Modelling the utility and occupancy costs of local authority office buildings

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Abstract

A review of the published literature revealed that although obsolescence in buildings has been the subject of academic interest for a number of decades, existing research into the subject is limited. There have been a number of empirical studies into property depreciation, which have resulted in statistical models for explaining variation between the value of buildings based on differences in their physical and locational characteristics. However, these models are intended for use by property owners and investors. This study therefore developed comparable models for occupiers, using data from a sample of 64 office buildings spread across five English local authorities. The primary contribution of this study is in the theoretical framework and research methods that were used to develop the models.

Data were collected in respect of the physical characteristics of the sample buildings, the characteristics of the buildings' occupants and the characteristics of the occupier organisations. These characteristics were employed as explanatory variables in the analysis. Data were also collected in relation to the utility (functional performance) and operation costs (financial performance) of the buildings. These performance measures were employed as outcome variables in the analysis. One of the key contributions of this study was the development of a valid and reliable scale for evaluating utility. Derived from exhaustive focus group research with building occupants, the scale indicated that utility could be measured along 22 attributes and four distinct factors: configuration, environment, appearance and functionality.

The results of the statistical analysis lend support to the premise that the physical characteristics of a building and the characteristics of its occupants can be used to explain its utility relative to a group of similar buildings. The statistically significant relationships provided an insight into which combinations of building and occupant characteristics were associated with higher or lower scores on particular factors and attributes. By and large, the relative contribution of the two groups of explanatory variables varied across the four factors, a finding that might have implications for the management and refurbishment of buildings. Nevertheless, the inclusion of other additional explanatory variables, such as cultural indicators, might improve the level of explanation provided by the regression models.

The level of explanation provided by the operation cost models was found to be higher than for the utility models. Measures of cost efficiency were found to be correlated with building characteristics and occupancy characteristics. The results of the analysis were therefore an improvement over those from previous research, which had concluded that there was little

correlation between costs and building characteristics. This improvement might be attributed to the wider range of building characteristics analysed in this study. Moreover, by modelling utility and operation costs in tandem, it was possible to identify areas of divergence between functional and financial performance. Such information could be of use during the design and refurbishment of buildings. For instance, design characteristics or utilisation strategies that are associated with higher costs but lower utility could be changed or omitted.

Table of contents

List of tables

List of figures

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Author's declaration

I confirm that this thesis is the sole work of the author.

James Pinder

Chapter 1 Introduction

1.1 Background and rationale

Local authorities in the UK have been encouraged time and again to utilise their property assets more effectively (Smith *et al.*, 1984; SOLACE, 1986; Clark, 1988; Loring, 1993; Ching, 1994; DOE, 1994; Audit Commission, 1988a & 1988b; CIPFE,, 1988; Deakin, 1999; Audit Commission, 2000). Collectively, local authorities in England and Wales own non-residential property valued in excess of £75 billion, including thousands of office buildings that they use for delivering front-line services and carrying out administrative activities. The way that these buildings are used is central to the ability of local authorities to deliver Best Value[1] (Audit Commission, 2000). Nevertheless, a recent review of local authority property management by the Audit Commission (2000, p.8) concluded that 'too many authorities still devote insufficient attention to the use and cost of property assets'. Consequently, many buildings were found to be in poor physical condition, unfit for purpose and unnecessarily costly to run.

One of the key problems identified by the Audit Commission was that there was insufficient data to inform decisions about how best to manage local authority property assets. Indeed, a recent study conducted on behalf of the Royal Institution of Chartered Surveyors (Bootle and Kaylan, 2002) found that that this was a common problem amongst occupiers in the UK's commercial property sector. However, partly due to central Government initiatives, such as Comprehensive Performance Assessment[2], an increasing number of local authorities are beginning to benchmark the performance of their property assets against those of peers, particularly in relation to occupancy costs[3]. Nevertheless, whilst such benchmarking can provide a general insight into whether office buildings are 'good' or 'bad' from a particular aspect, there has been less focus on identifying factors that are associated with higher or lower levels of performance (DEGW, 2002).

Office buildings are designed and constructed to satisfy particular occupier requirements and, as such, possess certain physical and locational characteristics. These characteristics generally reflect standards of design and performance that were deemed acceptable at the

[1] Best Value was introduced under the Local Government Act (1999) as a replacement for Compulsory Competitive Tendering. The rationale behind Best Value is continuous improvement in the delivery of local authority services (Kelly and Hunter, 2003).

[2] Comprehensive Performance Assessment is a framework for evaluating the performance of local authority service delivery and the potential for continuous improvement (Audit Commission, 2003).

[3] This has been facilitated by benchmarking associations, such as the Local Government Property and Facilities Management Forum (Clark *et al.*, 2003) and National Best Value Benchmarking Scheme (IPF, 2000).

time of construction. Over the building life cycle, however, occupier requirements are liable to change and the performance of buildings may decline, relative, that is, to contemporary standards of design and construction (Ohemeng and Mole, 1996). Such a decline in the performance of a building is referred to in this thesis as 'obsolescence'[4]. The process of obsolescence means that buildings require regular injections of capital investment to improve their performance[5] (Bryson, 1997). Buildings that do not receive regular investment are likely to become out-dated and redundant. According to Nutt (1997, p.113), 'demand-side changes have resulted in unprecedentedly high levels of underutilisation, long-term vacancy and redundancy... particularly in the office sector'.

In the UK, a number of studies have examined the impact of different office building characteristics on rental and capital values (Salway, 1986; Jones Lang Wootton, 1987; Baum, 1991; Khalid, 1994; Barras and Clark, 1996; Baum, 1997; Yusof, 1999; Dixon *et al.*, 1999; Bottom *et al.*, 1999; Dunse and Jones, 2002). These studies have focused on developing models for explaining why office buildings with certain physical and locational characteristics experience higher rates of depreciation than others[6]. For instance, Baum's (1991) analysis of office buildings in the City of London suggested that the physical characteristics with the most significant impact on property depreciation were space configuration, internal specification and external appearance. Moreover, the relative importance of these physical characteristics was found to vary over time due to changing occupier requirements. Baum's (1997) follow-up study found that internal specification had become more important than configuration in explaining property depreciation.

The rationale behind the research in this thesis was that the analytical approach employed in the property depreciation studies described above could be used to explain the obsolescence, or variability in performance, of local authority office buildings. It was anticipated that models developed using this approach could then be used to determine the performance of office buildings using a small number of significant explanatory variables. Such models could be utilised by local authorities to inform Best Value reviews and the

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[4] The issue of obsolescence in buildings is a long-standing issues, having first come to the fore in the UK during the 1960s, owing to the growth in interest in urban decay, renewal and conservation (Switzer, 1963; Cowan, 1965; Lichfield & Associates, 1968; Medhurst and Lewis, 1969). The issue re-emerged during the 1980s, as the impact of information and communications technology caused certain types of office facilities to become prematurely obsolete (Bowie, 1983; Duffy, 1983; Bernard Williams Associates, 1994).

