Subsidiary

Key Org-Size 1901:

G	Giant
L	Large
M	Medium
S	Small
U	Unknown

(Source: Eason Database (Alumni MDB) 1997, constructed from Sheffield University Alumni Lists, in Sheffield University Applied Science Prospectus 1905-1919, and Sheffield Technical School Prospectus 1900 -1904.)

Appendix C:

Table One: Machines and Tools Requested by William Ripper (Professor of Engineering) for the Re-equipment of the Engineering Department of the Sheffield Technical School, 1900.

Tool/Machine	Cost
6" Centre, Sliding, Surfacing and Screw Cutting Lathe (model II Loewe pattern)	
Hendey-Norton Tool Room Lathe with compound rest	
Flather lathe, 7" centre, 6 feet long and taper attachment	
Loewe Pattern shaper	
Gray Planer	
Loewe Universal Milling Machine	
Set of tools for Universal Milling Machine	
Herbert, no.2, Hexagon Turret Lathe	
Walker Cutter Grinder	
Loewe, no.2 drilling machine	
Herbert Sensitive Drill	
Diamond, no.1, Emery Tool Grinders	
Shaper Centres	
Taylor's shaper Vice	
External Limit Gauges	
Internal Limit Gauges	
Turning Arbors	
Reamers with straight shanks	
Reamers with taper shanks	
Adjustable Reamers	
Twist Drills	
Sundry machine shop tools	
Fixing	total cost: £1,162

(Source: Summary of a statement made by Professor Ripper, February 1900 at a meeting of the Technical Committee of the Technical School, in SUA VIII/1/2, Sheffield Technical School Minute Book, no.2, p.120.)

Table Two: Total Students in Sheffield University Applied Science Department and its antecedent the Sheffield Technical School 1889-1914 (Divided into Day and Evening Students)

	1889-90	1890-91	1895-96	1896-97	1897-98	1898-99
Total Senior Day (Metallurgy & Engineering)	23	35	61	51	41	46
Junior Day	15	36	58	49	55	Closed
Evening	159	447	463	455	490	606
Total	197	518	582	555	586	652
	1902-03	1903-04	1905-06	1906-07	1912-13	1913-14
Total Senior Day (Metallurgy & Engineering)	87	101	109	99	420	373
Junior Day						
Evening	1063	1203	1159	1232	1242	1290
Total	1150	1304	1268	1331	1662	1663

(Source: constructed from SUA VIII/1/1 - 4, Sheffield University Applied Science Dept. Minute Books, no. 1-4.)

Table Three: Awards in Metallurgy and Engineering Granted by the Sheffield University and its Antecednt, the Sheffield Technical School Prior to 1919

Type of Award	No. of Awards made 1897-1919
Associate	205
Bachelor	94
Master	20
Doctor	9
Work's Pupils' Certificate	23
Associate Member (Technical Society)	33
Member (Technical Society)	12
Graduate Member (Technical Society)	3
Student member (technical Society)	3
Total	**402**
Average number of awards per year 1897-1919	**18.27**

(Source: Eason Database (Alumni MDB) 1997, constructed from *Sheffield University Applied Science Department* and *Sheffield Technical School Prospectus, 1897-1920.*)

Note 1: These awards were won by **307 students**. Thus some students were associates, masters and doctors.

Note 2: The average number of awards per year would have been higher were it not for the outbreak of World War One which severely disrupted the university's activities.

Note 3: In addition to the 307 students who won the awards in the above table, the university also turned out about 400 trained analytical chemists.

Table Four A: Standards 1 and 6 of the Elementary Code

Standard One

Reading	A short paragraph from a book used in the school not confined to words of one syllable
Writing	Copying manuscript character a line of print and write from dictation a few common words
Arithmetic	Simple addition and subtraction of numbers of not more than 4 figures, and the 2X table.

Standard Six

Reading	To read with fluency and expression.
Writing	A short essay or letter: the composition, spelling, grammar, and hand-writing to be considered
Arithmetic	Proportion, vulgar and decimal fractions.

(Sources: E. J. R. Eaglesham, *The Foundations of Twentieth Century Education in England* (London, 1967); E. W. Jenkins, *From Armstrong to Nuffield: Studies in Twentieth Century Science education in England and Wales* (London, 1979.))

Table Four B: Scheme of Work in Elementary Science, a Class Subject
Under article 101 of the Elementary Code

Standard One	Standard Two
Thirty lessons on common objects, e.g.: a a postage stamp; the post; money; a lead pencil: a railway train, foods and clothing materials, as bread, milk, cotton, wool. minerals; natural phenomena as gold, coal, the day, the year	Thirty lessons on common objects, such as animals, plants, and substances employed in ordinary life, e.g.: horses, leaves, sparrows, roots, soap, stems, cork, buds, paper
Standard Three	Standard Four
Simple principles of classification of plants and animals. Substances used in the arts and manufactures. Phenomena of the earth and atmosphere.	Simple mechanical laws in their application to common life & industries. Pressures of liquids and gases. A more advanced knowledge of special groups of common objects, such as: Animals, or plants, with particular reference to (a) agriculture; or (b) substances employed in arts and manufactures; or (c) some simple kinds of (c) Some simple kinds physical and mechanical appliances: e.g. the thermometer, barometer, lever, pulley, wheel and axle
Standard Five	Standard Six
(A)Simple chemical laws in their application	(A) The commonest elements and their

to industries	their compounds.
Standard Five Continued	Standard Six Continued
(b) The principles and processes involved in one of the chief industries of England	(B) The mechanical powers.
(c) The physical and mechanical principles involved in the construction of some common instruments	
Standard Seven	
(a) Properties of common gases. (b) Sound, or light, or heat, or electricity, with applications.	

(Sources: E. J. R. Eaglesham, *The Foundations of Twentieth Century Education in England* (London, 1967); E. W. Jenkins, *From Armstrong to Nuffield: Studies in Twentieth Century Science education in England and Wales* (London, 1979.))

Table Four C: Scheme of Work in Mechanics Under Article 101 of the Elementary Code

1st stage	2nd stage	3rd stage
Matter in three states: solids, liquids, and gases. The mechanical properties in each state - Matter is porous, compressible, elastic elastic.	Matter in motion: the weight of a body, its inertia and momentum Measure of force and work	The simple mechanical powers: (1) the lever (2) the wheel and axle (3) pulleys (4) the inclined plane .
4th stage		5th Stage
Measurement as practised by the mechanic		Further study of: the wedge, the screw and Liquid pressure.
6th stage		7th stage
Measures of length, time, velocity and space		The hydro-static press, liquid under the action of gravity. The parallelogram of velocities, the parallelogram of forces

(Sources: E. J. R. Eaglesham, *The Foundations of Twentieth Century Education in England* (London, 1967); E. W. Jenkins, *From Armstrong to Nuffield: Studies in Twentieth Century Science education in England and Wales* (London, 1979.))

Tables 5 - 14 Employment of Sheffield University (Sheffield Technical School) Graduates and Associates in Metallurgy and Engineering: Cumulative Percentages of all Graduates / Associates for various years, 1900 - 1910

Table Five: % Distribution of the Employments of Sheffield Technical School's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1900) in 1900

Org_Type	%
Sheffield Tool and Engineering Firms	52
Sheffield Consulting Engineers	3.7
Sheffield Basic (producers of iron and steel)	3.7
British Manufacturing	11
Foreign Manufacturing	3.7
Sheffield Public Utilities	3.7
British Public Utilities	3.7
Unknown	18.5

Table Six: % Distribution of the Employments of Sheffield Technical School's Cumulative population of Graduates and Associates in Metallurgy and Engineering (1897-1901) in 1901

Org_Type	%
Sheffield Tool and Engineering	56.3
Sheffield Cutlery and Tool	3.1
Sheffield Consulting Engineers	3.1
Sheffield Basic (producers of iron and steel)	3.1
British Manufacturing	9.4
Foreign Manufacturing	3.1
Sheffield Public Utilities	3.1
British Public Utilities	6.3
British Education	3.1
British Armed Services	3.1
Unknown	6.3

Table Seven: % Distribution of the Employments of Sheffield Technical School's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1902) in 1902

Org_Type	%
Sheffield Tool and Engineering	52.8
Sheffield Cutlery and Tool	2.8
Sheffield Consulting Engineers	2.8
Sheffield Basic (producers of Iron and Steel)	2.8
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	11.1
Foreign Manufacturing	2.8
Sheffield Public Utilities	2.8
British Public Utilities	5.6
British Armed Services	2.8
Sheffield Education	5.6
British Education	2.8
Unknown	5.6

Table Eight: % Distribution of the Employments of Sheffield University College's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1904) in 1904

Org_Type	%
Sheffield Tool and Engineering	48.8
Sheffield Basic (producers of iron and steel)	9.3
Sheffield Cutlery and Tool	2.3
Sheffield Consulting Engineers	2.3
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	11.6
Foreign Manufacturing	7
Sheffield Public Utilities	2.3
British Public Utilities	4.7
Sheffield Education	4.7
Births Education	2.3
Unknown	4.7

Table Nine: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1905) in 1905

Org_Type	%
Sheffield Tool and Engineering	44.2
Sheffield Basic (producers of iron and steel)	9.3
Sheffield Consulting Engineers	2.3
Sheffield Cutlery and Tool	2.3
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	14
Foreign Manufacturing	7
Sheffield Public Utilities	2.3
British Public Utilities	4.7
Sheffield Education	2.3
British Education	4.7
British Manufacturing	2.3
Unknown	4.7

Table Ten: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1906) in 1906

Org_Type	%
Sheffield Tool and Engineering	42.4
Sheffield Basic	6.8
Sheffield Consulting Engineers	1.7
Sheffield Cutlery and Tool	3.4
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	16.9
Foreign Manufacturing	8.5
Sheffield Public Utilities	1.7
British Public Utilities	3.4
Sheffield Education	3.4
British Education	3.4
British Mining Industry	1.7
British Armed Services	3.4
Unknown	3.4

Table Eleven: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1907) in 1907

Org_Type	%
Sheffield Tool and Engineering	45.6
Sheffield Manufacturing Foreign Subsidiary	1.5
Sheffield Manufacturing	1.5
Sheffield Consulting Engineers	1.5
Sheffield Cutlery and Tool	4.4
Sheffield Basic	4.4
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	16.2
Foreign Manufacturing	7.4
Sheffield Public Utilities	1.5
British Public Utilities	2.9
Sheffield Education	4.4
British Education	2.9
British Mining Industry	1.5
British Armed Services	1.5
Unknown	2.9

Table Twelve: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1908) in 1908

Org_Type	%
Sheffield Tool and Engineering	45.7
Sheffield Manufacturing Foreign Subsidiary	1.2
Sheffield Manufacturing	1.2
Sheffield Cutlery and Tool	3.7
Sheffield Basic	4.9
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	17.3
Foreign Manufacturing	6.1
Sheffield Public Utilities	1.2
British Public Utilities	2.5
Sheffield Education	4.9
British Education	2.5
Sheffield Consular Services	1.2
British Mining Industry	1.2
British Armed Services	1.2
Unknown	4.9

Table Thirteen: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1909) in 1909

Org_Type	%
Sheffield Tool and Engineering	44.4
Sheffield Manufacturing Foreign Subsidiary	1.1
Sheffield Manufacturing	1.1
Sheffield Cutlery and Tool	3.3
Sheffield Basic	4.4
Sheffield Consulting Metallurgists	1.1
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	16.7
Foreign Manufacturing	6.7
Sheffield Public Utilities	2.2
British Public Utilities	3.3
Sheffield Education	3.3
British Education	2.2
Foreign Education	1.1
Sheffield Consular Services	1.1
British Mining Industry	1.1
British Armed Services	1.1
Unknown	5.6

Table Fourteen: % Distribution of the Employments of Sheffield University's Cumulative Population of graduates and associates in Metallurgy and Engineering (1897-1910) in 1910

Org_Type	%
Sheffield Tool and Engineering	48
Sheffield Basic	5
Sheffield Manufacturing	1
Sheffield Cutlery and Tool	1
British Manufacturing & Foreign Manufacturing Subsidiary in Britain	15
Foreign Manufacturing	5
Sheffield Public Utilities	4
British Public Utilities	4
Sheffield Education	6
British Education	2
Foreign Education	1
Sheffield Consular Services	1
British Armed Services	1
Unknown	6

(Source: Eason Database (Alumni MDB) 1997, constructed from Sheffield University Applied Science / Sheffield Technical School Alumni Lists in *Sheffield Technical School* and *Sheffield University Applied Science Department Prospectus, 1900 - 1910.*)

Table Fifteen: % of Sheffield University's Cumulative Population of Metallurgy and Engineering Graduates / Associates Employed in Manufacturing Industry, Various Years, 1900-1910

	1900	1901	1902	1904	1905	1906	1907	1908	1909	1910	1900 - 1910
% Employed in Sheffield Manufacturing	59.4	65.6	61.2	62.7	58.1	54.3	58.9	56.7	55.4	55	**59**
% Employed in British Manufacturing (exclusive of Sheffield)	11	9.4	11.1	11.6	14	16.9	16.2	17.3	16.7	15	**14**
% Employed in British manufacturing (inclusive of Sheffield)	70.4	75	72.3	74.3	72.1	71.2	75.1	74	72.1	70	**73**

(Source: Constructed from tables 5 - 14.)

Appendix D:

Profile of Mr. Collin Shaw:

Mr. Shaw began his career with Thomas Firth & Sons Ltd in 1909, at the age of 13. He received his practical training working in the Saw Department under the tuition of his father Mr Tom Shaw. But from his earliest days at work he was quick to appreciate the advantages of evening classes, and on several occasions took first prize in technical subjects in connection with the firm's educational scheme. He was transferred to the Norfolk Work's Repair Shop in 1915 and In 1916 he took his engineering group certificate at the Sheffield Technical School. He left Firths in 1918 and joined the Navy as an Engine Room Artificer. However, he returned to the firm at the age of 24 to take up the situation of Repair Shop Foreman at Tinsley, and soon afterwards he passed the examination for the Associateship of the Institute of Mechanical Engineers. Commenting on his career the Bombshell claimed that: "His example should serve as a spur to the many apprentices on the firm who are interested in technical education, for he is one of our own lads, having risen in the firm from apprentice to foreman."

(Source: *The Bombshell,* vol.6, no.6 (June 1922), p.228-231.)

Table One: No. of Sheffield University's Graduates / Associates in Metallurgy and Engineering Recruited by Sheffield's Largest Tool and Engineering Firms, 1900-1919.

Firm	No of Graduates, Associates, Work's Pupils' Certificates recruited 1900-1919
Vickers	15
Firth's	10 (including one graduate recruited for Firth's Russian subsidiary) Firth's also recruited from other universities including the Jesus College Cambridge and the Bradford and Bedford Technical Schools
Brown Bayley's	6
Hadfield's	7
John Brown's	8
Cammell Laird's	9

(Sources: Eason Database (Alumni MDB) 1997, constructed from Sheffield University Applied Science Department Alumni Lists, in *Sheffield University Applied Science Department Prospectus / Sheffield Technical School Prospectus, 1900 - 1919;* see also *The Bombshell, (*1917 - 1930.))

Table Two: Graduates and Military Specialists (who were non-family members) Promoted to the Board of Directors at Hadfield's and Spear and Jackson's

Company	Student Name	Qualification	Subject
Hadfield's	E. J. Barnes	Associate	Metallurgy
	W. E. Parker	Associate	Metallurgy
	W. J. Dawson	Associate	Metallurgy
	A. B. H. Clerke	Major	Army
	I. B. Milne	Bachelor	Metallurgy
Spear and Jackson's	F. F. Gordon	Bachelor	Metallurgy

(Sources: Eason Database (Alumni MDB) 1997); *The Mermaid; The Hadfield Bulletin;* SLSL, 338.4SQ,

Hadfield's Chairman's Speech and reports (Inter-War Years.))