[5] The increasing frequency of such investments reflects a growing demand amongst occupiers' for occupational flexibility and shorter lease terms. For instance, average new lease terms in the UK property market have fallen to around eight years, with largest fall being amongst public sector occupiers (Nelson Bakewell and OPD, 2003; ODPM, 2004).

[6] The term 'depreciation' is used in this study to refer to the decline in value of property.

development of asset management plans[7] by identifying office buildings that are under-performing and in need of refurbishment or disposal. The research method underpinning the development of these models is explained below.

1.2 Structure of the thesis

The following thesis comprises seven chapters (Figure 1.1). After this introductory chapter, Chapter 2 provides a critical review of the key studies into property depreciation and obsolescence and identify gaps in the existing body of knowledge. The first part of Chapter 2 (Section 2.2) discusses the background theory behind the two groups of studies, focusing particularly on defining and explaining concepts such as building performance, utility, value, service life, obsolescence and depreciation. Section 2.3 provides a critical review of research that has been conducted into obsolescence. This is followed by a critical review of research into property depreciation (Section 2.4). Chapter 2 concludes by reconciling the findings from both sets of studies, highlighting gaps in knowledge and identifying areas for further research (Section 2.5).

Chapter 3 describes the research method that was used in this study. The first part of the chapter discusses the conceptual and theoretical frameworks that underpin this study, and provides operational definitions of key concepts (Section 3.2). It also explains the research design, data requirements and sample selection. The second part of the chapter describes the survey techniques that were used to collect empirical data for use in this study. Section 3.3 describes the collection of data, by means of walk-through surveys, relating to the physical characteristics of a sample of 64 local authority office buildings. This is followed by Section 3.4, which explains the collection of occupancy cost and occupancy characteristics data for the sample buildings. The final section in Chapter 3 describes the collection of data relating to the utility of the sample buildings and the characteristics of the buildings' occupants. This involved: focus groups with building occupants to identify the criteria by which they evaluate the utility of their workplace; a preliminary online questionnaire survey of 1,800 occupants of a public sector office building to identify attributes and factors with which to measure workplace utility; and an online questionnaire survey of the sample buildings' occupants (approximately 5,000 office users) to collect data on their working practices and the utility of the sample buildings. The results of the surveys are discussed in Chapter 4.

[7] Local authorities are required, as part of the Government's capital allocation strategy, to develop and implement asset management plans, which outline how the authority utilises its assets and how they contribute to improvement in service delivery (DTLR, 2002).

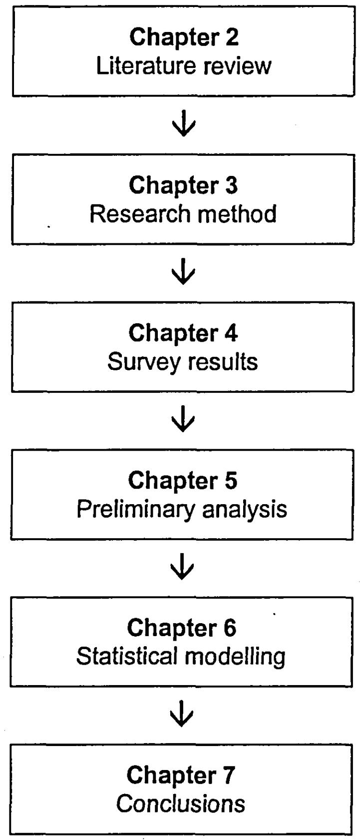

Figure 1.1: Structure of the thesis

The first section in Chapter 4 provides a profile of the sample buildings using data relating to their physical characteristics (Section 4.2). It focuses particularly on the site, location, construction and workspace characteristics of the sample buildings. The second section in Chapter 4 examines the occupancy costs and occupancy characteristics of the sample buildings, and addresses problems of missing data (Section 4.3). Finally, Section 4.4 describes the utility of the sample buildings and provides a profile of the buildings' occupants using data relating to their demographics and working practices. The variables described in this chapter are subjected to further analysis in Chapters 5 and 6.

Chapter 5 examines the significant relationships between the different groups of explanatory and outcome variables. The first section focuses on the relationships between the physical characteristics and utility of the sample buildings to determine whether their utility varies in accordance with differences in their physical characteristics (Section 5.2). This is followed by an analysis of the relationships between the utility of the sample buildings and the characteristics of the buildings' occupants (Section 5.3). Section 5.4 focuses on the relationships between the operation costs and physical characteristics of the sample buildings to determine whether operation costs vary in accordance with differences in physical characteristics. The final section in Chapter 5 examines the relationships between the operation costs and occupancy characteristics of the sample buildings (Section 5.5).

The relationships described in Chapter 5 form the basis of the statistical modelling described in Chapter 6. Chapter 6 explains the modelling procedure and selection of variables for inclusion in the analysis (Sections 6.2.1 - 6.2.3). It also discusses the assumptions underpinning the analysis, the results of modelling and validation of the models (Section 6.2.4 - 6.2.6). Chapter 7 brings together the main findings from the preceding chapters and draws conclusions about the overall outcomes of this study. It also discusses the limitations of this study, outlines areas for further research and reflects on the research process.

1.3 References

Audit Commission (1988a) *Local Authority Property: A Management Overview*, HMSO, London.

Audit Commission (1988b) *Local Authority Property: A Management Handbook*, HMSO, London.

Audit Commission (2000) *Hot property: getting the best from local authority assets*, Audit Commission, London.

Audit Commission (2003) *Comprehensive Performance Assessment: Scores and analysis of performance for single tier and county councils*, Audit Commission, London.

Barras, R. and Clark, P. (1996) Obsolescence and performance in the Central London office market, *Journal of Property Valuation and Investment*, **14** (4) 63-78.

Baum, A. (1991) *Property investment depreciation and obsolescence*, Routledge, London.

Baum, A. (1997) The causes and effects of depreciation in office buildings: a ten year update, *In proceedings of the Royal Institution of Chartered Surveyors Cutting Edge Conference*, Royal Institution of Chartered Surveyors, London.

Bernard Williams Associates (1994) *Facilities Economics*, Building Economics Bureau, Bromley.

Bootle, R. and Kalyan, S. (2002) *Property in business - a waste of space?*, The Royal Institution of Chartered Surveyors, London.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999) Appraising the functional performance characteristics of office buildings, *Journal of Property Research*, **16** (4), 339-358.

Bryson, J.R. (1997) Obsolescence and the process of creative reconstruction, *Urban Studies*, **34** (9), 1439-1458.

Bowie, N. (1983) The depreciation of buildings, *Journal of Valuation,* **2** (1), 5-13.

Ching, C.H. (1994) *Property management in English local authorities: a corporate approach to the management of operational property*, PhD, University of Liverpool.