Table Three: Family Firms and the Training of Sons for Managerial Succession: Sons who Qualified as Graduates or Associates in Metallurgy and Engineering at the Sheffield University 1897-1924

Org_Name	Org_Type	Org_Size 1901	Student Name	Type of Award	Subject
Boswell Son & Naylor	SCT	S	Boswell, Albert. J.	Associate	Metallurgy
Cornthwaite Bros.	STE	S	Cornthwaite, Stanley	Associate	Metallurgy
Cravens Ltd	STE	G	Craven, Alfred	Associate	Engineering
Edgar Allen	STE	L	Everitt, L. K.	Bachelor	Metallurgy
Ernest. H. Hill Ltd	STE	S	Hill, Ernest. H.	Associate	Metallurgy
Hattersley and Davidson	STE	M	Davidson, Albert	Member	Institute of mechanical Engineers
Howell & Co. Ltd	STE	L	Howell, Eric. E.	Associate Member	Institute of Civil Engineers
Howell & Co. Ltd.	STE	L	Howell, Clive. E	Member	Institute of Mechanical Engineers
J. & P. Hill Engineers	SCE	S	Hill, Alfred. P.	Associate	Engineering
J. J. Habershon & Sons	SB	L	Habershon, Percy. J	Associate	Metallurgy
John Baker & Sons	STE	L	Baker, George	Associate	Metallurgy
John Baker & Sons	STE	L	Baker, Henry	Bachelor	Engineering
John Baker & Sons	STE	L	Baker, Sidney. E.	Associate	Engineering
Muxlow & Knott	STE	S	Muxlow, Edgar. A.	Associate	Metallurgy
Mylan & Smith Engineers Ltd	STE	S	Mylan, William. F.	Associate	Engineering
Peace & Sons Well meadow Steel Works	STE	S	Peace, Herbert	Associate	Metallurgy

ORg_Name	Org-Type	Org-Size 1901	Student_ Name	Type of Award	Subject
R. Hyde & Sons Ltd	SB	S	Hyde, John. R.	Associate	metallurgy
S. S. Brittain & Co.	STE	S	Brittain, Lawrence	Associate	Metallurgy
Taylor and Co.	STE	S	Taylor, J. H.	Associate	Metallurgy
Thomas W. Ward & Sons	SCT	M	Ward, William	Associate	Engineering
W. Smith & Co.	SB	S	Smith, Charles. S.	Associate	Metallurgy
Worrall Bros. Ltd	STE	S	Worrall, Stanley	Associate	Metallurgy

Key:
Organisation Type

SB	Sheffield Basic (producer of iron and steel)
SC	Sheffield Cutlery
SCT	Sheffield Cutlery and Tool
STE	Sheffield Tool and Engineering

Key:
Organisation Size

S	Small
M	Medium
L	Large
G	Giant

(Source: M. Eason, Database (Alumni MDB) 1997, constructed from Sheffield University / Sheffield Technical School Alumni Lists in *Sheffield University Applied Science Department / Sheffield Technical School Prospectus, 1900 - 1924.*)

Note 1: many sons followed a university training in metallurgy and engineering at Sheffield University without qualifying as graduates or associates. For example, J. A. E. Wells of Edgar Allen's, Robert Balfour of Arthur Balfour and Co., Leslie Jackson Combe and D. J. Haggie of Spear and Jackson.

Note 2: Some sons of Sheffield manufacturers graduated at other universities, for example Percy Wilton Lee graduated from Cambridge where he studied metallurgy, engineering, economics and accountancy.

Note 3: Approximately 7 more graduates entered their family businesses in areas outside of Sheffield.

(Sources: *Edgar Allen News,* (1919-1940)*; The Mermaid* (1922-1929)*; Lee Steel, 1874-1974* (Sheffield 1974); *Arthur Balfour and Co. Ltd. 1865-1965, Centenary* (Sheffield, 1965.))

Table Four: Financial Data of Thomas Firth & Sons, 1893-1918

Year	Value Sales (£)	Net Profit (£)	Total Capital (£)	% Returns of net profit to total capital employed	Net Profit as a % of total sales
1893	245,538				
1894	273,383				
1895	301,714				
1896	384,947	61,761			16.04
1897	428,690	52,773			12.31
1898	421,619	87,855			20.84
1899	487,957	90,530			18.55
1900	586,559	140,204			23.9
1901	633,175				
1902	415,621	50,454	868,650	5.81	12.14
1903	469,990	62,348	865,651	7.2	13.27
1904	405,752	56,884	883,189	6.44	14.02
1905	483,879	82,853	942,075	8.79	17.12
1906	594,941	85,971	1,001,998	8.58	14.45
1907	503,362	51,702	1,205,312	4.29	10.27
1908	507,884	58,203	1,421,133	4.1	11.46
1909	533,653	69,265	1,463,344	4.73	12.98
1910	597,692	62,827	1,480,000	4.25	10.51
1911	709,388	99,693	1,541,126	6.47	14.05
1912	836,576	123,349	1,753,882	7.03	14.74
1913	1,067,746	159,004	1,817,750	8.75	14.89
1914	1,192,145	339,246	1,953,842	17.36	28.46
1915	2,601,470	265,639	2,855,149	9.3	10.21
1916	4,916,027				
1917	4,733,048				
1918	4,852,663	178,650	4,656,543	3.84	3.68

(Source: SCA, Records of Firth-Brown Ltd, Firth-Brown Boxes 85, 15.)

Table Five: Financial Data for Vickers Ltd., 1888 - 1914

Year	Ordinary Shares (£)	Preference Shares (£)	Profit After Tax (£)	Ordinary Dividend (%)
1888	750,000	750,000	70,154	4
1889	750,000	750,000	91,631	6.5
1890	750,000	750,000	95,372	7.5
1891	750,000	750,000	85,292	6.5
1892	750,000	750,000	87,235	6.5
1893	750,000	750,000	55,126	4
1894	750,000	750,000	102,868	7.5
1895	750,000	750,000	244,013	10+5 bonus
1896	750,000	750,000	285,369	10+5 bonus
1897	750,000	750,000	216,371	15
1898	1,000,000	1,500,000	347,470	15
1899	1,500,000	1,500,000	404,653	20 0n £1.25m 15 on £0.25m
1900	2,000,000	1,500,000	542,891	20
1901	3,300,000	1,500,000	646,332	15
1902	3,689,500	1,500,000	541,434	12.5
1903	3,689,500	1,500,000	556,121	10
1904	3,689,500	1,500,000	686,895	12.5
1905	3,700,000	1,500,000	787,778	15
1906	3,700,000	1,500,000	879,905	15
1907	3,700,000	1,500,000	768,525	15
1908	3,700,000	1,500,000	416,846	10
1909	3,700,000	1,500,000	288,044	10
1910	3,700,000	1,500,000	510,668	10
1911	3,700,000	1,500,000	641,686	10
1912	3,700,000	1,500,000	872,033	10
1913	4,440,000	1,500,000	911,996	12.5
1914	5,550,000	1,500,000	1,019,035	12.5

(Source: C. Trebilcock, *The Vickers Brothers: Armaments and Enterprise, 1854-1914* (London, 1977); J. D. Scott, *Vickers: A History* (London, 1962.))

Table Six: Profits at Arthur Lee and sons 1907-1915

Year	Net Profit (£)
1907	4412
1909	6000
1911	10000
1913	15355
1915	17961

(Source: Constructed from *Lee Steel, 1874-1974* (Sheffield 1974.)

Appendix E:

Table One A: Number of Pupils of 12 and Over in Secondary Schools on the Grant List in the Large Towns in England Expressed per 1,000 of Population and per 1,000 of the Number of Children in Public Elementary Schools

City	Population 1911	No. of Public Elementary School Children	No. of Full time pupils 12 and over in Grant Supported Secondary Schools	No. in Column 4 per 1,000 of the No in Column 2	No. in column 4 per 1,000 of the No in column 3
Hull	277,991	49,241	1,453	5.2	30
Bradford	288,458	44,054	2,384	8.3	54
Bristol	357,114	58,884	2,296	6.4	39
Leeds	454,155	76,113	2,620	5.8	34
Sheffield	460,183	82,277	1,043	2.3	13
Manchester	714,385	121,193	2,587	3.6	21
Liverpool	753,353	132,282	3,265	4.3	25
Birmingham	840,202	149,345	3,006	3.6	20
London	4,521,685	722,199	17,561	3.9	24

(Source: CA 321, Secondary School Sectional Sub-Committee Minute Book, no.2, p.27.)

Table One B: Number of Pupils of 12 and over in Secondary schools on the Grant List in the Large Towns in England expressed per 1,000 of Population and per 1,000 of the Number of Children in Public Elementary Schools

City	Population 1921	No Public Elementary School Children	No of Full-time Pupils 12 + over in Secondary Schools on the Grant List	No in Column 4 Per 1,000 of the no. in Column 2	No in column 4 per 1000 of the no in column 3
Hull	287,013	48,063	1,968	6.9	41
Bradford	285,979	35,824	4,473	15.6	125
Bristol	377,061	55,775	3,575	9.5	64
Leeds	458,320	70,412	4,449	9.7	63
Sheffield	490,724	83,470	2,740	5.6	33
Manchester	730,551	115,644	5,066	6.9	44
Liverpool	803,118	136,692	6,467	8.1	47
Birmingham	919,438	144,155	5,107	5.6	35
London	4,483,249	676,897	27,381	6.1	40

(Source CA 622 (6), Higher Education Sub-Committee Minute Book, no.8, p.32.)

Table Two: The Number of Students in Sheffield's Evening Schools, 1917-1924

Year	No. enrolled Technical Subjects	No. enrolled commercial subjects	Total Enrolled
1917-18			11,608
1918-19			9,815
1919-20			9,705
1920-21			9,815
1921-22	5,245	5,820	9,142
1922-23	1,763	3,193	6,436
1923-24	1,793	3,326	6,864

(Source: CA 622 (6), Sheffield Higher Education Sub-Committee Minute Book, no.8, (1924-26), p.320.)

Table Three: The Percentage of Sheffield's Ex-Elementary Pupils who Immediately entered Evening Schools, 1917-1923

Year	The percentage of boys who joined evening schools immediately after completing their day elementary education
1917-18	55
1918-19	35.5
1919-20	23.5
1920-21	22.7
1921-22	16.1
1922-23	15.4

(Source: CA 622 (6) Higher Education Sub Committee Minute Book, no.8, 1924 - 1926, p.320.)

Table Four: Results of Sheffield Junior Technical Schools Diploma Exams., 1936-38

Grade	1936	1937	1938
First	16.4	18.6	15.4
Second	27.9	37.2	15.4
Third	27.9	20.9	20.5
Fail	27.9	23.2	48.7

(NB. In order to obtain the diploma a student had to pass (i.e. obtain 40% of the marks) in exams in each of the following subjects: English, History, Geography, French, Metal work, Wood work, Maths, Physics, Chemistry, Mechanics, Geometrical Drawing, Machine Drawing. Failure in any one of these subjects would mean failure to obtain the diploma.)

(Source CA 626 (22 A), Junior Technical School Diploma Examination Assessment Advisory Committee Minute Book.)

Table Five: Employment Obtained by Pupils who Left Sheffield's Secondary Schools at Mid-Summer 1935

Boys No.	Girls No.	Total No.	Qualification	Occupation
38	6	44	HSC	University
1	1	2	HSC	Training college for teachers
	1	1	HSC	Central Day Commercial College
3	6	9	HSC	Student Teachers
	1	1	HSC	Works Laboratory
	1	1	HSC	Taking a course in commercial subjects
1		1	HSC	Civil Service
1		1	HSC	Secretarial Post
1		1	HSC	Shop Assistant
1		1	HSC	Insurance Office
9	1	10	SC	University
	2	2	SC	Training college
1	1	2	SC	College of Arts and Crafts
5	41	46	SC	Central Day Commercial College
3	1	4	SC	Transferred to other secondary schools
10	12	22	SC	Student Teachers
1		1	SC	Articled to law
1		1	SC	Journalism
1		1	SC	Commercial Traveller
1		1	SC	Fruit Merchant
1		1	SC	Surveyor
1	2	3	SC	Apprenticed to a pharmacy
1		1	SC	Plumbing
12		12	SC	Engineering
1		1	SC	Upholstery
1		1	SC	Spring maker
1		1	SC	Builders merchant
1		1	SC	Iron monger
6		6	SC	Works Laboratories
1	1	2	SC	Civil Service
2		2	SC	HM Forces
2		2	SC	Works Drawing Offices
48	34	82	SC	Clerical occupations, (banks, insurance offices etc.)
9	4	13	SC	Shop Assistants
1		1	SC	Parents Business
	7	7	SC	Required at home
3	17	20	SC	Taking Commercial subjects
1		1	SC	Studying privately
1		1	SC	Left the city
1		1	SC	Died
3		3	SC	Are working but no particulars
5	3	8	SC	Have not furnished information
11	10	21	SC	Have not yet obtained employment
21	14	35	Obtained neither HSC or SC	Entered clerical occupation
4		4	Obtained neither HSC or SC	Steel
1		1	Obtained neither HSC or SC	Timber

Boys No.	Girls No.	Total No.	Qualification	Occupation
2		2	Obtained neither HSC or SC	Engineering
1		1	Obtained neither HSC or SC	Plumbing
1		1	Obtained neither HSC or SC	Farming
1		1	Obtained neither HSC or SC	Tailoring
1		1	Obtained neither HSC or SC	Printing
1		1	Obtained neither HSC or SC	Hay and corn dealer
2		2	Obtained neither HSC or SC	Works laboratories
1		1	Obtained neither HSC or SC	Works Drawing Office
2		2	Obtained neither HSC or SC	Chauffeurs
1		1	Obtained neither HSC or SC	HM Forces
5	7	12	Obtained neither HSC or SC	Shop Assistants
	2	2	Obtained neither HSC or SC	Hairdressers
3	11	14	Obtained neither HSC or SC	Central Day Commercial College
1	9	10	Obtained neither HSC or SC	Taking courses in commercial subjects
	1	1	Obtained neither HSC or SC	Telephonist
	1	1	Obtained neither HSC or SC	Post Office Probationer
	1	1	Obtained neither HSC or SC	Ballet Dancer
	1	1	Obtained neither HSC or SC	Warehouse
3		3	Obtained neither HSC or SC	Errand boys
1		1	Obtained neither HSC or SC	Apprenticed to pharmacy
3		3	Obtained neither HSC or SC	At home owing to illness
18		18	Obtained neither HSC or SC	Transferred to other secondary schools
13	2	15	Obtained neither HSC or SC	Left the city
	3	3	Obtained neither HSC or SC	Needed at home
4		4	Obtained neither HSC or SC	Working but no particulars
2		2	Obtained neither HSC or SC	Have not furnished information
12	1	13	Obtained neither HSC or SC	Have not obtained employment
		500		

Key:
SC School Certifcate
HSC Higher School Certificate

(Source: CA 323, Sheffield Secondary School Sectional Sub-Committee Minute Book, no.8 (1935-37), pp.90-91.)

Table Six: Employment Obtained by Pupils who left Sheffield's Secondary Schools at Mid-Summer 1936

Boys No.	Girls No.	Total No.	Qualification	Occupation
29	9	38	HSC	University
2	4	6	HSC	Training College for Teachers
	1	1	HSC	Domestic Science College
5	2	7	HSC	Student Teachers
1	1	2	HSC	Civil Service
3		3	HSC	Business Posts
	2	2	HSC	Clerical Posts
8	1	9	SC	University
9	7	16	SC	Training College
2	1	3	SC	College of Arts and Crafts
2	46	48	SC	Central Day Commercial College
2		2	SC	Agricultural college
	1	1	SC	Domestic Science College
1		1	SC	Tutorial College
1		1	SC	Royal College of Science
2		2	SC	Wireless college
5	7	12	SC	Student Teachers
65	19	84	SC	Clerical Occupations (Banks, Insurance offices etc.)
10		10	SC	Engineering
3		3	SC	Steel
2		2	SC	Building
1		1	SC	Sheet metal
1		1	SC	Timber
1		1	SC	Mining
1		1	SC	Silver
1		1	SC	Coach building
2		2	SC	Ironmongery
2	24	26	SC	Commercial Subjects
3		3	SC	Accountancy
1		1	SC	Surveying
3	1	4	SC	Apprentices
9	1	10	SC	Laboratories
1	5	6	SC	Civil Service
2		2	SC	Royal Air Force
3	2	5	SC	Works Drawing Offices
	1	1	SC	Hair dresser
	1	1	SC	Viewer in an Engineering Works
1		1	SC	Optician
1		1	SC	Cashier
	4	4	SC	Employed at the Bennett College
1		1	SC	Employed on the Railway
	3	3	SC	Warehouses
1		1	SC	Messenger
	1	1	SC	Laundry
1		1	SC	Lorry Driver
1		1	SC	Canvasser
9	5	14	SC	Shop Assistants
1		1	SC	Helping in fathers business
	2	2	SC	Required at home

Boys No.	Girls No.	Total No.	Qualification	Occupation
1		1	SC	Studying privately
3	2	5	SC	Left the city
14	3	17	SC	Not furnished information
21	14	35	SC	Not yet obtained employment
2	19	21	Neither SC or HSC	Central Day Commercial College
	26	26	Neither SC or HSC	Taking courses in commercial subjects
19	13	32	Neither SC or HSC	Clerical occupations
3		3	Neither SC or HSC	Steel
1		1	Neither SC or HSC	Silver
2		2	Neither SC or HSC	Decorating
1		1	Neither SC or HSC	Cabinet making
1		1	Neither SC or HSC	Die sinking
1		1	Neither SC or HSC	Tube making
1		1	Neither SC or HSC	Hacksaw making
1		1	Neither SC or HSC	Joinery
1		1	Neither SC or HSC	Brewing
8		8	Neither SC or HSC	Engineering
2		2	Neither SC or HSC	Grocery
5		5	Neither SC or HSC	Laboratories
4		4	Neither SC or HSC	Works Drawing Offices
	1	1	Neither SC or HSC	Domestic service
	1	1	Neither SC or HSC	Waitress
5	11	16	Neither SC or HSC	Shop Assistant
	2	2	Neither SC or HSC	Hairdresser
	2	2	Neither SC or HSC	Telephonist
	3	3	Neither SC or HSC	Cashiers
1	2	3	Neither SC or HSC	Warehouses
1	1	2	Neither SC or HSC	Helping in fathers business
2		2	Neither SC or HSC	Apprentices
	5	5	Neither SC or HSC	At home owing to illness
	2	2	Neither SC or HSC	Needed at Home
20	8	28	Neither SC or HSC	Transferred to other schools
	2	2	Neither SC or HSC	Left the city
	2	2	Neither SC or HSC	Viewers in Engineering Works
2		2	Neither SC or HSC	Salesmen
1	1	2	Neither SC or HSC	Confectioners
	1	1	Neither SC or HSC	Dental Assistant
1		1	Neither SC or HSC	University
1		1	Neither SC or HSC	Having private tuition
1		1	Neither SC or HSC	Technical College
2		2	Neither SC or HSC	H.M. Forces
7	1	8	Neither SC or HSC	Have not yet furnished information
4	5	9	Neither SC or HSC	Have not obtained employment
		616		

Key:

SC School Certificate

HSC Higher School Certificate

(Source: CA 323, Sheffield Secondary School Sectional Sub-Committee Minute Book, no.8, (1935-37), pp.221-222.)