CIPFA (1998) *Capital accounting by local authorities : people + pounds + property = services : a guide to the use of capital accounting to improve asset management and service performance*, Charted Institute of Public Finance and Accountancy, London.

Clark, L., Price, I. and Agahi, H. (2003) *What customers want from FM: Satisfaction with facilities services in local government*, Local Government Facilities Management Research and Application Forum, Facilities Management Graduate Centre, Sheffield Hallam University, Sheffield.

Clark, S.P. (1988) *Local authority property management*, Occassional paper No. 1, Hillier Parker May and Rowden.

Cowan, P. (1965) Depreciation, obsolescence and ageing, *The Architects Journal*, **141**, 1395-1401.

Deakin, M. (1999) *Local authority property management: initiatives, strategies, re-organisation and reform*, Ashgate, Aldershot.

DEGW (2002) *Research for occupiers: Priority issues*, Occupier.org, http://www.occupier.org

Dixon, T.J., Law, V. and Cooper, J. (1999) *The dynamics and measurement of commercial property depreciation in the UK*, The College of Estate Management, Reading.

DTLR (2002) *Implementation of asset management plans and corporate capital strategies: Baseline report*, Department for Transport, Local Government and the Regions, London.

DOE (1994) *Extension of CCT to local authority professional construction-related and property services*, Department of the Environment, London.

Duffy, F. (1983) *Information technology and office design: the Orbit study*, DEGW and EOSYS Ltd, London.

Dunse, N. and Jones, C. (2002) Rental depreciation, obsolescence and location: the case of industrial properties, *In proceedings of European Real Estate Society Conference*, Glasgow.

IPF (2000) *National Best Value Benchmarking Scheme*, Institute of Public Finance, London http://www.ipf.co.uk/

Jones Lang Wootton (1987) *Obsolescence: The financial impact on property performance*, Jones Lang Wootton, London.

Kelly, J. and Hunter, K. (2003) The three wheels of Best Value: A service focused approach to the measurement of Best Value, *Research Papers*, **4** (23), RICS Foundation, London.

Khalid, G. (1994) Obsolescence in hedonic price estimation of the financial impact of commercial office buildings: The case of Kuala Lumpa, *Construction Management and Economics*, **12**, 37-44.

Lichfield & Associates (1968) *Economics of conservation*, HMSO, London.

Loring, J. (1993) *Practical approaches to local authority property management*, Institute of Advanced Architectural Studies, University of York.

Medhurst, F. and Lewis, J.P. (1969) *Urban decay: an analysis and a policy*, Macmillan, London.

Nelson Bakewell and OPD (2003) *Occupational flexibility and corporate strategy*, Nelson Bakewell, London.

Nutt, B. (1997) Adapting and re-using buildings, *International Journal of Facilities Management*, **1** (3), 113-121.

ODPM (2004) *Monitoring the code of practice for commercial leases: interim report*, Office of the Deputy Prime Minister, London.

Ohemeng, F.A. and Mole, T. (1996) Value-focused approach to built asset renewal and replacement decisions, *In proceedings of the Royal Institution of Chartered Surveyors COBRA Conference*, Royal Institution of Chartered Surveyors, London.

Salway, F. (1986) *Depreciation of commercial property,* The College of Estate Management, Reading.

Smith, G., Hoar, D., Jervis, B., Neville, R. and Tegerdine, M. (1984) *Life cycle cost planning: A guide to life cycle cost planning and financial appraisal of local authority property and new construction*, Society of Chief Quantity Surveyors in Local Government, London.

SOLACE (1986) *Our heritage: Property management in a local authority,* Society of Local Authority Chief Executives, Maidstone.

Switzer, J.F.Q. (1963) The life of buildings in an expanding economy, *The Chartered Surveyor*, August, 70-77.

Yusof, A.M. (1999) *Modelling the impact of depreciation: a hedonic analysis of offices in the city of Kuala Lumpur, Malaysia*, PhD, University of Aberdeen.

Chapter 2
Literature review

Chapter 2 Literature review

2.1 Introduction

Occupier organisations utilise buildings, in conjunction with other services and resources, as workplaces[8] (Haynes *et al.*, 2000). Workplaces are created to support people in the delivery of goods, services or knowledge to clients and customers. Feedback from clients and customers will ultimately impact on the activities of an occupier organisation and, in turn, its property requirements (Figure 2.1). However, as an organisation's property requirements change over time there is a possibility that the performance of the building(s) that it occupies will decline. Such a decline in the performance of a building is referred to in this study as obsolescence.

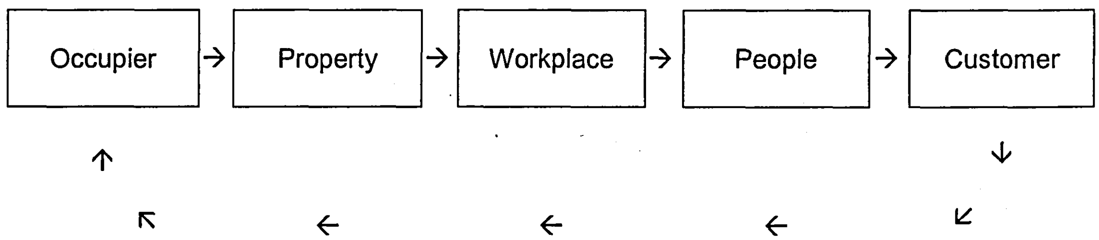

Figure 2.1: Occupiers' property chain and customer feedback
(adapted from Haynes *et al.*, 2000; p.6 and McLennan, 2000; p.169)

Anecdotal evidence suggests that obsolescence can have an adverse impact on the performance of an occupier organisation, for instance through decreased operational efficiency, reduced output or declining morale in the workplace (Building Research Board, 1993). However, difficulties in establishing a causal relationship between the performance of buildings and either individuals' productivity or organisational outcomes mean that this claim is hard to substantiate (Haynes *et al.*, 2000; EKOS Limited and Ryden Property Consultants, 2001). What has been easier to establish is the negative impact that obsolescence has on the value of buildings. By and large, as the performance of a building declines, so does its value. This decline in value is more commonly known as depreciation. Depreciation is problematic because it undermines the ability of property to show long-term growth in rental and capital values (Salway, 1986). Property owners are therefore faced with the choice of accepting lower financial returns or incurring the costs of upgrading their buildings to satisfy changing occupier requirements.

[8] The term 'workplace' is used in this study to refer to the entire physical environment for work, whether it be an entire floor, building or campus (Brill *et al.*, 2001).

Previous empirical studies into property depreciation and obsolescence have primarily been grounded in the real estate and planning disciplines, respectively (Figure 2.2). In the planning discipline, researchers have tended to adopt a demand-side approach and examine the impact of changing occupier requirements on obsolescence at an urban or regional level (Medhurst and Lewis, 1969; Hendry, 1970; Cowan *et al.*, 1970c; Emery, 1971; Nutt *et al.*, 1976; Fulcher and Gallagher, 1977; Williams, 1985; Bryson, 1997; EKOS Limited and Ryden Property Consultants, 2001). By contrast, researchers in the real estate discipline have tended to adopt a supply-side approach and analyse the impact of obsolescence on the depreciation of property values in specific locations, such as the City of London (Baum, 1991; Khalid, 1994; Dixon *et al.*, 1999; Bottom *et al.*, 1999; Yusof, 1999; Dunse and Jones, 2002). The purpose of this chapter is to critically review the key studies from each discipline and identify gaps in the existing body of knowledge.

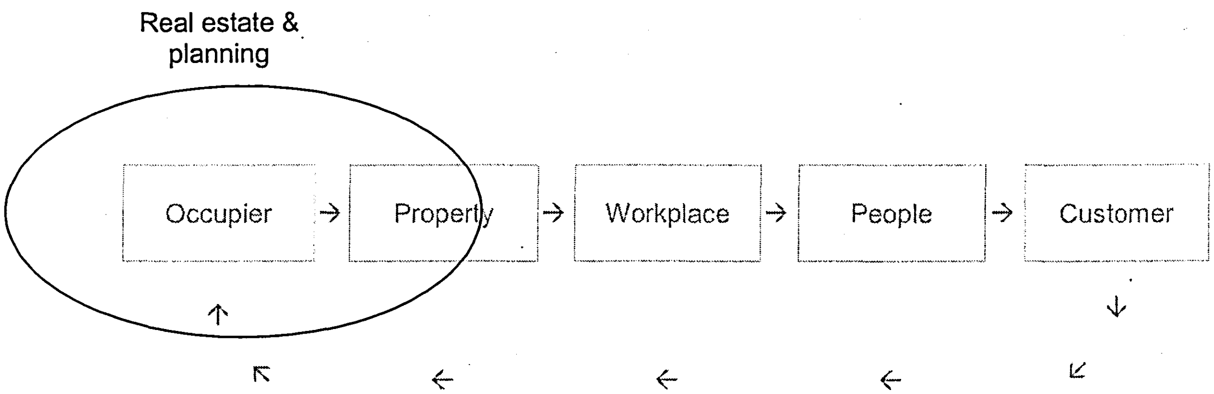

Figure 2.2: Scope of previous research into property depreciation and obsolescence (adapted from Haynes *et al.*, 2000; p.6 and McLennan, 2000; p.169)

The next section in this chapter (Section 2.2) discusses the background theory behind the two groups of studies described above (Figure 2.3). It focuses particularly on defining and explaining concepts such as building performance, utility, value, service life, obsolescence and depreciation. Section 2.3 provides a critical review of research that has been conducted into obsolescence. The review focuses on the research methods employed and the findings arising from the research. This is followed by a critical review of research into property depreciation (Section 2.4). The focus here is on the analytical techniques that have been developed for estimating the impact of property depreciation over time. This chapter concludes by reconciling the findings from both sets of studies, highlighting gaps in knowledge and identifying areas for further research (Section 2.5).

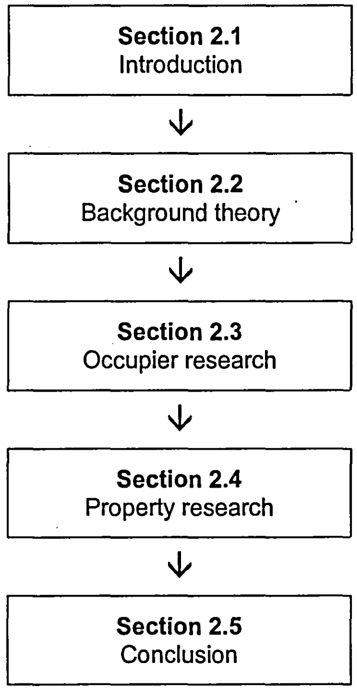

Figure 2.3: Structure of Chapter 2

2.2 Background theory

2.2.1 Building performance

When constructed, buildings are presumed to be state of the art, having been built to contemporary standards of construction and appropriately located (Tiesdell *et al.*, 1996). After commissioning, they typically operate at or near optimum performance (Figure 2.4). According to Williams (2003), there are three interrelated facets of building performance (Figure 2.5). These are:

- physical performance;
- functional performance; and
- financial performance.

Physical performance is the behaviour of a building's fabric, services and finishes (Williams, 2003). Although buildings are, in general terms, very durable, they are inevitably subject to physical deterioration and, consequently, declining performance (Chanter and Swallow, 1996). Physical deterioration is an *absolute* decline in performance. It is the loss of the physical capacity of a building to perform the function for which it was designed, and is primarily a function of environmental factors (the action of the elements) and wear and tear resulting from use (Figure 2.6). Left unchecked, physical deterioration will continue until the building reaches the end of its physical life (Figure 2.4), the time period after which the building can no longer perform its function because physical deterioration has rendered it useless (Trowbridge, 1964; BS ISO 15686-1, 2000).

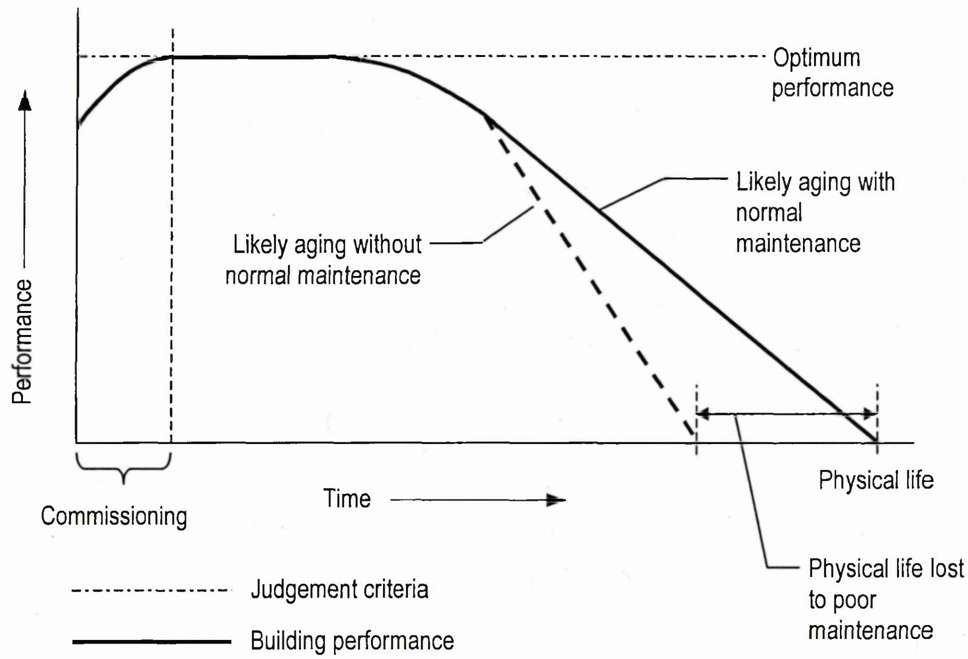

Figure 2.4: Conceptual view of physical life (adapted from Building Research Board, 1993; p.16)