Table Seven: Sheffield Corporation Grants to the Applied Science Dept. Sheffield University, 1921-1929

Financial Year	Degree (£)	Non-Degree (£)	Applied Science Total £
1921-22	5,513	19,525	25,038
1922-23	6,818	20,102	26,920
1923-24	1,560	16,629	18,189
1924-25	2,000	14,771	16,771
1925-26	2,948	13,658	16,606
1926-27	4,857	11,970	16,827
1927-28	4,850	4,489	9,339
1928-29	4,838	4,072	8,910

(Source: A. W. Chapman, *The Story of a Modern University* (Oxford, 1955), p.343.)

Table Eight A: Awards in Metallurgy and Engineering and Technical Science, won by students at the Sheffield University 1919-1942.

Type of Award	No of Awards made 1919-1942
Associate	761
Bachelor	386
Master	128
Doctor	54
Work's Pupils' Certificate	50
Total	**1,380**
Average no. of awards per year, 1919-1942	**60**

(Source: Eason Database (Alumni MDB) 1997, constructed from *Sheffield University Applied Science Department Prospectus, 1929- 1932*; *Sheffield University Graduates and Associates to 1962* (Sheffield, 1962.))

Note: These awards were won by **1,119** students. Thus some students were associates, bachelors, masters and doctors.

Table Eight B: Sheffield University and Sheffield Technical School Awards in Metallurgy and Engineering Achieved by Students Prior to 1919

Type of Award	No. of Awards made 1897-1919
Associate	205
Bachelor	94
Master	20
Doctor	9
Work's Pupils' Certificate	23
Associate Member (Technical Society)	33
Member (Technical Society)	12
Graduate Member (Technical Society)	3
Student member (technical Society)	3
Total	**402**
Average number of awards per year 1897-1919	**18.27**

(Source: Eason Database (Alumni MDB) 1997, constructed from *Sheffield University Applied Science Department* and *Sheffield Technical School Prospectus, 1897-1920.*)

Table Nine: National and Higher National Certificate Awards at Sheffield University 1928-37

		1928-29		1929-30		1930-31		
Subject	Level	Pres.	Pass	Pres.	Pass	Pres.	Pass	Dist.
Mech. Eng.	HNC		9	13	10	19	17	8
Mech. Eng.	ONC		13	25	16	25	11	7
Elec. Eng.	HNC		3	3	1	3	2	
Elect Eng.	ONC		5	6	4	6	3	
Total			30	47	31	53	33	15

		1931-32			1932-33		
		Pres.	Pass	Dist.	Pres.	Pass	Dist.
Mech. Eng.	HNC	13	9	5	11	9	6
Mech. Eng.	ONC	19	12	4	33	23	16
Elec. Eng.	HNC	6	4		4	3	
Elec. Eng.	ONC	6	4		7	5	1
Total		44	29	9	55	40	23

		1935-36			1936-37		
		Pres.	Pass	Dist.	Pres.	Pass	Dist.
Mech. Eng.	HNC	14	8	5	15	6	3
Mech. Eng.	ONC	15	10	7	17	8	1
Elec. Eng.	HNC	7	3	2	5	2	
Elec. Eng.	ONC	11	6	2	8	1	
Total		47	27	16	45	17	4

		1937		
		Pres.	Pass	Dist.
Mech. Eng.	HNC	14	10	1
Mech. Eng.	ONC	42	18	3
Elec. Eng.	HNC	4	2	
Elec. Eng.	ONC	10	5	
Total		70	35	4

Key to Table Nine:

ONC	Ordinary National Certificate
HNC	Higher National Certificate
Dist	Distinction
Pre	Presented

(Source: constructed from SUA VIII/1/5 - 8, Sheffield University Applied Science Department Minute Books, no.5 - 8.)

Tables 10 - 15: Employment of Sheffield University (Sheffield Technical School) Graduates and Associates in Metallurgy and Engineering: Cumulative Percentages of all Graduates / Associates for Various Years, 1919-29

Table Ten: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1919) in 1919

Org_Type	%
Sheffield Tool and Engineering	42.2
Sheffield Manufacturing Foreign Subsidiary	0.4
Sheffield Manufacturing	0.9
Sheffield Cutlery and Tool	0.9
Sheffield Cutlery	0.9
Sheffield Basic (producers of iron and steel)	2.7
British Manufacturing, British Manufacturing Foreign Subsidiary & Foreign Manufacturing Subsidiary in Britain	18.8
Foreign Manufacturing	4
Sheffield Public Utilities	2.2
Foreign Public Utilities	2.7
British Public Utilities	4
Sheffield Education	2.7
British Education	0.9
Foreign Education	1.3
British Service Industry	0.4
British Armed Services	2.2
Unknown	12.6

Table Eleven: % Distribution of the Employment of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1921) in 1921

Org_Type	%
Sheffield Tool and Engineering	37.1
Sheffield Manufacturing Foreign Subsidiary	0.4
Sheffield Manufacturing	3.3
Sheffield Cutlery and Tool	1.1
Sheffield Cutlery	1.5
Sheffield Basic	3.4
British Manufacturing, British Foreign manufacturing Subsidiary & Foreign Manufacturing Subsidiary in Britain	17.3
Foreign Manufacturing	2.9
Sheffield Public Utilities	1.5
British Public Utilities	4.8
Foreign Public Utilities	3.3
Sheffield Education	2.2
British Education	2.2
British Service Industry	0.4
British Armed Services	2.2
Unknown	15.8

Table Twelve: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1923) in 1923

Org_Type	%
Sheffield Tool and Engineering	30
Sheffield Manufacturing	4.5
Sheffield Mining Industry	0.5
Sheffield Cutlery and Tool	1.1
Sheffield Consulting Engineers	0.5
Sheffield Cutlery	1.6
Sheffield Basic	2.4
British Manufacturing, British Manufacturing Foreign subsidiary & Foreign Manufacturing Subsidiary in Britain	17
Foreign Manufacturing	1.6
Foreign Mining Industry	0.5
Sheffield Public Utilities	3.2
British Public Utilities	5.6
Foreign Public Utilities	3.5
Sheffield Education	2.4
British Education	2.4
Foreign Education	1.3
British Service Industry	0.3
British Research Association	1.1

Org_Type	%
British Armed Services	2.1
Unknown	18.9

Table Thirteen: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1925) in 1925

Org_Type	%
Sheffield Tool and Engineering	28.2
Sheffield Manufacturing	2.9
Sheffield Mining Industry	0.2
Sheffield Cutlery and Tool	0.5
Sheffield Cutlery	1.1
Sheffield Basic	1.6
British Manufacturing, British Foreign Manufacturing Subsidiary in Britain & Foreign Manufacturing Subsidiary in Britain	18
Foreign Manufacturing	1.8
Foreign Mining Industry	0.2
Sheffield Public Utilities	2.4
British Public Utilities	7.5
Foreign Public Utilities	3.5
Sheffield Education	2.6
British Education	2.7
Foreign Education	0.5
British Service Industry	0.5
British Research Association	0.9
British Armed Services	2.4
Unknown	22

Table Fourteen: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1927) in 1927

Org_Type	%
Sheffield Tool and Engineering	27.8
Sheffield Mining Industry	0.3
Sheffield Manufacturing	3.3
Sheffield Cutlery and Tool	0.5
Sheffield Consulting Metallurgists	0.2
Sheffield Cutlery	1.1
Sheffield Basic	1.6
British Manufacturing, British Foreign Manufacturing Subsidiary & Foreign Manufacturing Subsidiary in Britain	18.9
Foreign Manufacturing	2
Foreign Mining Industry	0.2
Sheffield Public Utilities	3.1

Org_Type	%
British Public Utilities	6.7
Foreign Public Utilities	4.8
Sheffield Education	2.5
British Education	1.9
Foreign Education	0.5
Sheffield Tourist	0.2
British Service Industry	0.5
British Research Association	1.2
British Armed Services	2.3
Unknown	20.5

Table Fifteen: % Distribution of the Employments of Sheffield University's Cumulative Population of Graduates and Associates in Metallurgy and Engineering (1897-1929) in 1929

Org_Type	%
Sheffield Tool and Engineering	22.4
Sheffield Mining Industry	0.4
Sheffield Manufacturing	2.8
Sheffield Cutlery and Tool	0.2
Sheffield Consulting Metallurgists	0.2
Sheffield Cutlery	0.8
Sheffield Basic	1.2
British Manufacturing, British Manufacturing Foreign Subsidiary & Foreign Manufacturing Subsidiary in Britain	15.9
Foreign Manufacturing	2
Foreign Mining Industry	0.2
Sheffield Public Utilities	2.1
British Public Utilities	5.3
Foreign Public Utilities	3.8
Sheffield Education	1.7
British Education	1.7
Foreign Education	0.7
Sheffield Tourist	0.1
Sheffield Automobile Distributor	0.1
British Service Industry	0.3
British Research Association	0.3
British Armed Services	1.9
Unknown	35.8

(Source: Eason Database (Alumni MDB) 1997, constructed from Sheffield Univeristy Applied Science Department Alumni lists in *Sheffield University Applied Science Department Prospectus, 1919 - 1929.*)

Table Sixteen: % of Sheffield University's Cumulative Population of Metallurgy and Engineering Graduates / Associates Employed in Manufacturing Industry, Various Years 1919-1929

	1919	1921	1923	1925	1927	1929	1919-1929
% Employed in Sheffield manufacturing	48	46.8	40.6	34.5	34.8	28	39
% Employed in British manufacturing Exclusive of Sheffield	18.8	17.3	17	18	18.9	15.9	18
% Employed in British Manufacturing (Inclusive of Sheffield)	66.8	64.1	57.6	52.5	53.7	43.9	56

(Source: constructed from tables ten to fifteen.)

Appendix F:

Table One: Firth's Day Continuation: Sample of Examination Results 1927-28 Session

	First Year					Second Year				
Subject	Presented	1st	2nd	3rd	Fail	Presented	1st	2nd	3rd	Fail
Civics	51	8	8	19	16	42	13	16	10	3
English	52	12	21	5	14	43	16	18	6	3
Maths	52	9	6	9	28	42	19	8	8	7
Engineering Science	53	5	5	16	27	40	15	10	10	5
Engineering Drawing	51	13	8	9	21	38	24	5	4	5
Total	259	47	48	58	106	205	87	57	38	23
%		18			41		42			11

	Third Year				
Subject	Presented	1st	2nd	3rd	Fail
Civics	15	8	5	1	1
English	14	10	4		
Maths	14	9	1	3	1
Engineering Science	13	7	3	1	2
Engineering Drawing					
Total	56	34	13	5	4
%		61			7

(Source: constructed from *The Bombshell* (1928.))

Table Two: Pass Rates of Firth's Evening School Students 1918-19

	Pass All Subjects	Pass Some But Not All	Fail Completely
Percentage	42	49	19

(Source: constructed from *The Bombshell* (1919.)

Table Three: Sheffield University Associates and Bachelors in Metallurgy and Engineering Who Came Through Firth's and Edgar Allen's Training Programmes, 1917-1932

Company	Student Name	Type of Award	Subject	Year of Award
Firth's	Colclough, Tom. P.	Associate	Metallurgy	1918
Firth's	Black, Arthur	Associate	Metallurgy	1921
Firth's	Osborne, Alice. K.	Associate	Metallurgy	1921
Firth's	Goodsir, Thomas. B.	Associate	Engineering	1921
Firth's	Eadon, Eric. W.	Associate	Metallurgy	1922
Firth's	Staton, Roland	Associate	Metallurgy	1922
Firth's	Thornton, Albert. E.	Associate	Metallurgy	1922
Firth's	Gray, A.	Associate	Metallurgy	1922
Firth's	Allsop, Harry	Associate	Metallurgy	1923
Firth's	Barraclough, Sydney	Associate	Metallurgy	1923
Firth's	Stanfield, Arthur	Associate	Metallurgy	1923
Firth's	Priest, Olive	Associate	Metallurgy	1923
Firth's	Stevenson, Walter. W.	Associate	Metallurgy	1923
Firth's	Armitage, Arthur	Associate	Metallurgy	1923
Firth's	Cook, Thomas	Associate	Engineering	1925
Firth's	Hall, Douglas	Associate	Metallurgy	1927
Firth's	Sewell, Norman. M.	Associate	Metallurgy	1927
Firth's	Dent, Harry	Associate	Metallurgy	1928
Firth's	Shutt, Stuart. R.	Associate	Metallurgy	1928
Firths	Jubb, P.	Associate	Metallurgy	1930
Firth's	Jeffries, R.	Associate	Metallurgy	1931
Firth's	Burnan, W.	Associate	Metallurgy	1931
Firth's	Crosby, C. B.	Associate	Metallurgy	1931
Edgar Allen's	Higginbottom, Alfred	Master	Metallurgy	1918
Edgar Allen's	Kershaw, Harold. E.	Associate	Metallurgy	1920
Edgar Allen's	Swannack, Frank. C.	Associate	Metallurgy	1922
Edgar Allen's	Newhouse, Charles. E.	Associate	Metallurgy	1922
Edgar Allen's	Everitt, Leonard. K.	Bachelor	Metallurgy	1924
Edgar Allen's	Gregory, Arthur. H.	Associate	Metallurgy	1925
Edgar Allen's	Brook, Noel.	Associate	Metallurgy	1925
Edgar Allen's	Coles, Geoffrey. H.	Bachelor	Engineering	1925
Edgar Allen's	Bramley, Harry	Associate	Metallurgy	1927
Edgar Allen's	Parkin, Leonard	Associate	Engineering	1928
Edgar Allen's	Hewitt, Samuel. P.	Associate	Metallurgy	1928

(Source: Eason Database (Alumni MDB) 1997, constructed from Sheffield University Applied Science Department Alumni Lists in *Sheffield University Applied Science Department Prospectus, 1917 - 1929*; *The Bombshell*, (1917 - 1931), *The Edgar Allen News*, (1919 - 1932), *The Edgar Allen Works and Sports Magazine*, (1922- 1930)

Table Four : Sample of The Staff of the Brown-Firth Research Laboratories 1938

<u>Research:</u>

Director: W. H. Hatfield **(DMet, FRS)**
Assisted by:
Mr. G. Stanfield **(BSc, MEng, Member of the Institute Mechanical Engineers)**
Mr. J. Woolman **(MSc)**
Mr. H. J. Shirley **(BSc, ARCS)**
<u>Commercial:</u>

Mr. C. C. Hall
Mr R. Staton **(Associate Metallurgy)**
Mr. J. MacWilliam **(MEng)**
Mr. E. Smith
<u>Manufacturing:</u>

Mr. C. S. Morris **(Associate Metallurgy)**
Mr. C. C. Gegg **(BMet, ARSM)**
Mr. G. W. Giles **(BSc)**
Mr. H. Kirkby **(Associate Metallurgy)**
Mr J. D. Townsend **(BEng)**
<u>Development Department:</u>

Mr. Earle **(BMet, ARSM)**
Mr. Rotherham **(MSc)** - Physical Laboratory
Mr. C. G. Nicholson **(Associate Metallurgy)** - Metallographical Laboratories
Mr. H. T. Shirley **(BSc, ARCS)** - Corrosion Laboratories
Mr. B. Bagshawe **(Associate Metallurgy)** - Chemical Laboratories
Mr. N. B. McGregor - Mechanical Testing Laboratories
Mr. L. C. Trevelyan (BA) - Refractories Laboratory
Dr. A. H. B. Cross **(BMet)** - Refractories Laboratory
Dr. D. W. Davison **(BSc)** - X-Rays Laboratory
Dr. W. C. Newell **(BSc, ARCS (Chem) AIC)** - Gases and Inclusions Laboratory
Mr. E. Ward - Pyrometry Control Laboratory
Mr. F. C. Martin **(Associate Metallurgy)** - Experimental Melting
Mr. H. Burden - Carbide Laboratories
<u>Library:</u>

Miss. A. K. Osborne **(Associate Metallurgy)**
<u>General Offices:</u>

Miss. M. K. Walshaw

There is not sufficient evidence to show where each individual took his/her degree. But Brown-Firth took their graduates mainly from the following universities and technical colleges:
Sheffield, Oxford, Cambridge, London, Birmingham, Edinburgh and Manchester University, and the Royal College of Mines and the Royal School of Science.

(Source: *The Brown-Firth Research Laboratories* (Sheffield, 1938.))

Table Five: The Directors of Thomas. Firth & John. Brown Ltd and Its Associated Companies in 1938:

Directors of Thomas. Firth & John. Brown Ltd

Lord. Aberconway CBE (A Hamilton Scholar, awarded the Tyndale-Bruce Prize for Metaphysics. Received an advanced technical education at Edinburgh University and the Universities of Bonn & Heidelberg.) - Chairman

Mr. Allan. J. Grant JP (A Whitworth-Exhibitioner, he was educated in Engineering at Liverpool University and became a Member of the Institute of Naval Architects and a Member of the Institute Mechanical Engineers) - Managing Director

Mr. Edward Dixon OBE (Joined Firth's as an engineering apprentice in October 1890. He received a thorough training in the various works departments, an advanced technical education at university and then additional training in a number of large French steel works and in Firth's French Agency. During his works career he progressed from Manager of Firth's Shot Forge, to Manager of the Gun Works and finally to General Manager & Director of the Gun Works.)

Mr Percy. W. Fawcett OBE (Served an engineering apprenticeship prior to coming to Firth's in 1897. He worked his way through the ranks to the position of Chief Engineer, which he held until 1921, and in 1922 he was elected to the Board of Thomas Firth & Sons Ltd whilst continuing to act in the capacity of Consulting Engineer)

Mr. Charles. F. Spencer JP (No details)

Sir. Holberry Mensforth CBE KCB (A Master of Science and a Member of the Institute Civil and Mechanical Engineers)

Mr. J. Wortley Fawcett (Served a 5 year engineering apprenticeship between Ferrartes and Lawrence Scott before joining Firths in 1901. In 1912 he was appointed Works Manager of the Tinsley steel Department)

Dr. W. H. Hatfield (DMet, FRS.) came from John Crowley and Co. Ltd, joined the research laboratory and became its Director, 1916 to 1944.

Mr. Arthur Matthews OBE (Awarded a BEng and a MA from Cambridge University. He was an Associate Member of the Institute of Mechanical Engineers and a Member of the Iron & Steel Institute. He served his engineering apprenticeship at Messrs. Armstrong-Whitworth & Co. Ltd, Manchester, where he obtained a thorough training in the various works and administrative departments. He eventually became General Manager of Whitworth's Steel Works in Openshaw, but in 1921 he left to become the Manager of Firth's Norfolk Works). He became a director some 15 years later.

Mr. Mark Firth - (No details)

Mr. J. F. Bridge - General Secretary

Directors of John Brown & Co. Ltd.

Lord. Aberconway CBE (a Hamilton Scholar, Awarded the Tyndale-Bruce Prize for Metaphysics. Received an advanced technical education at Edinburgh University and the Universities of Bonn & Heidelberg.) - Chairman

Sir. Thomas Bell KBE (No details)

Mr. Charles. F. Spencer JP (No details)

Sir. Holberry Mensforth KCB, CBE, (A Master of Science and a Member of the Institutes of Civil and Mechanical Engineers)

Sir Gerald. F. Talbot KCVO, CMG

Dr. S. J. Pigott (DEng) - Resident Director at Clydebank

S. W. Rawson (MA)

Mr. J. F. Bridge - General Secretary

Directors of Firth-Vickers Stainless Steels Ltd

Mr. Allan. J. Grant JP (A Whitworth-Exhibitioner, he was educated in Engineering at Liverpool University and became a Member of the Institute of Naval Architects and a Member of the Institute Mechanical Engineers) - Chairman

Mr. J. W. Fawcett (Served a 5 year engineering apprenticeship between Ferrartes and Lawrence Scott before joining Firths in 1901. In 1912 he was appointed Works Manager of the Tinsley steel Department) - Managing Director

Sir. Charles Craven OBE, RN

Mr. A. Dunbar (No details)

Dr. W. H. Hatfield (DMet, FRS)

Mr. Arthur Matthews OBE (Awarded a BEng and a MA from Cambridge University. He was an Associate Member of the Institute of Mechanical Engineers and a Member of the Iron & Steel Institute. He served his engineering apprenticeship at Messrs Armstrong Whitworth & Co. Ltd Manchester where he obtained a thorough training in the various works and administrative departments. He eventually became General Manager of Whitworth's Steel Works in Openshaw but in 1921 he left to become the Manager of Firth's Norfolk Works)

Mr F. Pickworth (No details)

Mr. A. B. Winder (Awarded the Associateship in Metallurgy from the Sheffield Technical School. He joined Firths in 1894 and received a thorough practical training in all the jobs in the firms Siemens Steel Department. He eventually became Works Manager of this Department. He left Firths twice during his career to work for Jonas & Colver Ltd, however, he was enticed back each time.)
Mr H. Green - Secretary

Directors of Firth-Derihon Stampings Ltd

Mr. Edward Dixon OBE (Joined Firths as an Engineering Apprentice in October 1890. He received a thorough training in the various works departments and then additional training in a number of large French steel works and in Firths French Agency. During his Works career he progressed from Manager of Firth's Shot Forge, to Manager of the Gun Works and finally to General Manager & Director of the Gun Works.) - Chairman

Mr J. D. Julien (No details)

Mr. J. W. Fawcett (Served a 5 year engineering apprenticeship between Ferrartes and Lawrence Scott before joining Firths in 1901. In 1912 he was appointed Works Manager of the Tinsley steel Department)

Mr. E. Derihon (No details)

Mr C. S. Dickie (No details)

Mr J. A. Wooldridge - Secretary

(Source: *The Brown-Firth Research Laboratories* (Sheffield, 1938.))

Table Six: Edgar Allen's General Sales Representatives

A. Mr C. M. Myers (Representative for Lancashire) had a thorough metallurgical training, both theoretical and practical, under-went a tour of the works and was a recognised specialist in steel foundry work.

B. C. E. Newhouse (Appointed representative for New Zealand, 1928), joined Edgar Allen's in 1917 working in the General laboratory. He studied ferrous metallurgy at Sheffield University, where he acquired the associateship in 1922, he under-went a tour of the works and spent a considerable period in Edgar Allen's research laboratory.

(Source: constructed from *Edgar Allen News*, (1919-1940); *Edgar Allen's Works and Sports Magazine* (1922- 1930))

Table Seven: Edgar Allen's Product-Specific Salesmen

A. Mr. Lewis (Technical Representative for Edgar Allen's cement and quarry trade). In 1919 he began a university course in engineering, surveying and building construction and was trained as a draughtsman in Edgar Allen's drawing offices. From 1926 to 1928 he was sent to gain experience at Barnstone Cement Co. Ltd, before returning to Edgar Allen's to complete his tour of the works. In 1929 he was appointed technical representative for Edgar Allen's cement and quarry trade, having qualified as an Associate of the Institute of Quarrying.

B. Mr J. Davies Pitt (Technical Representative for Edgar Allen's motor-vehicle trade) An Associate Member of the Institute of Mechanical Engineers recruited from Wolseley Motors for his " long and exceptional engineering experience in the design and production of motor cars", his remit being to "deal solely with Edgar Allen's special steels for motor cars"

(Source: constructed from the *Edgar Allen News,* 1919 - 1940); *Edgar Allen's Works and sports Magazine* (1922-1930.))

Table Eight: The Sales & Net Profits of the Firth Sterling Steel Co. 1926-1938

Year	Sales ($)	Net Profit ($)
1924		60,011
1925		171,486
1926	2,293,651	
1927	2,167,453	
1928	3,073,231	370,980
1929	3,823,637	565,529
1930	2,439,354	-132,981
1931	1,621,631	-335,273
1932	1,205,341	-283,598
1933	1,399,919	-73,699
1934	2,150,823	26,146
1935	2,997,580	243,257
1936	4,224,741	386,126
1937	5,034,276	396,818
1938	2,147,327	

(Source: SCA, records of Firth-Brown Ltd, Firth-Brown Box 160 (A.))

Table Nine: Firth's Financial Data 1914-1940 (From 1930 figures are for Firth-Brown Ltd, inclusive of Firth-Vickers)

	Value Sales (£)	Net Profit (£)	Total Capital (£)	% Net Profit to Capital	% Net Profit to Total Sales
1914	1,192,145	339,246	1,953,842	17.36	28.46
1915	2,601,470	265,639	2,855,149	9.30	10.21
1916	4,916,027				
1917	4,733,048				
1918	4,852,663	178,650	4,656,543	3.84	3.68
1919	2,366,859	179,236	4,302,610	4.17	7.57
1920	2,381,706	157,507	4,327,135	3.64	6.61
1921	1,046,229	250,000	3,030,302	8.25	23.90
1922		60,436	3,003,140	2.01	
1923		42,999	2,774,870	1.55	
1924		101,730	2,932,186	3.47	
1925		97,049	2,887,169	3.36	
1926		69,568	2,928,677	2.38	
1927		152,749	2,947,241	5.18	
1928		157,776	3,044,695	5.18	
1929		126,090	3,089,847	4.08	
1930		10,902	3,012,242	0.36	
1931		-44,669	4,002,578	-1.12	
1932		-75,950	3,879,366	-1.96	
1933		12,518	3,966,090	0.32	
1934	2,543,131	345,038	4,359,260	7.92	13.57
1935	2,671,289	353,029	4,948,555	7.13	13.22
1936	2,949,456	390,533	5,532,727	7.06	13.24
1937	3,973,149	537,681	6,252,007	8.60	13.53
1938	4,755,369	515,056	6,176,885	8.34	10.83
1939	6,031,364	508,459	6,656,902	7.64	8.43
1940	7,791,444	390,821	8,229,736	4.75	5.02

(Source: SCA, records of Firth-Brown Ltd, Firth-Brown Boxes, 15, 16, 17, 18, 85, 87.)

Table Ten: Miscellaneous Net Profit and Loss data for Various Sheffield Firms in the Inter-War Years

Company	£ 1918	£ 1919	£ 1920	£ 1921	£ 1922	£ 1923
Spear & Jackson's			12,794	15,840	528	Loss 204
Edgar Allen's					Profit	Loss
Hadfield's		203,154	107,856	158,157	187,250	106,510
John Baker's					14,445	Loss 17,501
United Steels					Loss	Loss

	£ 1924	£ 1925	£ 1926	£ 1927	£ 1928	£ 1929
Spear & Jackson's	24,509	20,126	Loss 3,108	1,968	4,166	3,582
Vickers			K written down by £13 million			
Edgar Allen's	Profit	33,000	55,000		77,374	16,783
Hadfield's	80,621	117,660	68,875	187,223	112,053	112,992
John Baker's	33,680	34,443	10,693	Loss 5,650	31,918	18,485
United Steels	Loss	Loss	Loss			

	£ 1930	£ 1931	£ 1932	£ 1933	£ 1934	£ 1935
Baker-Bessemer's	19,120		2,409	Loss 7822	2,539	20,521
Vickers			529,000	466,000	547,000	613,261
Edgar Allen's	22,530	loss	loss	loss	38,000	38,283
Darwin's						8,543
Sanderson's						Loss 2319
United Steels			187,000	351,000	947,680	1,115,205
Kayser Ellison's				10,754	30,015	35,965
Brown Bayley's				2,252	43,503	58,566
ESC	Loss	Loss	Loss	Loss	435,638	783,223
Spear & Jackson's	Loss	Loss	Loss			

Company	£	£	£	£	£	£
Vickers		775,925	574,493	529,038	543,364	
Hadfield's	42,995	Loss 30093	Loss 36,206	Loss 21,622	32,179	93,995
Andrews Toledo	Loss 12,629	Loss 23,810	Loss 7,611	438	4,905	13,650

	£ 1936	£ 1937	£ 1938	£ 1939	£ 1940	£ 1941
ESC	510,000	722,452	649,809	663,257	458,751	
Spear & Jackson's	54,142	41,123	34,279			
Vickers	928,105	1,162,610	851,055	1,398,853	1,226,870	
Vickers-Armstrong			867,540	1,074,883	1,028,142	
Edgar Allen's	60,000	132,937		156,272	214,570	
US	1,378,587	1,850,330	2,426,547	1,938,984		
Kayser Ellison's	48,556					
Hadfield's		219,423	269,040	278,465	259,621	
Darwin's			17,396			
Andrews Toledo		6,575	26,035	loss 17,296	2,591	10,199
Marsh Bros.				7,810	24,950	
Baker-Bessemer's	30,875	41,114	49,087	65,823		

(Sources: SJC 8, Spear and Jackson Ltd. Directors Minute Books
SJC 22 Spear & Jackson Ltd, Director's Reports and Accounts
Vickers News, *Edgar Allen's News*, *Edgar Allen's Works and Sports Magazine*
British Steel Maker, SLSL, Hadfield's Ltd Chairman's Speech and AGM, 1929-29
SCA, Hadfield's 8, Shareholders Minute Book, no.2
SCA, Aurora 57, Andrews Toledo Minute Book
SCA, Aurora 61/1-12, Andrews Toledo's Directors Reports at OGMS 1930-1940
SCA, Marsh 140/1-2, Marsh Bros. P & L Acc. 1939-40.
RLSL, 442/B 05367, John Baker AGM 1922-76
RLSL, 442/B/23624, Reports of the Directors of United Steels Ltd, 1930s)

Table Eleven: Analysis of Purposes for which Staybrite and Staybrite Steels were Supplied
(Percentage Distribution of Deliveries for the 16 Months Jan. 1933 - April 1934)

Purpose	Total Home & Export	
	Staybrite %	Stainless %
Aircraft	2.68	13.19
Architectural Fittings	8.45	0.31
Artificial Silk	0.26	0.01
Auto Engineering	5.35	11.1
Brewery Work	0.63	0.06
Brick Industry	0.11	0.04
Chemical Plant	6.22	0.59
Cutlery	0.08	20.85
Dairy Work	3.96	0.12
Domestic Purposes	1.86	0.33
Dredger Work	0.01	
Dyeing	4.51	0.01
Electrical Engineering	2.67	7.06
Electric Power Plant	0.06	
Fabricators	10.89	0.17
Field Kitchens	0.05	
Food Manufacturing	0.36	0.01
Foundry Lumps	0.43	
Gas Industry	0.66	0.7
General Engineering	15.13	22.6
Glass Industry	0.06	0.21
Golf Clubs	0.01	0.14
Hearth Furniture	0.99	0.05
Hollow-ware	1.51	0.01
Laundry Work	0.12	
Marine Engineering	1.22	6.32
Mining Industry	0.03	
Nameplates	0.37	
Nuts, Bolts etc.	0.84	0.31
Oil Industry	0.02	0.35
Optical Appliances	0.01	0.05
Paper Industry	0.43	0.05
Pen nibs	0.28	0.56
Photography	0.27	
Railway Work	0.21	0.09
Refrigerator industry	1.83	0.37
Safe industry	0.01	0.05
Shipping industry	0.01	
Soap Industry	0.02	0.01
Spoons & Forks	4.55	0.05
Stampings	0.38	0.34
Sugar Industry	0.28	0.08
Surgical Appliances	0.76	0.5
Telephone Industry	0.01	0.01
Textile Industry	0.7	
Tobacco Industry	0.83	0.01
Turbine Blades	0.1	10.17
Water Turbine Work	0.03	0.04

Purpose	Staybrite %	Stainless %
Weighing Appliances	0.37	0.03
Wire Drawers	2.08	0.6
Restaurant Engineering	1.94	0.13
Road Studs	0.71	0.26
Rubber Industry	0.12	0.37
Unclassified	14.53	2.68
	100	100.99

(Source: *Firth-Vickers Newsletter* no.2 (August 1934), p.28.)

Appendix G

List of Cutlery Firms that Recruited Graduates or Associates in Metallurgy or Engineering From the Sheffield University and its Antecedent the Sheffield Technical School, 1900-1929

Org_Name	Org_Type
Thomas W. Ward & Sons	Sheffield Cutlery and Tool
Boswell Son & Naylor	Sheffield Cutlery and Tool
Cooper Bros. & Son	Sheffield Cutlery
George Ibberson & Son	Sheffield Cutlery
J. W. Pearson Ltd	Sheffield Cutlery
John Round & Sons Ltd	Sheffield Cutlery
Joseph Rodgers & Sons	Sheffield Cutlery
P. Ashbury & Sons	Sheffield Cutlery
T. Bradbury & Sons	Sheffield Cutlery
Thomas Staniforth & Sons	Sheffield Cutlery
* Burgon and Ball	Sheffield Tool and Engineering

(Source: Eason Database (Alumni MDB) 1997, constructed from Sheffield University Applied Science Department / Sheffield Technical School Alumni Lists, in *Sheffield University Applied Science Department / Sheffield Technical School Prospectus, 1900 - 1929)*

Note: Wostenholm's possessed metallurgists and engineers, but we do not know where they graduated. Needham Veall and Tyzack also recruited engineers from other institutions, as did Burgon & Ball (* Ostensibly a tool and engineering firm this company retained a capability in the production of the larger cutlery articles)

(Sources: SCA, records of Burgon and Ball Ltd, B & B 15 (a), Agreement between Charles Burgon (Manufacturer) and William Yates Lambert (Engineer); Records of Needham Veall and Tyzack, NVT 12; H. Bexfield, *A Short History of Sheffield Cutlery and the House of Wostenholm* (Sheffield, 1945.))