Physical deterioration can be controlled to some extent by selecting appropriate components and materials at the design stage (Ashworth, 1999), and by correct maintenance during a building's physical life (Figure 2.4). Although effective maintenance policies are not the norm, it is clear that building maintenance has begun to be approached in a more informed way; the increased use of planned maintenance programmes being a case in point (Chanter and Swallow, 1996). Life cycle cost techniques are also being developed to facilitate choice between alternative design options and to enable designers to take into consideration all costs that are likely to emerge during a building's physical life (Kirk and Dell'Isola, 1995; Clift and Bourke, 1999). Finally, those involved with the management of buildings have devised methods for observing, measuring and recording the extent of physical deterioration and decay over time, allowing more accurate estimation of a building's physical life (Cook and Hinks, 1992; Douglas, 2002).

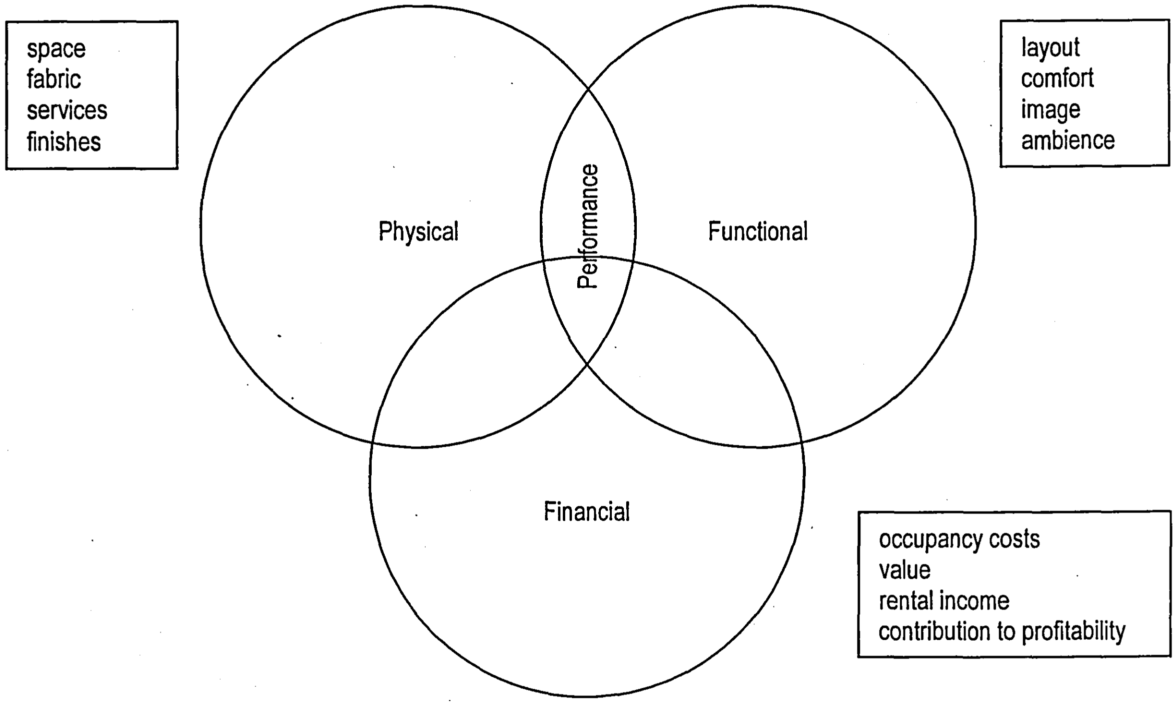

Figure 2.5: Facets of building performance and their interrelationships (adapted from Williams, 2003; p.A-22)

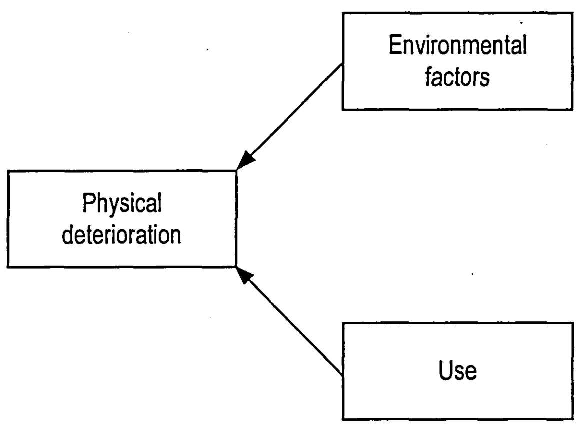

Figure 2.6: Causes of physical deterioration

It is important, however, to distinguish between a building's physical life and its service life. Service life is the period of time over which a building functions above a minimum acceptable level of performance (Figure 2.7). Whatever the cause, any building that has reached the end of its physical life has, in fact, failed and must be renewed. In contrast, a building that has reached the end of its service life can continue to function, albeit at less than acceptable performance, and may or may not be renewed (Building Research Board, 1993). Service life is therefore affected by the rate of physical deterioration of the building and the standard of maintenance practices (Figure 2.7). It is also affected by increasing expectations created by changes in equipment, materials, style, laws, standards and the many other extraneous factors that cause a building to lose performance in the eyes of its user (Trowbridge, 1964). The impact of such factors is obsolescence (Figure 2.8). Obsolescence is discussed further in Section 2.2.2.

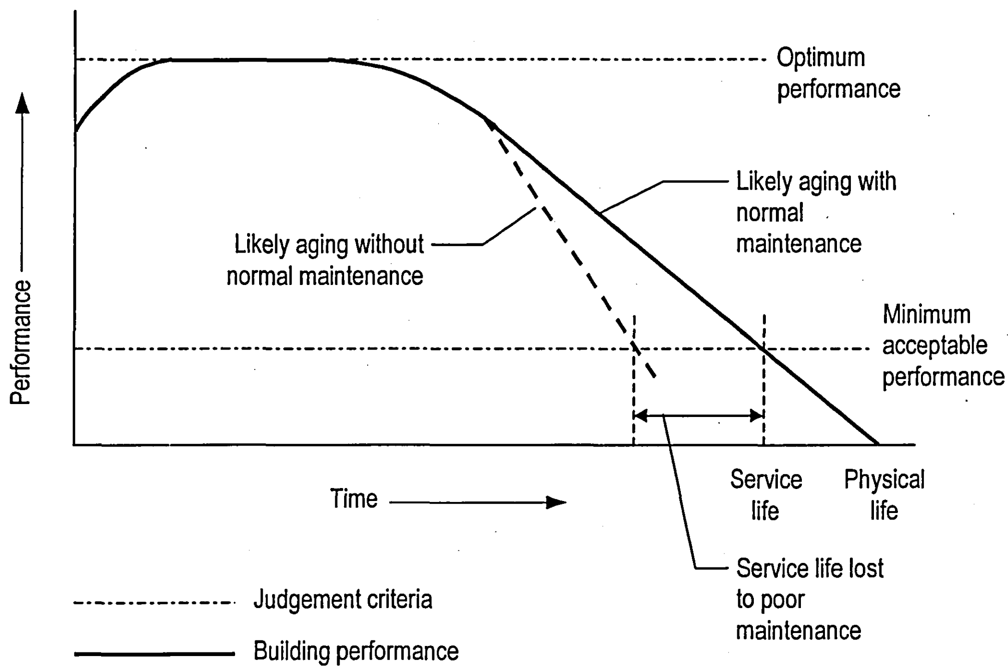

Figure 2.7: Conceptual view of service life (adapted from Building Research Board, 1993; p.19)

Functional performance is a measure of the attributes afforded by a building to the benefit, or otherwise, of its occupier (Williams, 2003). It is, in effect, a measure of a building's utility for those people that use it (Aronoff and Kaplan, 1995). Utility is a subjective concept and has been defined in numerous ways. The *Concise Oxford Dictionary* defines utility in broad terms, as 'the state of being useful, profitable or beneficial' (Pearsall, 2001; p.1580). By contrast, in the field of economics utility has been defined more narrowly as the 'the pleasure or satisfaction derived by an individual from being in a particular situation or from consuming goods or services' (Bannock *et al.*, 1992; p.437). In this research, as in previous studies of property depreciation and obsolescence, the word 'utility' is taken to mean 'usefulness' (Salway, 1986).

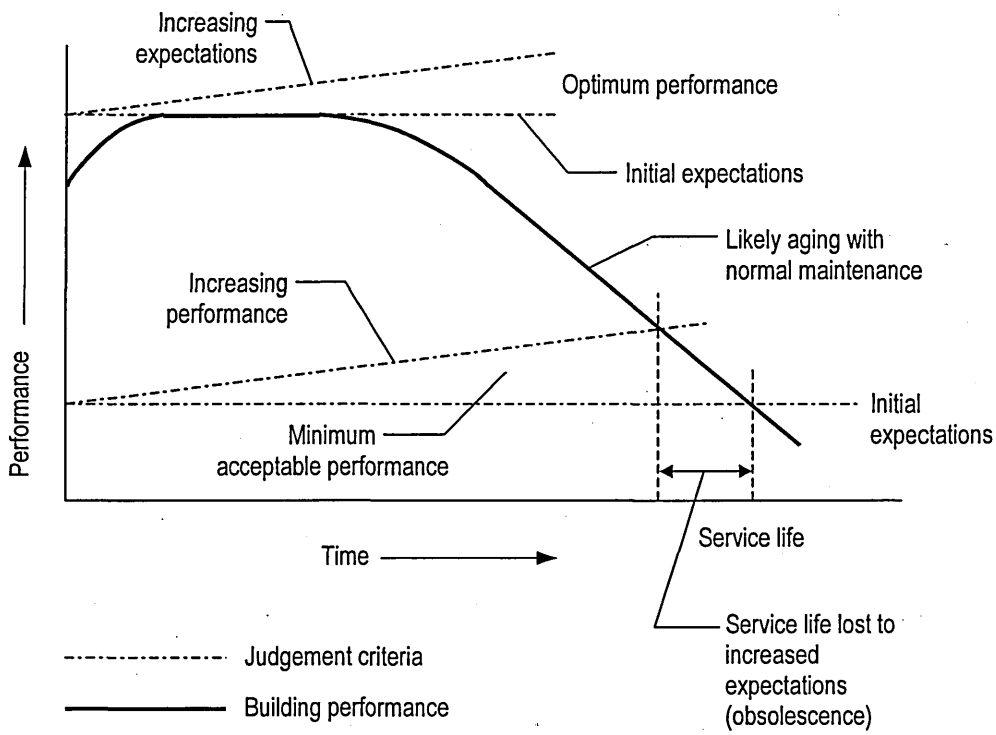

Figure 2.8: Conceptual view of obsolescence (adapted from Building Research Board, 1993; p.20)

Measuring utility has often proven problematic, not least because it is such a subjective concept. For instance, in economics debate about the measurement of utility has traditionally revolved around the competing theories of cardinal utility, an absolute measurement made through direct judgements, and ordinal utility, a relative measurement that is based on consumer preferences (Rutherford, 1992; Abdellaoui *et al.*, 2001). In the context of the built environment, the measurement of utility is complicated by the fact that buildings often have multiple user interests. For example, the users of an office building typically include occupants (employees who work in the building), senior managers or executives in the organisation (who may not necessarily work in the building) and visitors, including members of the public, who have business in the building (Gray and Tippett, 1992). Each of these groups have different objectives and will therefore assess the utility of the building in different ways (Williams, 1985).

The physical performance and utility of a building will affect its financial performance (Williams, 2003). As with utility, what constitutes the financial performance of a building will depend on who is evaluating it. For an occupier organisation, be it a tenant or owner-occupier, a building's financial performance will depend on its costs-in-use and contribution to the profitability of the core business, although the latter is particularly difficult to measure (Haynes *et al.*, 2000; Salway, 1986). The costs-in-use, or occupancy costs, of a building include all the day-to-day costs associated with meeting occupier requirements, but exclude the costs of business activities conducted within the building (Clift and Butler, 1995).

For a property owner, financial performance is likely to be measured in terms of rental income and market value. In the everyday meaning of the word, 'value' is the 'worth of something to its owner' (Bannock *et al.*, 1992; p.438). In this research, value is taken to mean the price that a building might reasonably be expected to be sold for at a given time (Jones Lang Wootton, 1987). In a market where there is zero inflation[9] the value of a building will decline in accordance with its utility. This loss in value is known as depreciation. If the market is not balanced, however, changes in supply and demand will have a distorting effect (Figure 2.9). For example, in markets where there is excess demand, a building with a low level of utility may have a value close to that of a state of the art building (Khalid, 1992). Likewise, if the assumption of zero inflation is invalid, depreciation will not always be apparent and a building's value will fail to provide a reliable indication of its usefulness (Salway, 1986). Inflation can therefore conceal depreciation, as property owners found to their cost in the 1980s when a sustained period of inflation was followed by deep recession and a crash in property values (Bowie, 1983). As leases ended, property owners were left with buildings requiring extensive refurbishment (Bryson, 1997). For owner-occupiers, the decline in property values meant that buildings that were once assets became liabilities (Gibson, 1994). Concerns over the costs of property depreciation stimulated a series of empirical studies into the issue. These studies are reviewed in Section 2.4.