Bibliography

1. Primary Sources

A. Trade Directories

White's Commercial Directory for Sheffield and Rotherham, 1901, 1911, 1919, 1921, 1935.

B. Business Records

Burgon & Ball's:
SCA, B & B 14 (B), Letter from W. Lambert (engineer) to Charles Burgon, July 26th 1894.
SCA, B & B 15 (A), An Agreement between Charles Burgon and William Lambert (engineer) as to Conditions of Employment, 1895.
SCA, B & B 126 (A), Indenture of Apprenticeship, William Sykes to James Ball, May 2nd 1871.

Christopher Johnson's:
SCA, MD 2367, Letter Book, Foreign General.
SCA, MD 2374, Australian Letter Book.

Edgar Allen's:
SCA, MD 3970, Edgar Allen Letter Book.

Firth-Brown's:
SCA, Firth-Brown, Box 15, Firth-Brown Board Reports.
SCA, Firth- Brown, Box 16, Reports of the Directors of Firth-Brown Ltd., 1936-38.
SCA, Firth-Brown, Box 17, Reports of the Directors of Firth-Brown Ltd., 1938-1939.
SCA, Firth-Brown, Box 18, Reports of the Directors of Firth-Brown Ltd., 1940-1941.
SCA, Firth-Brown, Box 85, Balance Sheets and Accounts of Thomas Firth and Sons, 1902-1940.
SCA, Firth-Brown, Box 87, Annual Reports and Accounts of Firth-Brown Ltd., 1930-1940.
SCA, Firth-Brown, Box 91, Firth-Brown ,Export Department Reports.
SCA, Firth-Brown, Box 97, Correspondence with Sales Representatives.
SCA, Firth-Brown, Box 104, Re: The Employment and Education and Training of Apprentices, 1939-1944.
SCA, Firth-Brown, Box 113, Firth-Brown Welfare Committee Reports.
SCA, Firth-Brown, Box 114, Miscellaneous Staff Notices.
SCA, Firth-Brown, Box 119 (A), Works Managers Reports 1934.
SCA, Firth-Brown, Box 134 , Material Relating to Firth-Brown's Armaments Trade.
SCA, Firth-Brown, Box 160(A), Profits of, and Correspondence with, the Firth-Sterling Steel Co. of America.
SCA, Firth-Brown, Box 160(B), Dr. W. H. Hatfield's U.S. & Canadian Reports.
SCA, Firth-Brown, Box 177, ESC Technical Representatives Report on the Co-ordination Possibilities between ESC and Firth-Brown Ltd., and commentary by the Firth-Brown Technical Representatives on this report.
SCA, Firth-Brown, Box 336, Balance Sheets and Profit and Loss Figures for the Coventry Ordnance Works Ltd.
SCA, Firth-Brown, Box 337, Miscellaneous Reports of Thomas Firth & Sons and its Subsidiaries.
SCA, Firth-Brown, Box 352, Reports on the Performance of John Brown's Apprentices at Evening School 1920-21.

George Wostenholm's:
SCA Wos R3, Letters to America.
SCA, Wos R4, Loose Letters.
SCA, Wos R6, Office Re-organisation, 1915-17.
SCA, Wos R7, Papers Relating to Machinery for the new Pocket Knife Department.
SCA, Wos R8, Papers on a Proposed Cutlery Factory in the U.S.A.
SCA, Wos R9, Letter to W. Nixon, 3rd Aug. 1920.
SCA, Wos R11, Letters and Accounts Concerning the Erection of Machinery.
SCA, Wos R12(A), Correspondence Concerning the New York Agency.
SCA, Wos R12(B), Financial Accounts of the New York Office.

SCA, Wos R12(E), The Reports of Edward Beckett (agent in the U.S.A.).

Hadfield's:
SCA, Hadfield 4, Minutes of Brown Bayley's, 1905-1916.
SCA, Hadfield 7, Hadfield's Steel Foundry Co. Ltd., Shareholders' Minute Book.
SCA, Hadfield 8, Hadfield's Ltd., Shareholders' Minute Book.
SCA, Hadfield 51, Hadfield's Steel Foundry Co. Ltd., Directors' Minute Book, no.1.
SCA, Hadfield 93, Hadfield's Steel Foundry Co. Ltd., Directors' Minute Book, no.2.
SLSL, 338.4 SQ Hadfield's, Chairman's Speech and Annual Reports (inter-war).
SLSL, BBSTQ, Hadfield, R. A., Personal Collection:
Hadfield, R. A., *Advances in the Metallurgy of Iron and Steel: Presidential Address to the Faraday Society* (1914).
Hadfield, R. A., *Address when declaring open the new engineering and metallurgical laboratories at the 21st Anniversary Celebrations of the Sheffield University* (1926).
Hadfield, R. A., *A Plea for Practical Education* (1899).

J. Beardshaw & Son Ltd.:
SCA, MD 7081/5, Minute Book.

J. H. Andrew Ltd.:
SCA, Aurora 56, J. H. Andrew & Co. Ltd., Minute Book, no.2.
SCA, Aurora 57, Andrews Toledo Ltd., Minute Book.
SCA, Aurora 61/1-14, Directors' Reports of Andrews Toledo Ltd., 1930-1941.

John Baker & Sons Ltd.:
RLSL, 442/B/05366(55), Correspondence with the ESC.
RLSL, 442/B/05367, Directors' Reports and Balance Sheets, 1920-1940.
RLSL, 442/B/05366(69), Correspondence with Hadfield's.
RLSL, 442/B/10273(A), Board Minutes, 1920-1938.

Marsh Bros.:
SCA, Marsh 140/1-4, Profits and Sales Figures, 1936-1941.

Needham, Veal & Tyzack's:
SCA, NVT 7, Indenture of Harry Evans as a Spring-Knife Maker to Messrs. Saynor, Cooke & Rydal, 2nd March 1914.
SCA, NVT 8, Minute Book.
SCA, NVT 12, The Appointment of J. H. Cooke as a Machine Grinder at Needham, Veal & Tyzack, 28th May 1915, H. Senior (U.S.A. agent) to NVT, 15th Jan. 1913 and 1st Feb. 1916.
SCA, NVT 22, H. Willey, *Sheffield Cutlery Manufacturers Association: Report of the Sheffield Cutlery Manufacturers visit to Solingen 1918* (Sheffield 1918)

Spear & Jackson's:
SCA, SJC 8, Directors' Minute Book.
SCA, SJC 22, Directors' Reports and Accounts.

Vickers Ltd.:
CUL, Vickers Document 58, Folder 65, Research, Experimental and Development Expenditure.
CUL, Vickers Document 58, Folder 79, Unprofitable Ventures in Peace Products since 1918, Lord Plender's' Report on the Vickers Armstrong's Merger, 1927.
CUL, Vickers Document 58, Folder 101, Particulars of Warship Builders and Warship Machinery Agreements.
CUL, Vickers Document 58, Folder 94, Number of Employees and Staff on the Books of the Vickers' Group of Companies, 28th December 1935.
CUL, Vickers Document 58, Folder 112, Trading Results of Various Steel and Armament Companies for the Period 1930-1934.
CUL, Vickers Document, 316-319, Profits of Vickers (Aviation) Ltd., 1928-1937.
CUL, Vickers Document 551, Vickers Negotiations with Armstrong-Whitworth, 1906-1913.
CUL, Vickers Document 553, Prospectus of Agreement of Service for Apprentices in the Works of Sir. W. G. Armstrong Whitworth & Co. Ltd. on Tyneside.

CUL, Vickers Document 577, Early Apprentice Records, 1891-1907.
CUL, Vickers Document 612, Educated Women as War Workers: A Practical Scheme, Commenced July 19th 1915.
CUL, Vickers Document 621, Material relating to Vickers Crayford Works.
CUL, Vickers Document 628, Biographical details of Sir Trevor Dawson.
CUL, Vickers Document 629, Folder 157, *Conference on the Limitation of Armaments, Washington, 1921-1922, Treaties and Resolutions* (Washington, 1922)
CUL, Vickers Document 642, A History of the ESC, (See In particular Folder 593, Vickers River Don Works, Sheffield.)
CUL, Vickers Document 695, folder 267, Notes of a Meeting between Mr. J. D. Scott & Colonel A. T. Maxwell concerning the acquisition of the Westinghouse Electrical Co. in 1918, on 14th May 1959.
CUL, Vickers Document 722, Quarterly Reports.
CUL, Vickers Document 747, material relating to Vickers Supermarine Aviation Works, Southampton.
CUL, Vickers Document 762, D. Vickers: A Short History of Vickers Ltd.
CUL, Vickers Document 771, The Winding Up of Wolseley Motors Ltd., 1926 (contains Profit and Loss Data.)
CUL, Vickers Document 804, H. E. Scrope: A Short History of the Aviation Activities of the Vickers Group of Companies 1909-1956.
CUL, Vickers Document 900, D. Bean, *Armstrong's Men: The Story of the Shop Stewards Movement in the Tyneside Works* (1967).
CUL, Vickers Document 1159, contains a small run of the *Armstrong-Whitworth Record* (In-House Journal.)
CUL, Vickers Document 1168, *Armstrong-Whitworth: From Battleships to Tool Steel and Small Tools* (1923).
CUL, Vickers Document MS 1903, Indenture of Denis Web as a premium apprentice at Vickers Aviation Works, 1926.
SLSL, LS260, *Vickers Centenary Video* (1967).

United Steels:
RLSL, 442/B/23624(V), Reports and Accounts of United Steels, 1930-1950.

C. Education Records

Sheffield University:
SUA VIII/1/1-SUA VIII/1/2, Sheffield Technical School Minute Books. (1884-1903).
SUA VIII/1/3-SUA VIII/1/8, Applied Science Department Minute Books. (1903-1940).
SUA VIII/1/66-SUA VIII/1/74, Sheffield University Evening Department Letter Books.
SUA VIII/1/127/1-SUA VIII/1/127/2, Professor Arnold Letter Books.
SUA VIII/2/2 University of Sheffield Advisory Committee for the Foundry Department Minute Book.
Firth College Prospectus, 1884-1885 (Sheffield).
Sheffield Technical School Prospectus, 1885-1886, 1891-1892 and 1900-1904 (Sheffield).
Sheffield University Department of Applied Science Prospectus, 1905-1931 (Sheffield).

Sheffield University, Chapman Collection:
SUA 5/1/1, Papers relating to the History of the Firth College 1879-1895.
SUA 5/1/2 (i)-SUA 5/1/2 (iii), Papers relating to the History of the Sheffield Technical School 1884-1952.
SUA 5/1/20, Papers Relating to the Teaching of Modern Languages 1901-1938.
SUA 5/1/22, Papers relating to the History of the Department of Chemistry and Physics 1918-1922.
SUA 5/1/32, Papers Relating to the History of the Faculty of Engineering 1920-1931.
SUA 5/1/33, Papers Relating to the History of the Department and Faculty of Metallurgy 1907-1966.

SCA, Sheffield Education Committee and School Board Records:
350/E2/1- 350/E2/17, Sheffield School Board Minutes and Committee Reports (1885-1901).
350/E3/1 - 350/E3/4, Sheffield Education Committee Minute Books of the Reports of Sub-committees and Managers (1903-1907).
350/E5/1 - 350/E5/9, Minutes of the Sheffield School Board (1873-1882).
CA 137/37, Technical Instruction Minute Book, no.2 (February 1892-April 1903.

CA 316, Sheffield School Board, School Management Committee Minute Book, no.20. (1902-1903).
CA 318, Governors' of Central Secondary School Minute Book, no.2 (1907-11).
CA 319, Governors' of Central Secondary School Minute Book, no.3 (1911-15).
CA 320, Governors' of Central Secondary School Minute Book, no.4 (1915-19).
CA 321, Secondary Schools Sectional Sub-Committee Minute Book, no.2, (1924-27).
CA 322, Secondary School Sectional Sub-Committee Minute Book, no.3, (1927-28).
CA 323, Secondary School Sectional Sub-Committee Minute Book, no.8, (1935-37).
CA 328, Governors' of the King Edward VII School Minute Book, no.2, (1909-15).
CA 329, Managers' of the Technical School of Art Minute Book, no.3, (1913-19).
CA 419, Higher Education Sub-Committee Minute Book (1928-1930).
CA 522, (1) - CA 522 (10), Sheffield School Board School Management Committee Minute Books (1879-1896).
CA 622 (1), Minute Book of Miscellaneous Education Committees and sub- Committees (1873-1920).
CA 622 (4), City of Sheffield Higher Education Sub-Committee Minute Book no.1 (1903-1907).
CA 622 (5), City of Sheffield Higher Education Sub-Committee Minute Book no.2 (1907-1912).
CA 622 (6), City of Sheffield Higher Education Sub-Committee Minute Book no. 8 (1924-1926).
CA 622 (7), City of Sheffield Higher Education Sub-Committee Minute Book no. 11 (1930-1931).
CA 622 (8), City of Sheffield Higher Education Sub-Committee Minute Book no. 12 (1931-1933).
CA 622 (9), City of Sheffield Higher Education Sub-Committee Minute Book no. 13 (1933-1934).
CA 622 (10), City of Sheffield Higher Education Sub-Committee Minute Book no. 14 (1934-1936).
CA 622 (14), City of Sheffield Education Committee Special Minute Book no.3 (1920-1943).
CA 622 /42, Report on Re-organisation of Schools, April 1939.
CA 630 (51), King Edward VII School Correspondence with the Board of Education.
CA 681/8/1 - CA 681/8/6, Sheffield School Board Annual Reports (1896-1902).
CA 681/9/1 - 28, Sheffield Education Committee Annual Reports (1903-1939).
Sheffield College of Arts and Crafts Prospectus, 1928, 1930-37 (Sheffield).

D. Newspapers and Professional Journals

American Machinist (European Edition).
Edgar Allen Magazine (In-House Magazine).
Edgar Allen News (In-House Magazine).
Edgar Allen Works and Sports Magazine (In-House Magazine).
Enchiridion.(In-House Magazine of Firth-Vickers Ltd).
Engineering.
Firth Vickers Newsletter.
Hadfield Bulletin (In-House Magazine).
Journal of the Iron and Steel Institute.
Quality (Journal of the Sheffield Chamber of Commerce).
Sheffield Daily Telegraph.
Sheffield Technical School Metallurgical Society Journal.
Sheffield University Magazine.
SLSL Newspaper Cuttings relating to Sheffield, vol.25. (1940).
The Baltic Steel Works Gazette.(In-House Magazine of Joseph Beardshaw and Sons Ltd).
The Bombshell (In-House Magazine of Thomas Firth and Sons Ltd).
The British Steelmaker.
The Engineer.
The Firth Worker (Journal of the Firth Worker Committee, a nascent Shop Stewards Movement).
The Hand and Heart Magazine (In-House Magazine of Samuel Osbourne and Co. Ltd).
The Mermaid. (In-House Magazine of Spear and Jackson Ltd).
The Metallurgist.
The Sheffield and Rotherham Independent.
The Worker.
Vickers News (In-House Magazine).

E. SCA, Miscellaneous Minute Books

Sheffield Trades Technical Societies:

LD 1803, Sheffield Cutlery Trades Technical Society Minute Book.
LD 1807, Sheffield Tool Trades Technical Society Minute Book.
LD 1815, Sheffield Spring Trades Technical Society Minute Book.
LD 1809, Sheffield Rolling, Forging and Tilting Trades Technical Society Minute Book.
LD 1805, Sheffield File Trades Technical Society Minute Book.
LD 1818, Sheffield Trades Commercial Society Minute Book.
LD 1813, Sheffield Foundry Trades Technical Society Minute Book.
LD 1795, Handbook of the Sheffield Trades Technical Societies.

Sheffield Chamber of Commerce and Manufacturers:
LD 1986/1-LD 1986/24, Minute Books (c. 1865-1940).

Sheffield Mechanics' Institute:
SCA, MD 231, Sheffield Mechanics' Institute Minute Book, no.5.

F. Official

P.P., 1868, *Report from the Select Committee on the Provisions for Giving Instruction in Theoretical and Applied Science to the Industrial Classes, 1867-68.*
P.P., 1872, *First and Second Reports from the Royal Commission on Scientific Instruction and the Advancement of Science, 1871-72.*
P.P., 1874, *Third, Fourth and Fifth Reports from the Royal Commission on Scientific Instruction and the Advancement of Science, 1873-74.*
P.P., 1884, *First and Second Report from the Royal Commission on Technical Instruction, 1882-84.*
P.P., 1886, *First and Second Reports of the Royal Commission on the Depression in Trade and Industry, 1884-86.*
P.P., 1887, Hansard Commons Parliamentary Debates, Third Series, vol.318.
P.P., 1895, *Royal Commission on Secondary Education, vol.3, 1895.*
Board of Education Report of the Consultative Committee on Attendance, Compulsory or Otherwise at Continuation Schools (London, 1909).
Ministry of Labour Report of an Enquiry into Apprenticeship and Training for the Skilled Occupations in Britain and Northern Ireland, 1925-26 (London, 1926).
Balfour Committee on Industry and Trade: Factors in Industrial and Commercial Efficiency, 4 vols. (London, 1927).
Report (Robbins) of the Committee on Higher Education (London, 1963).
The Report of the Minister of Education for the Year 1950 (London, 1950).
White Paper on Technical Education (London, 1956).