[9] 'The general increase in prices and fall in the purchasing value of money' (Pearsall, 2001; p.726).

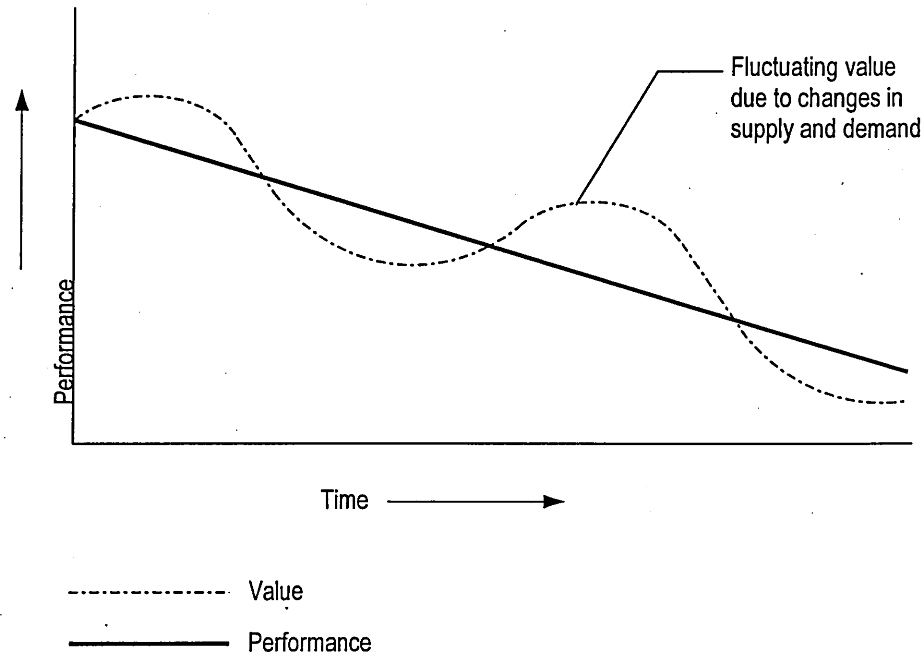

Figure 2.9: Peformance and market value (Khalid, 1990; p.18)

2.2.2 Obsolescence

One of the earlier explanations of obsolescence was by Burton (1933), who argued that if it were possible to hold stationary the physical conditions of a building, obsolescence would be the difference between the existing demand for the characteristics of the building and the demand that was anticipated when the building was constructed. The building may not necessarily be dilapidated, worn out, or otherwise dysfunctional; although these factors may accentuate the obsolescence, the building simply does not measure up to contemporary expectations (Building Research Board, 1993). According to Nutt *et al.* (1976) obsolescence increases as the performance provided by the building decreases *relative* to changing requirements. Equally, a building that has lost performance because of changing requirements may benefit from further change (Weatherhead, 1999). For example, many office buildings that became redundant during the 1980s because they were unable to accommodate information and communications technology (ICT) have since come back into use because of further technological innovation.

According to Nutt *et al.* (1976) any change that reduces the ability of a building to meet occupier requirements, relative to other buildings in its class, will contribute towards its obsolescence. The causes of obsolescence are therefore wide-ranging, embracing changes that relate to buildings, the sites that buildings occupy and their surroundings (Mansfield, 2000b). Examples include:

- Changes in aesthetics and architectural style. A building may lose utility if its appearance becomes out-dated, incompatible with the occupier's image or tarnished due to physical deterioration (Khalid, 1992; Salway, 1986).
- Changes in law. The enactment of new legislation, new standards in health and safety, or changes in building regulations can cause a building to exhibit diminished utility or financial performance (Tiesdell *et al.*, 1996). A recent example is the introduction of the Disability Discrimination Act (1995), which required service providers in all sectors to make their buildings accessible to disabled people. The scope of the Act included the provision of ramps and automatic doors to entrances, modification of WC facilities, improvements to emergency warning systems and the installation of stair lifts (Mansfield, 2001). In extreme cases legal changes of this kind may render a building obsolete because of the costs of compliance (Salway, 1986).
- Changes in technology. A building may be physically sound, but exhibit a lower level of utility or financial performance relative to newer buildings that have benefited from technological progress (Salway, 1986). Examples include the introduction of air-conditioning into office buildings in the 1980s to cope with growth in the use of ICT. Office buildings that did not have air-conditioning, or could not accommodate it, were technologically obsolete.
- Changes in functional requirements. The performance of a building may decline because of changes in the functions or activities of its users. An example of functional change is the inability of some warehouses and industrial buildings to cope with changes in manufacturing and logistical processes, due to inadequate eaves heights, restricted dock design and closely-spaced structural columns (McKnight, 1999).
- Changes in development economics. A building may experience a relative decline in performance when the site on which it stands becomes more suitable for a use that the building cannot accommodate, due to new planning policies, re-zoning or changing economic conditions. An extreme example was Tokyo in the 1980s, where comparatively new hotels were demolished to make way for office buildings (Brand, 1994).

- Changing environmental conditions. In particular, negative environmental changes, such as detrimental neighbouring land uses or unsightly adjacent buildings (Baum, 1991). What was once considered a prime location for a particular building may lose its attractiveness, thereby causing a decline in the utility and financial performance of the building (Khalid, 1992).

From this list of changes, it is possible to identify two distinct forms of obsolescence: building obsolescence and locational obsolescence (Figure 2.10). Building obsolescence is caused by aesthetic, functional, legal or technological changes. It is the performance of a building relative to the stock of similar buildings (Nutt *et al.*, 1976). Building obsolescence is a function of physical characteristics; two buildings in the same location may exhibit different levels of performance because of differences in their physical characteristics; one building will be less obsolescent than the other (Bryson, 1997). Locational obsolescence is caused by changes in development economics or local environmental conditions. It is the degree of usefulness of a location relative to other locations; two buildings with the same physical characteristics may have different levels of performance because they are in different locations.