2. Secondary Sources

A. Theses:
Dalvi, M. A., "Commercial Education in England During 1851-1902: An Institutional Perspective" (Unpublished PhD, London University, 1957).
Daniels, L., "Metropolis of Steel, Patterns of Sheffield's Industrial History" (Unpublished PhD, Sheffield City Polytechnic, 1980).
Garlick, P. C., "The Sheffield Cutlery and Allied Trades and Their Markets in the Eighteenth and Nineteenth Centuries" (Unpublished Thesis, Sheffield University, 1951).
Gintz, H., "Effects of Technical Change on Labour in Selected Sections of the Iron and Steel Industries of Great Britain, the United States and Germany, 1901-1939" (Unpublished Thesis, London University, 1954).
Hayter, M., "Technical Change and Labour in the Sheffield Staple Trades, 1850-1914" (Unpublished Thesis, Sheffield City Polytechnic, 1983).
Lewis, M. J., "The Growth and Development of Sheffield's Industrial Structure, 1880-1930" (Unpublished PhD, Sheffield City Polytechnic, 1989).
Taylor, S., "Tradition and Change: The Sheffield Cutlery Trades 1870-1914" (Unpublished PhD, Sheffield University, 1988).
Timmins, G., "Commercial Development of the Sheffield Crucible Steel Industry" (Unpublished M. A., Sheffield University, 1976).

B. Books, Articles and Conference Papers:

A Souvenir of a visit to the Atlas and Norfolk Works of Thomas Firth and John Brown Ltd., Sheffield, April 8th 1954 (Sheffield, 1954).
A Souvenir of a visit to the Atlas and Norfolk Works of Thomas Firth and John Brown Ltd., Sheffield, March 14th 1957 (Sheffield, 1957).
A Lifetime in Steel: A Pictorial History of Iron and Steel Making in Rotherham (Rotherham, 1987)
A Royal Record: The Brief History of a Famous Sheffield House, Joseph Rodgers and Sons Ltd. (Sheffield, 1930).
Ab'e, E., "The Technological Strategy of a Leading Iron and Steel Firm: Bolckow Vaughan & Co. Ltd., Late Victorian Industrialists Did Fail", *Business History,* vol.38, no.1, (January 1996).
Adler, P. S., "Marx, Machines and Skill", *Technology and Culture,* vol.31, no.4, (October 1990).
Albu, A., "British Attitudes to Engineering Education: A Historical Perspective" in Pavitt, K., (eds.), *Technological Innovation and British Economic Performance* (London, 1980).
Aldcroft, D. H. & Richardson, H. W., *The British Economy 1870-1939* (London, 1969).
Aldcroft, D. H., "Introduction: British Industry and Foreign Competition 1875-1914", in Aldcroft, D. H. (eds.), *The Development of British Industry and Foreign Competition, 1875-1914* (London, 1968).
Aldcroft, D. H., "Education and Britain's Growth Failure 1950-1980", in Tortella, G. (eds.), *Education and Economic Development Since the Industrial Revolution* (Valencia, 1990).
Aldcroft, D. H., "Investment in and Utilisation of Manpower: Britain and Her Rivals, 1870-1914", in Ratcliffe, B. M. (eds.), *Britain and Her World, 1750-1914* (Manchester, 1975).
Aldcroft, D. H., *Education, Training and Economic Performance 1944-90* (Manchester, 1992).
Aldcroft, D. H., *The British Economy, vol.1 : The Years of Turmoil, 1920-1951* (Sussex, 1986).
Alford, B. W. E., "Entrepreneurship, Business Performance and Industrial Development", *Business History*, vol.19, no.2. (1977).
Alford, B. W. E., *Depression and Recovery? British Economic Growth 1918-39* (London, 1975).
Allen, G. C., *The British Disease* (Hertfordshire, 2nd edition 1979).
Allen, R. C., "International Competition in Iron and Steel in 1850-1913", *Journal of Economic History,* vol.39, no.4, (1979).
Alvesson, M., *Cultural Perspectives on Organisations* (Cambridge, 1993).
Anderson, C. A., & Bowman, M. J., "Concerning the Role of Education in Economic Development", in Kiker, B. F. (eds.), *Investment in Human Capital*, (Columbia, 1971).
Anderson, C. A. & Bowman, M. J. (eds.), *Education and Economic Development* (Chicago, 1965).
Andrews, P. W. S. & Brunner, E., *Capital Development in Steel: A Study of the United Steel Companies Ltd.* (Oxford, 1951).
Armstong, Lord, "The Vague Cry for Technical Education.", *Quarterly Review* (October 1888).
Armytage, W. H. G., "Education in Sheffield", in Linton, D. L. (eds.), *Sheffield and its Region: A Scientific and Historical Survey* (Sheffield, 1956)
Armytage, W. H. G., "Sheffield Schools, 1893-1918", in Binfield, C. et al (eds.), *History of the City of Sheffield: vol.2, Society* (Sheffield, 1993)
Arnold, A. J., "Should Historians Trust Late Nineteenth Century Company Financial Statements", *Business History*, vol.38, no.2, (April 1996).
Arnold, J. O. & Mcwilliam, A., "The Application of Science to the Steel Industry", in Porter, W. (eds.), *Sheffield, 1910, British Association Handbook and Guide* (Sheffield, 1910.)
Arrow, K. J., "Higher Education as a Filter", *Journal of Public Economics*, vol.2, (1973).
Arthur Balfour & Co. Ltd., 1865-1965, Centenary (Sheffield, 1965).
Ashton, D. & Green, F., *Education, Training and the Global Economy* (Cheltenham, 1996).
Aukrust, O., "The Growth Residual and The Human Factor - Investment and Economic Growth" in Kiker, B. F. (eds.), *Investment in Human Capital* (Columbia, 1971).
Bagley, J. J. & A. J., *The State of Education in England and Wales, 1833-1968* (New York, 1969).
Bailey, B., "The Development of Technical Education, 1934-1939", *History of Education*, vol.16, no.1, (March 1987).
Bailey, B., "Technical Education and Secondary Schooling, 1905-45", in Summerfield, P. & Evans, E. J. (eds.), *Technical Education and the State since 1850,* (Manchester, 1990).
Baker, E. L., "Managing Organisational Culture", *Management Review*, (June 1980)
Baker, H. C., *Human Factors: A Survey of Management Opinion* (Sheffield, 1957)
Barnett, C., "Long-Term Industrial Performance in the U. K.: The Role of Education and Research 1850-1939", in Morris, D., (eds.), *The Economic System in the U. K.* (Oxford, 3rd Edition 1985).
Barnett, C., *The Audit of War: The Illusion and Reality of Britain as a Great Nation*, (London, 1986).
Baron, A., "Winning Ways with Culture", *Personnel Management*, vol.26, (Oct. 1994).

Barraclough, K. C., *Steelmaking Before Bessemer, vol.2: Crucible Steel: The Growth of Technology* (London, 1984).
Barraclough, K. C., *Steelmaking 1850-1900* (London, 1990).
Becker, G. S., "Investment in Human Capital: A Theoretical Analysis", *Journal of Political Economy,* vol.70, no.5, part 2, (October 1962).
Becker, G. S., *Human Capital* (New York, 1964).
Berghoff, H. & Moller, R., "Tired Pioneers & Dynamic Newcomers? A Comparative Essay on English and German Entrepreneurial History, 1870-1914", *Economic History Review,* vol.XLVII, no.2, (1994).
Bexfield, H., *A Short History of Sheffield Cutlery and the House of Wostenholm* (Sheffield, 1945).
Bhargava, M & Dubelaar, C., "Reconciling Diverse Measures of Performance: A Conceptual Framework and a Test of a Methodology", *Journal of Business Research*, vol.31, (Oct.-Nov. 1994).
Bingham, J. H., *The Sheffield School Board, 1870-1903* (Sheffield, 1949).
Blackford, M. G., "Small Business in America: A Historiographic Survey", *Business History Review,* vol.65, no.1, (Spring 1991).
Blaug, M., "The Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey", *Journal of Economic Literature*, vol. XIV, (Sept. 1976).
Blaug, M., *Where are we now in the Economics of Education?*, A Special Professional Lecture delivered at the University of London Institute of Education, 16th June 1983.
Blaug, M., *An Introduction to the Economics of Education* (London, 1970).
Blaug, M., *The Economics of Education: A Selected Annotated Bibliography* (Oxford, 1978).
Bolino, A. C., *A Century of Human Capital by Education and Training* (Washington, 1989).
Boot, H. M., "How Skilled were Lancashire Cotton Factory Workers in 1833?", *Economic History Review*, vol. XLVIII, no.2, (May 1995).
Bowen, W. J., "Revitalising a Mid-sized Company Through Executive Education", *Executive Development*, vol.6, no.5, (1993).
Bowman, M. J. & Anderson, C. A., "Concerning the Role of Education in Development", in Kiker, B. F. (eds.), *Investment in Human Capital* (Columbia, 1971).
Boylan, M.& Riloy, G., *The University of Sheffield: An Illustrated History* (Sheffield, 1981).
Braverman, H., *Labour and Monopoly Capital: The Degradation of Work in the Twentieth Century* (London, 1974).
Brearley, H., *Harry Brearley, Stainless Pioneer: Autobiographical Notes* (Birmingham, 1989)
Brearley, H., *Steelmakers* (London, 1933).
Broadberry, S. N., *The British Economy Between the Wars: A Macro-Economic Survey* (Oxford, 1986).
Brown, A. D. & Starkey, K. D., "The Effect of Organisational Culture on Communication and Information", *Journal of Management Studies*, vol.31, no.6, (Nov. 1944).
Brown, C. M. "Industrialists and their Factory Schools", *History of Education,* vol.9, no.2, (1980).
Brown, J. & Rose, M. B., *Entrepreneurship, Networks and Modern Business* (Manchester, 1993).
Burgess, K., "British Employers and Education Policy, 1935-45: A Decade of Missed Opportunities?", *Business History*, vol.36, no.3, (July 1994).
Burgess, K., "Did the Late Victorian Economy Fail?", in Gourvish, T. R. & O' Day, A. (eds.), *Later Victorian Britain, 1867-1900* (London, 1988).
Burnell, G. & Morgan, G., *Sociological Paradigms & Organisational Analysis*, (London, 1979).
Burnham, T. H. & Hoskins, G. O., *Iron and Steel Industry in Britain, 1870-1930* (London, 1943).
Cain, P., "Political Economy in Edwardian England: The Tariff Reform Controversy", in 'O Day, A. (eds.), *The Edwardian Age: Conflict and Stability* (London, 1979).
Capie, F., *Depression and Protection: Britain Between the Wars* (London, 1983).
Carr, B. J., "Sheffield Technical School of Art", in Holme, C. (eds.), *Arts and Crafts a Review of the Work Executed by Students in the Leading Art Schools of Britain and Ireland* (London, 1924).
Carter, C. & Pinder, J., *Policies for a Constrained Economy* (London, 1982).
Casson, M., "Entrepreneurship and Business Culture", in Brown, J. & Rose, M. (eds.), *Entrepreneurship, Networks and Modern Business* (Manchester, 1993).
Casson, M., *The Entrepreneur: An Economic Theory* (Oxford, 1982).
Chandler, A. D., *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass., 1990).
Chandler, A. D., *Strategy and Structure: Chapters in the History of the American Industrial Enterprise* (London, 1962).
Chapman, A. W., *The Story of a Modern University* (Oxford, 1955).
Church, R., "Deconstructing Nuffield: The Evolution of Managerial Culture in the British Motor Industry", *Economic History Review*, vol.XLIX, no.3, (Aug. 1996).
Church, R., "The Family Firm in Industrial Capitalism: International Perspectives on Hypotheses and History", *Business History*, vol.35, no.4, (1993).

Cohn, E., *The Economics of Education* (New York, 1972).
Coleman, D. C. & Macleod, C., "Attitudes to New Techniques: British Businessmen, 1800-1950", *Economic History Review,* vol. 34, no.4, (1986).
Coleman, D. C., "The Uses and Abuses of Business History", *Business History*, vol.24, no.2, (1987).
Cotgrove, S. F., *Technical Education and Social Change* (London, 1958).
Crafts, N. F. R., "The Golden Age of Economic Growth in Western Europe, 1950-73", Economic History Review, vol.XLVIII, no.3, (August 1995)
Crouzet, F., *The Victorian Economy* (London, 1982).
Curtis, S. J. & Boultwood, M. E. A., *An Introductory History of English Education Since 1800* (London, 1960).
Cyert, R. M. & March, J. G., *A Behavioural Theory of the Firm* (London, 2nd Edition 1994).
D'Aveni, R. A. & Ravenscroft, D. J., "Economies of Integration Versus Bureaucracy Costs: Does Vertical Integration Improve Performance?", *Academy of Management Journal*, vol.37, no.5, (1994).
Daly, A. (et al), "Productivity, Machinery and Skills in a Sample of British and German Manufacturing Plants", *National Institute Economic Review*, vol.111, (1985).
Daly, A., "The Contribution of Education to Economic Growth in Britain: A Note on the Evidence", *National Institute Economic Review*, vol.101, (1982).
Dandridge, T. C., "The Life Stages of a Symbol: When Symbols Work and When They Can't", in Frost, P. J. et al (eds.) *Organisational Culture* (London, 1985).
Davenport-Hines, R. P. T., "The British Marketing of Armaments, 1885-1935", in Davenport-Hines, R. P. T., *Markets and Bagmen Studies in the History of Marketing and Industrial Performance*, 1830-1939 (Aldershot, 1986).
Davenport-Hines, R. P. T., "Vickers as a Multi-national Before 1945" in Jones, G. (eds.), *British Multinationals: Origins, Management and Performance* (Aldershot, 1986).
Davy High Speed Forging Presses (Sheffield, 1921).
De Long, J. B., "Productivity Growth and Machinery Investment: A Long-Run Look", 1870-1980, *Journal of Economic History*, vol.52, no.2, (1992).
Deal, T. & Kennedy, A., *Corporate Cultures: The Rites and Rituals of Corporate Life* (London, 1982).
Denison, E. F., "Education, Economic Growth and Gaps in Information", *Journal of Political Economy*, vol.70, no.5, Part 2, (October 1962).
Dent, H. C., *1870-1970: Century of Growth in English Education* (London, 1970).
Derry, J. & Baxter, G. S., "Elementary and Secondary Education", in Porter, W. (eds.), *Sheffield 1910, British Association Handbook and Guide* (Sheffield, 1910).
Derry, J. W., *The Story of Sheffield* (London, 1915).
Desch, C. H., *The Steel Industry of South Yorkshire: A Regional Study*, a paper read to the Sociological Society on 24th January 1922.
Dintenfass, M., *The Decline of Industrial Britain*, 1870-1980, (London, 1992).
Divall, C., "Education for Design and Production: Professional Organisation, Employers and the Study of Chemical Engineering in British Universities", *Technology and Culture*, vol.35, no.2, (April 1994).
Divall, C., "A Measure of Agreement: Employers and Engineering Studies in the Universities of England and Wales 1897-1939", *Social Studies of Science*, vol.20, no.1, (1990).
Donnelly, J. F., "Representatives of Applies Science, Academics and the Chemical Industry in late Nineteenth Century England", *Social Studies of Science*, vol.16, no.2, (1986).
Donnelly, J. F., "Industrial Recruitment of Chemistry Students from English Universities: A Reevaluation of its Early Importance", *British Journal of History of Science*, vol. 24, (1991).
Doyle, P., "Setting Business Objectives and Measuring Performance", *Journal of General Management*, vol.20, no.2, (Winter 1994).
Ducommun, C., "Considerations and Suggestions on Commercial Education.", in LD 1986 (3).
Eaglesham, E. J. R., *The Foundations of Twentieth Century Education in England* (London, 1967).
Eccles, R. G., "The Performance Measurement Manifesto", *Harvard Business Review*, (Jan.-Feb. 1991).
Edgar Allen Trade Catalogue (Sheffield, 1934).
Edgerton, D. E. H., & Horrocks, S. M., "British Industrial Research and Development Before 1945", *Economic History Review*, vol.XLVII, no.2, (1994).
Edgerton, D. E. H., *England and the Aeroplane: An Essay in a Militant and Technological Nation* (London, 1991).
Edgerton, D. E. H., "Science and Technology in British Business History", *Business History*, vol.29, no.4, (1987).
Edgerton, D. E. H., *Science, Technology and the British Industrial 'Decline' 1870-1970* (Cambridge, 1996).

Elbaum, B., & Lazonick, W. (eds.), *The Decline of the British Economy: An Institutional Perspective* (Oxford, 1986).
Elbaum, B., "The Steel Industry Before World War One", in Elbaum, B. & Lazonick, W. (eds.), The *Decline of the British Economy: An Institutional Perspective* (Oxford, 1986).
Erickson, C., *British Industrialists: Steel and Hosiery, 1850-1950* (Cambridge, 1959).
Evans, E. W., & Wiseman, N. C., "Education, Training and Economic Performance: British Economists' Views 1868-1939", *Journal of European Economic History*, vol.13, no.1, (Spring 1984).
Exhibition of Sheffield Workmanship (Sheffield, 1928).
Feldman, J., "The Meaning of Ambiguity: Learning From Stories and Metaphors", in Frost, P. J. et al. (eds.), *Reframing Organisational Culture* (London, 1991).
Fine, D., *Sheffield History and Guide* (Gloucestershire, 1997).
Finegold, D., & Soskice, D., "The Failure of Training in Britain: Analysis and Prescription", *Oxford Review of Economic Policy*, vol.4, no.3, (Autumn 1988).
Firmager, J., "Sir Henry Hadow, The Education of the Adolescent" History of Education, vol.10, no.4, (1981).
Firth Brown Publication, no.224 (Sheffield, 1947).
Firth-Brown Small Tool Products (Sheffield, 1935)
Floud, R., "Technical Education and Economic Performance: Britain 1850-1914", *Albion,* vol.14, (1982).
Floud, R., "Britain 1860-1914: A Survey", in Floud, R. & McCloskey, D. N. (eds.), *The Economic History of Britain Since 1700, vol.2., 1860-1970's* (Cambridge, 1981).
Fonda, N. & Hayes, C., "Education, Training and Business Performance", *Oxford Review of Economic Policy*, vol.4, no.3, (Autumn 1988).
Fox, R. & Guagnini, A., "An Introduction", in Fox, R. and Guagnini, A. (eds.), *Education, Technology and Industrial Performance in Europe* (Cambridge, 1993).
Geary, F., "Accounting for Entrepreneurship in Late Victorian Britain", *Economic History Review*, vol.XLIII, no.2, (1990).
Geske, T. G., *The Economics of Education* (Oxford, 3rd Edition 1990).
Godley, A. & Westall, O. M., (eds.), *Business History and Business Culture* (Manchester, 1996).
Gonyea, J. G. & Bradley, K. G., "Make Business Culture a Family Affair", *Works Study*, vol.43, (Sept./Oct. 1994).
Goodman J., "The Results of Technical Education in England", *Transactions of the Manchester Association of Engineers,* (1905).
Goold, M., Campbell, A. & Alexander, M., "How Corporate Parents Add Value to the Stand Alone Performance of their Businesses", *Business Strategy Review*, vol.5, part 4, (Winter 1994).
Gospel, H. F. & Okayama, R., "Industrial Training in Britain and Japan, An Overview", in Gospel, H. F. (eds.), *Industrial Training and Technological Innovation: A Comparative and Historical Study* (London, 1991).
Gospel, H. F., "Managerial Structures and Strategies: An Introduction", in Gospel, H. F. & Littler, C. R. (eds.), *Managerial Strategies and Industrial Relations* (London, 1983).
Gospel, H. F., "Industrial Training and Technological Innovation: An Introduction", in Gospel, H. F. (eds.), *Industrial Training and Technological Innovation: A Comparative and Historical Study* (London, 1991).
Gospel, H. F., *Markets, Firms and the Management of Labour in Modern Britain* (Cambridge, 1992).
Gospel, H. F. & Palmer, G., *Industrial Relations* (London, 1993).
Gourvish, T. R., "British Business and the Transition to a Corporate Economy: Entrepreneurship and Management Structures", *Business History*, vol.29, no.4, (1987).
Gourvish, T. R., "Mechanical Engineering", in Buxton, N. K. & Aldcroft, D. H. (eds.), *British Industry Between the Wars: Instability and Industrial Development, 1919-1939* (London, 1979).
Grant, A., *Steel and Ships, The History of John Brown's* (London, 1950).
Greasey, C. H., *Technical Education in Evening Schools* (London, 1905).
Green, J. A., "The Higher Schools of Sheffield" in Porter, W. (eds.), *Sheffield 1910, British Association Handbook and Guide* (Sheffield 1910).
Gregory, K. L., "Native View Paradigms: Multiple Cultures and Culture Conflicts in Organisations", *Administrative Science Quarterly*, vol.28, no.3, (1983).
Griffiths, J., "Give My Regards to Uncle Billy: The Rites and Rituals of Company Life at Lever Brothers, c1900-1990", *Business History*, vol.37, no.4, (Oct. 1995).
Groves, H. M., *Education and Economic Growth* (Washington, 1961).
Guagnini, A., "Worlds Apart: Academic Instruction and Professional Qualifications in the Training of Mechanical Engineers in England, 1850-1914", in Fox. R. & Guagnini, A. (eds.), *Education, Technology and Industrial Performance in Europe, 1850-1939* (Cambridge, 1993).

Hadfield, R. A., "Presidential Address to the Iron and Steel Institute", *Journal of the Iron and Steel Institute*, no.1, (1905)
Hadfield's Steel Foundry Co. Ltd (Sheffield, 1905).
Hannah, L., *The Rise of the Corporate Economy* (London, 1983).
Harbison, F. & Myers, C. A., *Education, Manpower and Economic Growth* (New York, 1964).
Harley, C. K., "Skilled Labour and the Choice of Technique in Edwardian Industry", *Explorations in Entrepreneurial History,* vol.11, (1974).
Harvey, C., & Jones, G., "Introduction: Organisational Capability and Competitive Advantage", *Business History*, vol.34, no.1, (January 1992).
Hatfield, W. H., "Presidential Address to the Sheffield Association of Chemists", in *The Engineer*, vol.125, (1918).
Hatfield, W. H., *The Application of Science to the Steel Industry* (Ohio, 1928).
Hawson, H. K., *Sheffield: The Growth of a City, 1893-1926* (Sheffield, 1968).
Hendrick, H., "A Race of Intelligent, Unskilled Labourers: The Adolescent Worker and the Debate on Compulsory Part-time Day Continuation Schools, 1900-1922", *History of Education*, vol.9, no.2, (1980).
Hey, D., "Sheffield Schools, 1918-60", in C. Binfield et al (eds.), *The History of the City of Sheffield: vol.2, Society* (Sheffield, 1993).
Hobsbawn, E. J., *Industry & Empire: An Economic History of Britain since 1750* (London, 1968).
Hobson, A. J., "Sheffield Industries Cradle of the Modern Steel Trade: Highest Qualities in the World", SLSL Newspaper Cuttings Relating to Sheffield, vol.9.
Hofstede, G., "The Interaction Between National and Organisational Value Systems", *Management Studies*, vol.22, (1985).
Hough, J. R., *Education & the National Economy* (Kent, 1987).
Hull, J. P., "From Rostow to Chandler to You: How Revolutionary was the Second Industrial Revolution", *Journal of European Economic History*, vol.25, no.1, (Spring 1996).
Hutchinson, D. & Nicholas, S., "Modelling the Growth Strategies of British Firms", *Business History,* vol.29, no.4, (1987).
Industrial Sheffield 1919 (Derby, 1919).
Ingham, J. N., *Making Iron and Steel: Independent Mills in Pittsburgh, 1820-1920,* (Columbus Ohio, 1991).
Inglis, J., "The Apprentice Question", *Philosophical Society of Glasgow,* (1893-94).
Iron Steel and Allied Trades of Sheffield (Sheffield, 1905).
Jenkins, E. W., *From Armstrong to Nuffield: Studies in Twentieth Century Science Education in England and wales* (London, 1979).
John Bedford & Sons Ltd., 150th Anniversary, 1792-1942 (Sheffield, 1942).
Jones, G., "Origins, Management and Performance" in Jones, G., (eds.) British Multi-nationals: Origins, Management and Performance (Aldershot, 1986).
Jones, G. P., "Industrial Evolution", in Linton, D. L., (eds.), *Sheffield and its Region: a Scientific and Historical Survey* (Sheffield, 1956).
Jones, G. & Rose, M. B., "Family Capitalism", Business History, vol.35, no.4, (1993).
Jones, H., "Employers' Welfare Schemes and Industrial Relations in Inter-War Britain", *Business History*, vol.25, no.1, (March 1983).
Jones, S., "Cotton Employers and Industrial Welfare Between the Wars", in Jowitt, J. A. & McIvor, A. J. (eds.), *Employers and Labour in the English Textile Industries 1850-1939* (London, 1988).
Keasey, K. & Watson, R., *Small Firm Management: Ownership, Finance and Performance* (London, 1993).
Keats, B. W. & Bracker, J. S., "Towards a Theory of Small Firm Performance", *American Journal of Small Business*, vol.12, part 4, (1988).
Keep, E. & Mayhew, K., "The Assessment: Education, Training and Economic Performance", *Oxford Review of Economic Policy*, vol.4, no.3, (Autumn 1988).
Kennedy, W. P., "Notes on Economic Efficiency in Historical Perspective: The Case of Britain, 1870-1914", *Research in Economic History*, vol.9, (1984).
Kenney, J. & Reid, M., *Training Interventions* (London, 1986).
Kiker, B. F., *Human Capital in Retrospect* (Columbia, 1968).
Kirby, J., *The Sheffield School of Art, 1843-1940* (Sheffield, 1987).
Kirby, M., *The Decline of British Economic Power Since 1870* (London, 1981).
Kirby, M., "Institutional Rigidities and Economic Decline: Reflections on the British Experience", *Economic History Review*, vol.XLV, no.4, (1992).
Kirzner, I. M., *Competition and Entrepreneurship* (London, 1973).

Kitson, M. & Solomou, S., *Protectionism and Economic Revival, The British Inter-War Economy* (Cambridge, 1990).
Kotter, J. and Heskett,, L., *Corporate Culture and Performance* (New York, 1992).
Krefting, L. A. & Frost, P. J., "Untangling Webs, Surfing Waves and Wildcatting: A Multiple-Metaphor Perspective on Managing Organisational Culture", in Frost, P. J. et al (eds.), *Organisational Culture* (London, 1985).
Krippendorf, K., *Content Analysis: An Introduction to its Methodology* (London, 1980).
Landes, D. S., *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge, 1969).
Latham, G. P., "Human Resource Training and Development", *Annual Review of Psychology*, vol.39, (1988)
Lawson, J. & Silver, H., *A Social History of Education in England* (London, 1973).
Lazerson, M. H., "Organisational Growth of Small Firms: An Outcome of Markets and Hierarchies?", *American Sociological Review*, vol.53, (June 1988).
Lee, C. H., "Corporate Behaviour in theory and History: The Evolution of Theory", *Business History*, vol.32, no.1, (1990).
Lee Steel, 1874-1974 (Sheffield, 1974).
Levine, A. L., *Industrial Retardation in Britain, 1880-1914* (London, 1967).
Lipartito, K., "Culture and the Practice of Business History", *Business and Economic History*, vol.24, no.2, (Winter 1995).
Livesay, H. C., "Entrepreneurial Dominance in Business, Large and Small, Past and Present", *Business History Review,* vol.63, no.1, (Spring 1989).
Lloyd-Jones, R. & Lewis, M. J., "Personal Capitalism & British Industrial Decline: The Personally Managed Firm and Business Strategy in Sheffield, 1880-1920", *Business History Review*, vol.68, no.3, (Autumn 1994).
Lloyd-Jones, R. & Lewis, M. J., *Manchester and The Age of the Factory* (London, 1988).
Lloyd-Jones, R. & M. J. Lewis, "Business Structure and Political Economy in Sheffield: The Metal Trades 1880-1920s", in Binfield, C. et al. (eds.), *The History of the City of Sheffield: vol.2, Society* (Sheffield, 1993).
Loasby, B. J., "The Entrepreneur in Economic Theory", *Scottish Journal of Political Economy*, vol.29, no.3, (1982).
Locke, R. R., *The End of the Practical Man: Entrepreneurship and Higher Education in Germany, France and Britain, 1880-1914* (London, 1984).
Louis, M. R., "A Cultural Perspective on Organisations: The Need for and Consequences of Viewing Organisations as Culture bearing Mileux", *Human Systems Management*, vol.2, (1981).
Louis, M. R., "An Investigators Guide To Work Place Culture", in Frost P. J., et al (eds.), *Organisational Culture* (London 1985).
Lundberg, C. C., "On the Feasibility of Cultural Intervention", in Frost, P. J. et al. (eds.), *Organisational Culture* (London, 1985).
Maanen, J. V. & Barley, S. R., "Cultural Organisation: Fragments of a Theory", in Frost, P. J. et al (eds.), *Organisational Culture* (London, 1985).
Machlup, F., *Education and Economic Growth* (Nebraska, 1970).
Marrison, A. J., "Businessmen, Industries and Tariff Reform in Great Britain 1903-1930", *Business History,* vol.25, no.2, (1983).
Marshall, A. C. & Newbould, H., *The History of Firth's* (Sheffield, 1924).
Martell, K. D. & Carrott, S. J. Jnr., "The role of Human Resource Management in Supporting Innovation Strategies: Recommendations on how R & D Managers should be treated from a Human Resource Management Perspective", *Research and Development Management*, vol.25, no.1, (1995).
Martin, J. and Siehl, C., "Organisational Culture and Counter Culture: An Uneasy Symbiosis", *Organisational Dynamics*, vol. 12, (1983).
Martin, J., "Can Organisational Culture be Managed?", in Frost P. J. et al (eds.), *Organisational Culture* (London, 1985).
Martin, J., Bithin, B. & Boehm, M., "Founders and the Elusiveness of a Cultural Legacy" in Frost, P. J. et al. (eds.), *Organisational Culture* (London, 1985).
Matthews, D., Anderson, M. & Richard, J., "The Rise of the Professional Accountant in British Management", *Economic History Review*, vol.L, no.3, (August 1997).
McCloskey, D. N., *Economic Maturity and Entrepreneurial Decline: British Iron and Steel, 1870-1913* (Harvard, 1973).
McCloskey, D. N. & Sandberg, L. G., "From Damnation to Redemption: Judgements on the Late Victorian Entrepreneur", *Explorations in Economic History,* vol.9, no.1, (1971).

McKinlay, A., "A Certain Short-sightedness: Metal Working Innovation and Apprenticeship, 1897-1931", in Gospel, H. F. (eds.), *Industrial Training and Technical Innovation: A Comparative and Historical Study* (London, 1991).
McKinlay, A., & Zeitlin, J., "The Meanings of Managerial Prerogative: Industrial Relations and the Organisation of Work in British Engineering 1880-1939" *Business History*, vol.31, no.2, (1989).
Melling, J., "Employers, Industrial Welfare and the Struggle for Workplace Control in British Industry, 1880-1920", in Gospel, H. F. & Littler, C. R. (eds.), *Managerial Strategies and Industrial Relations: A Historical and Comparative study* (London, 1983).
Mercer, M., "Education in Sheffield: Early Provision, 1843-93", in C. Binfield et al (eds.), *The History of the City of Sheffield, 1843-93: vol.2, Society* (Sheffield, 1993).
Mills, C. T., *Technical Education, Its Development and Aims* (London, 1925).
Mincer, J., "On the Job Training: Costs, Returns and some Implications", *Journal of Political Economy*, vol.70, no.5, part 2, (October 1962).
Mitchell, W. & Singh, K., "Spill Back Effects of Expansion When Product Types and Firm Types Differ", *Journal of Management*, vol.21, no.1, (1995).
More, C., "Re-skilling and Labour Markets in Britain, c.1890-1940: Questions and Hypotheses", *Historical Studies in Industrial Relations*, vol.2, (September 1996).
More, C., "Skill and the Survival of Apprenticeship", in Woods, S. (eds.), *The Degradation of Work: Deskilling and the Labour Process* (London, 1982).
More, C., *Skill and the English Working Class* (London, 1980).
Morris, B. & Smyth, J., "Paternalism as an Employer Strategy, 1800-1960", in Rubery, J. & Wilkinson, F. (eds.), *Employer Strategy and the Labour Market* (Cambridge, 1994).
Morrish, I., *Education Since 1800* (London, 1970).
Moss, S., *An Economic Theory of Business Strategy* (Oxford, 1981).
Murphy, J., *Church, State and Schools in Britain 1800-1970* (London, 1971).
Musgrave, P. W., "The Definition of Technical Education, 1860-1910", *The Vocational Aspect*, (May 1964).
Musgrave, P. W., *Society and Education in England since 1800* (London, 1968).
Musgrave, P. W., *Technical Change, The Labour Force and Education: A Study of the British and German Iron and Steel Industries, 1860-1900* (London, 1967).
Muskin, S. J., "Health as Investment", Journal of Political Economy, vol.70, no.5, Part 2, (October 1962).
Musson, A. E., *The Growth of British Industry* (London, 1981).
Nicholas, S. J., "The Overseas Marketing Performance of British Industry, 1870-1914", *Economic History Review*, vol.37, no.4, (1984).
Nord, W. R., "Can Organisational Culture be Managed? A Synthesis.", in Frost P. J. et al (eds.) *Organisational Culture* (London, 1985).
Nunn, P., "Firth, Mark (1819-80): Steel Manufacturer", in Jeremy, D. J. (eds.), *Dictionary of Business Biography, vol.2* (London, 1984).
One Hundred Years in Steel: Firth - Brown Centenary, 1837-1937 (Sheffield, 1937).
Ouchi, W. G. & Wilkins, A. L., "Organisational Culture", *American Review of Sociology*, vol.2, (1985).
Owen, A. D. K., *A Report on Unemployment in Sheffield* (Sheffield, 1932).
Payne, P. L., *British Entrepreneurship in the Nineteenth Century* (London, 1974).
Payne, P. L., "The Emergence of the Large-Scale Company in Great Britain, 1870-1914", *Economic History Review,* vol.20, no.1, (1967).
Payne, P. L., "Iron and Steel Manufacturers", in Aldcroft, D. H. (eds.) *The Development of British Industry and Foreign Competition* 1875-1914 (London, 1968).
Peddie, R., *The United Steel Companies Ltd., 1918-1968: A History* (Manchester, 1969).
Peden, G. C., *Keynes, The Treasury and British Economic Policy* (London, 1988).
Peters, T., *Thriving on Chaos* (New York, 1987).
Peters, T. J. & Waterman, R. H., *In Search of Excellence* (New York, 1983).
Piore, M. J. & Sabel, C. F., *The Second Industrial Divide: Possibilities for Prosperity* (New York, 1984).
Pollard, S. & Robertson, P., *The British Shipbuilding Industry, 1870-1914* (London, 1979).
Pollard, S., *A History of Labour in Sheffield* (Liverpool, 1959).
Pollard, S., *Britain's Prime & Britain's Decline: The British Economy 1870-1914* (London, 1989).
Pollard, S., *The Development of the British Economy, 1914-1990* (London, 1992).
Pollard, S., *The Genesis of Modern Management: A Study of the Industrial Revolution in Britain* (London, 1965).
Pollard, S., *Three Centuries of Sheffield Steel: The Story of a Family Business, Marsh Bros. & Co. Ltd.* (Sheffield, 1954).

Porter, J. H., "Skill and the Struggle for Power at the Workplace", *Business History,* vol.23, no.3, (1981).
Porter, M. E., *Competitive Strategy: Techniques for Analysing Industries and Competitors* (New York, 1980).
Pratten, C. F., & Atkinson, A. G., "The Use of Manpower in British Manufacturing Industry", *Department of Employment Gazette* (June 1976).
Putnam, L., "The Interpretative Perspective: An Alternative to Functionalism", in Putnam, L. & Pacanowsky, M. (eds.), *Communication and Organisation: An Interpretative Approach* (London, 1983).
Raghuram, S., "Linking Staffing and Training Practices with Business Strategy: A Theoretical Perspective", *Human Resource Development Quarterly*, vol.5, no.3, (Fall 1994).
Ripper, W. & Arnold, J. O., "The Application of Science to the Steel Industry", in Porter, W. (eds.), *Sheffield 1910, British Association Handbook and Guide* (Sheffield, 1910).
Ripper, W., "Engineering Industry of the District", in Porter, W. (eds.), *British Association Handbook and Guide to Sheffield* (Sheffield, 1910).
Ripper, W., "Report on the Present Position of the Supply of Properly Trained Students to the Sheffield Trades and Industries, 7th October 1911", in Sheffield Technical School Minute Book, no.2, SUA VIII/1/2.
Ripper, W., "The War and University Education", *Industrial Sheffield and Rotherham 1919* (Derby, 1919).
Roach, J., "The University of Sheffield.", in Binfield, C. et al (eds.), *The History of the City of Sheffield: vol.2, Society* (Sheffield, 1993).
Robertson, P. L., "Technical Education in the British Shipbuilding and Marine Engineering Industries, 1863-1914", *Economic History Review*, vol.27, no.2, (1974).
Robertson, P. L., "Employers and Engineering Education in Britain and the U.S., 1890-1914", *Business History,* vol.23, no.1, (1981).
Roderick, G. W. & Stephens, M. D., *Education and Industry in the Nineteenth Century: The English Disease* (London, 1978).
Roderick, G. W. & Stephens, M. D., *Scientific and Technical Education in Nineteenth Century England* (Plymouth, 1972).
Roderick, G., & Stephens, M. D., "Scientific Studies and Scientific Manpower in the English Civic Universities 1870-1914", *Science Studies,* vol.4, (1974).
Rosenberg, N., *Exploring The Black Box, Technology, Economics and History* (Cambridge, 1994).
Rowlinson, M., "Strategy, Structure and Culture: Cadbury Divisionalisation and Merger in the 1960s", *Journal of Management Studies*, vol.32, no.2, (March 1995).
Royle, E., "Mechanics Institutes and the Working Classes 1840-1860", *Historical Journal,* vol.XIV, no.2, (1971).
Rubery, J., & Wilkinson, F., "Introduction" in Rubery, J., & Wilkinson, F. (eds.) *Employer Strategy and the Labour Market* (Oxford, 1994).
Rubery, J., "Internal and External Labour Markets: Towards an Integrated Analysis", Rubery, J., & Wilkinson, F. (eds.) *Employer Strategy and the Labour Market* (Oxford, 1994).
Sadler, M. E., *Continuation Schools in England and Elsewhere* (Manchester, 1908).
Sadler, M. E., *Report on Secondary and Higher Education in Sheffield* (London, 1903).
Salt, J., "The Creation of the Sheffield Mechanics Institute", *The Vocational Aspect*, vol.18, (1966).
Samuel, R., "The Workshop of the World", *History Workshop Journal*, vol.3, (1977).
Sandberg, L. G., "The Entrepreneur and Technological Change", in Floud, R., & McCloskey D. N., *The Economic History of Britain Since 1700, vol.2., 1860-1970s* (Cambridge, 1981).
Sanderson, M., "Research and the Firm in British Industry, 1919-1939", *Science Studies*, vol.2, (1972).
Sanderson, M., "Technical Education and Economic Decline, 1890-1980", *Oxford Review of Economic Policy*, vol.4, no.1, (Spring 1988).
Sanderson, M., "The Professor as Industrial Consultant: Oliver Arnold and the British Steel Industry, 1900-1914", *Economic History Review*, vol.31, no.2, (1978).
Sanderson, M., *The Universities and British Industry* (London, 1972).
Sanderson, M., "The Missing Stratum: The Problem of Technical School Education in England, 1900-1960", in Tortella, G., (eds.), *Education and Economic Development since the Industrial Revolution* (Valencia, 1990).
Sandy, W., "Link your Business Plan to a Performance Plan", *Journal of Business Strategy*, vol.11, no.6, (1990).
Schein, E., *Organisational Culture and Leadership* (Oxford, 1989).
Scholz, C., "Corporate Culture and Strategy: The Problem of Strategic Fit", *Long range Planning*, vol.20, no.4, (1987).
Schultz, T. W., *Investing in People: The Economics of Population Quality* (Chicago, 1981).

Schultz, T. W., *Investment in Human Capital: The Role of Education and Research* (New York, 1971).
Schultz, T. W., "Reflections on Investment in Man", Journal of Political Economy, vol.70, no.5, Part 2, (October 1962).
Science in Industry: Opportunity for Further Education, National Trades Technical Societies, Sheffield Section (Sheffield, 1944).
Scott, J. D., *Vickers a History* (London, 1962).
Scranton, P., "Diversity in Diversity, Flexible Production and American Industry, 1880-1930", *Business History Review*, vol.65, no.1, (Spring, 1991).
Scranton, P., "Learning Manufacturing: Education and Shop Floor Schooling in the Family Firm", *Technology and Culture*, vol.27, no.1, (Jan. 1986).
Scranton, P., "Labour and Technology", *Technology and Culture,* vol.29, no.4, (October 1988).
Scranton, P., *Figured Tapestry: Production, Markets and Power in Philadelphia Textiles, 1855-1941* (Cambridge, 1989).
Scwartz, H. & Davis, S. M., "Matching Corporate Culture and Business Strategy", *Organisational Dynamics* (Summer 1981).
Seaborne, M., *Recent Education From Local Sources* (London, 1967).
Searle, G. R., *The Quest for National Efficiency* (Oxford, 1971)
Seed, T. A., *Pioneers for a Century, 1852-1952, Samuel Osborn Co. Ltd.* (Sheffield, 1952).
Shaw, C., "Entrepreneurs in Distribution and the Steel Industry", *Business History*, vol.31, no.2, (1989).
Sheehan, J., *The Economics of Education* (London, 1973).
Sheffield University Publication, *Careers Open to Students of the Applied Science Department* (Sheffield, 1937).
Siehl, C., "After the Founder: An Opportunity to Manage Culture", in Frost P. J. et al (eds.), *Organisational Culture* (London, 1985).
Simons, E. N., & Gregory, E., *Steel Manufacture Simply Explained* (London, 1940).
Smircich, L., "Is the Concept of Culture a Paradigm for Understanding Organisations and Ourselves?", in Frost P. J. et al (eds.), *Organisational Culture (London, 1985).*
Smircich, L., "Concepts of Culture and Organisational Analysis", *Administrative Science Quarterly*, vol.28, no.3, (Sept. 1983).
Smircich, L., "Studying Organisations as Cultures", in Morgan, G., *Beyond Method: Strategies for Social Research* (London, 1983).
Smith, A., *An Inquiry into the Nature and Causes of the Wealth of Nations* (London, 1776).
Smith, D., *Conflict and Compromise. Class Formation in English Society 1830-1914: A Comparative Study of Birmingham and Sheffield (London,* 1982).
Soltow, J. H., "Origins of Small Business and the Relationship between Small and Large Firms: Metal Fabricating and Machine Making in New England, 1890-1957", in Bruchey, S. W. (eds.), *Small Business in American Life* (New York, 1980).
Spalding, C. W., *Tubes of Steel: the History of Howell & Co. Ltd, 1865 -1971* (Sheffield, 1971).
Spitzer, T. Q. & Tobia, P. M., "People-Wise Organisations: The Human Side of Change", *Management Review*, (Oct. 1994).
Stainton, J. H., *The Making of Sheffield 1865-1914* (Sheffield, 1924).
Stansfield, H., *Samuel Fox & Co. Ltd, 1842-1967* (Sheffield, 1967).
Stone, K., *The Origins of Job Structures in the Steel Industry*, conference paper on labour market stratification at Harvard University, (March 16th to 17th 1973).
Storey, J., "The Means of Management Control", *Sociology,* vol.19, no.2, (May 1985).
Summerfield, P. & Evans, E. J., "Introduction: Technical Education, the State and the Labour Market", in Summerfield, P. and Evans, E. J. (eds.), *Technical Education and the State since 1850* (Manchester, 1990).
Taylor, S., "The Industrial Structure of the Sheffield Cutlery Trades, 1870-1914" in Binfield, C. et al (eds.), *The History of the City of Sheffield 1843-1993: vol.2, Society (*Sheffield, 1993).
Temin, P., "The British Steel Industry, 1880-1913" in Rosovsky, H. (eds.) *Industrialisation in Two Systems: Essays in Honour of Alexander Gerschenkron* (London, 1966).
Tha'll Never Gerr in Theer: A Living History of King Edward VII School, 1905-95 (Sheffield, 1995).
The Brown-Firth Research Laboratories (Sheffield, 1938).
The Development of Staybrite Steel (Sheffield, 1935).
The Evolution of the Modern Armour-Piercing Projectile (Sheffield, 1924).
The Modern Projectile Factories of Thomas Firth and Sons Ltd (London, 1912).
Thoms, D. W., "Market Forces and Recruitment to Technical Education: The Example of the Junior Technical Schools", *History of Education,* vol.10, no.2, (1981).

Thwaite, B. H., "The Metallurgic Department of the Sheffield Technical School", *Journal of the Iron and Steel Institute*, part 2, (1891).
Timmins, G., "Concentration and Integration in the Sheffield Crucible Steel Industry", *Business History*, vol.24, no.1, (1982).
Tokesky, G. C. & Kornicles, J. F., "Strategic Human Resource Management is Vital", *Personnel Journal,* (Dec. 1994).
Tolliday, S. "Steel and Rationalisation Policies, 1918-1950" in Elbaum, B. & Lazonick, W. (eds.), *The Decline of the British Economy: An Institutional Perspective* (Oxford, 1986).
Tolliday, S., "Tariffs and Steel, 1916-1930: The Politics of Industrial Decline" in Turner, J. (eds.), *Businessmen and Politics: Studies of Business Activity in British Politics 1900-1945* (London, 1984).
Tortella, G. & Sandberg, L., "Education and Economic Development since the Industrial Revolution: A Summary Report", in Tortella, G. (eds.), *Education and Economic Development since the Industrial Revolution* (Valencia, 1990).
Toulson, P. & Smith, M., "The Relationship Between Organisational Climate and Employee Perceptions of Personnel Management Practices", *Public Personnel Management*, vol.23, no.3, (Fall 1994).
Townsend, H., "The Cutlery Trade" in Burn, D., (eds.), *Structure of British Industry: A Symposium*, vol.2, (Cambridge, 1958).
Trebilcock, C., *The Vickers Brothers, Armaments and Enterprise, 1854-1954* (London, 1977).
Tweedale, G., "Science Innovation and the rule of thumb: The Development of British Metallurgy to 1945" in Liebenhau, J. (eds.), *The Challenge of New Technology: Innovation in British Business Since 1850* (Aldershot, 1988).
Tweedale, G., "Sheffield Steel and America: Aspects of the Atlantic Migration of Special Steel Making Technology, 1850-1930", *Business History,* vol. 25, no.3, (1983).
Tweedale, G., "The Business and Technology of Sheffield Steel making", in Binfield, C. et al (eds.), *The History of the City of Sheffield*: vol.2, *Society,* 1843-1993 (Sheffield, 1993).
Tweedale, G., "Transatlantic Speciality Steels: Sheffield High Grade Steel Firms and the USA, 1860-1940" in Jones, G. (eds.), *British Multinationals: Origins and Performance* (Aldershot, 1986).
Tweedale, G., *Steel City: Entrepreneurship, Strategy and Technology in Sheffield, 1743-1993* (Oxford, 1995).
University of Sheffield Souvenir of the Openings of the New Engineering and Metallurgy Laboratories, 1905 (Sheffield, 1905).
Vaizey, J., Norris, K. & Sheehan, J., *The political Economy of Education* (London, 1972).
Vaizey, J., *The Economics of Education* (London, 1962).
Vatter, H. G., "The Position of Small Business in the Structure of American Manufacturing, 1870-1970", in Bruchey, S. W. (eds.), *Small Business in American Life,* (New York, 1980).
Vickers Ltd. River Don Works Sheffield Metallurgical Products (Sheffield, 1923).
Visit to a Sheffield Steel Works, W. Jessop and Sons, c.1911, paper written to be read before the Keighley Association of Engineers on March 11th 1911.
Vlaeminke, M., "The Subordination of Technical Education in Secondary Schooling, 1870-1914", in Summerfield, P. & Evans, E. J. (eds.), *Technical Education and the State since 1850* (Manchester, 1990).
W. T. Flather Ltd, Standard Steel Works (Sheffield, 1950).
Walter, Y., "Labour as a Quasi Fixed Factor", *Journal Of Political Economy*, vol.70, no.6, (Dec. 1962).
Walton, M., *Sheffield its Story and its Achievements* (Sheffield, 1968).
Ward, M., *Why Your Corporate Culture Is Not Working* (Aldershot, 1994).
Warren, K., "Iron and Steel", in Buxton, N. K. & Aldcroft, D. H. (eds.), *British Industry Between the Wars* (London, 1979).
Weber, A. K., "The Prestige of Sheffield Steel", *The Engineer*, vol.148, (1929).
Webster, A. "The Skill and Higher Educational Content of U.K. Net Exports", *Oxford Bulletin of Economics and Statistics*, vol.55, no.2, (May 1993).
Weiner, M. J., *The Decline of the Industrial Spirit* (Cambridge, 1981).
Weisbrock, B. A., "Education and Investment in Human Capital", *Journal of Political Economy*, vol.70, no.5, Part 2, (October 1962).
Willey, H., *Sheffield Cutlery Manufacturers Association, Report of the Sheffield Cutlery Mission to Solingen*, in SCA records of Needham Veal and Tyzack, NVT 22.
Williams, W. R., *I*XL Means I Excel*, (no publication details. Stored at SLSL).
Williamson, O. E., "Transaction Cost Economies: The Governance of Contractual Arrangements", Journal of Law and Economics, vol.22, (1979).
Wilson, A. K., "A Course for Business Management", *Quality,* vol.10, no.11, (1938).
Wilson, J., *British Business History, 1720-1994* (Manchester, 1995).

Wrigley, J. "Technical education and Industry in the Nineteenth Century", in Elbaum, B. & Lazonick, W. (eds.), *The Decline of the British Economy: An Institutional Perspective* (Oxford, 1986).
Zornitsky, J. J., "Making Effective Human Resource Management a Hard Business Issue", *Compensation and Benefits Management,* vol.11, (Winter 1995).
Zrebic, D. A., Pearce, R. F., & McCanna, W. F., "Effective Human Resource Management in the Total Quality Organisation" *Compensation and Benefits Management*, vol.10, Part 4, (1994).
Zukin, S. & Dimaggio, P., "Introduction", in Zukin, S. & Dimaggio, P. (eds.), *Structures of Capital: The Social Organisation of the Economy* (Cambridge, 1990).

Key:
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RLSL - Rotherham Local Studies Library.
SCA - Sheffield City Archives.
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SUA - Sheffield University Archives.