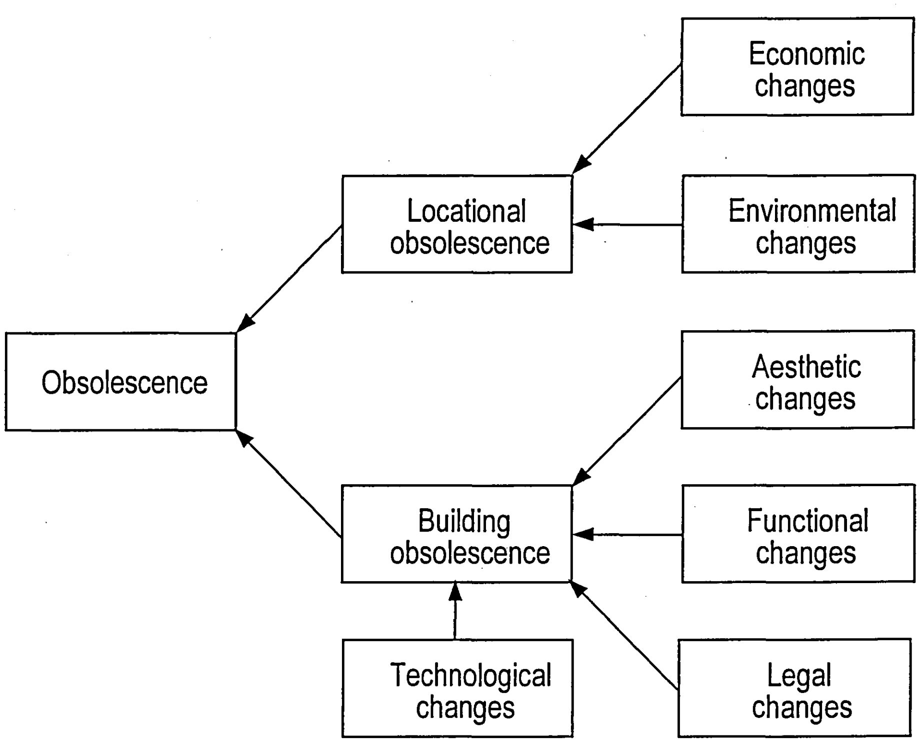

Figure 2.10: Causes of obsolescence

The distinction between building obsolescence and locational obsolescence is an important one. In most cases, it is not feasible for a property owner to remedy locational obsolescence, since this usually involves large-scale capital investment in order to improve infrastructure or reverse urban decay. Normally, regeneration on this scale can only be realised with co-ordinated investment and long-term planning by local authorities and other government agencies (EKOS Limited and Ryden Property Consultants, 2001). Although local authorities may be able to improve the environs of land in their ownership, this is usually outside the scope of most other property owners (Debenham Tewson & Chinnocks, 1985).

2.2.3 Flexibility and building renewal

Two characteristics of buildings mean that they are particularly susceptible to obsolescence (Raftery, 1991). The first is longevity. When buildings are carefully designed, constructed and maintained, their physical life spans can be almost indefinite (Ashworth, 1997). Buildings are therefore trapped in a social, technological and physical frame, as defined by standards acceptable at the time of construction (Ohemeng and Mole, 1996). This places limits on the capacity of buildings to accommodate changing demands over time. The second characteristic is that buildings have a fixed location, which means that buildings cannot move to accommodate changing demands (Raftery, 1991). Flexible design has, therefore, long been seen as an important factor in reducing the risk of obsolescence in buildings (Switzer, 1963; Cowan, 1965; Building Research Board, 1993; Slaughter, 2001). Flexibility is the capacity to accommodate new or more intense uses (Building Research Board, 1993). Examples of flexible building design include the provision of unconstrained interior spaces, accessible service areas and overcapacity in engineering services[10] (Building Research Board, 1993).

Anecdotal evidence suggests that the growth in importance of obsolescence is due to increasing rates of change in society (Building Research Board, 1993). For example, obsolescence appears to increase during periods of rapid technological change (Weatherhead, 1999). Whatever the reason, the predominance of obsolescence over physical deterioration is significant because unlike the gradual process of physical deterioration, obsolescence can occur at irregular and unpredictable intervals, causing step changes in the performance of a building. For example, the introduction of new legislation or

[10] The comparative costs and benefits of flexible design were highlighted by Slaughter (2001), who analysed the construction costs, physical characteristics and refurbishment costs of 48 buildings. The analysis revealed that on average flexible design strategies added less than two per cent to construction costs, reduced overall construction time and provided a two per cent saving on future refurbishment costs.

technology may result in a sudden rise in the minimum level of acceptable performance and a decrease in service life (Figure 2.11). This unpredictability means that the scope for preventative action is limited (Salway, 1986). Obsolescence is also more likely to be incurable. Whereas physical deterioration can usually be remedied through the replacement of like with like, the treatment of obsolescence often requires introducing new features into a building. This may not be feasible because of economic or technical constraints (Salway, 1986).

Efforts to counteract obsolescence are called renewal. Renewal involves increasing the performance of a building or site by reconciling the mismatch between its characteristics and the needs of its occupier. Periodic renewals can extend a building's service life (Figure 2.12). According to Tiesdell *et al.* (1996) there are three main types of renewal. These are refurbishment, conversion to a new use (adaptive reuse), and demolition and redevelopment.

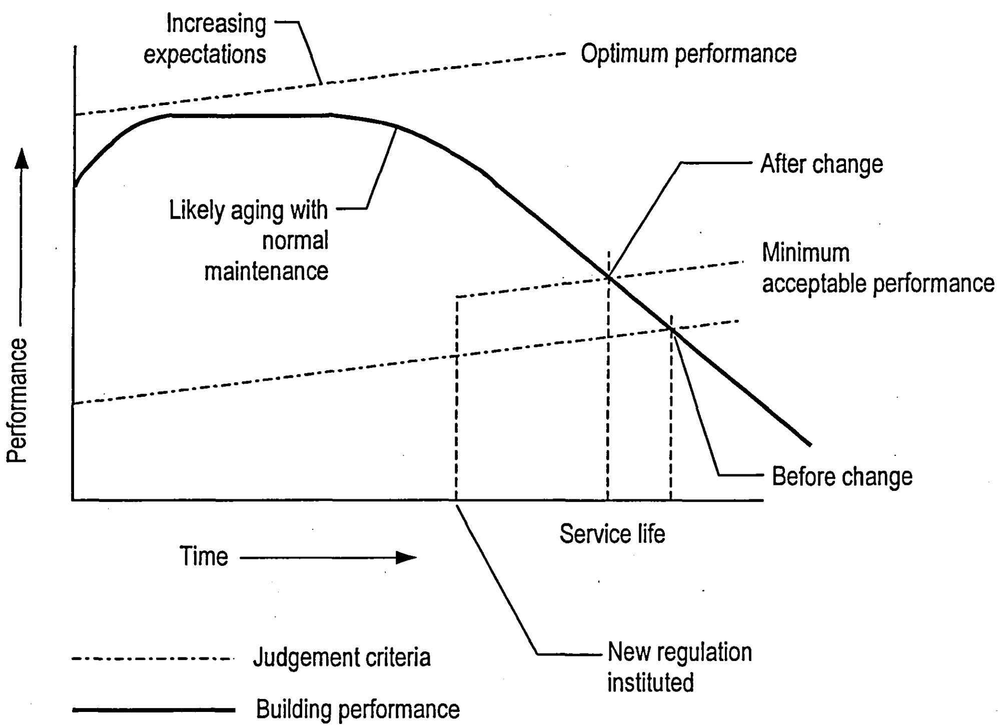

Figure 2.11: Impact of rapid changes on service life (adapted from Building Research Board, 1993; p.21)

Demolition and redevelopment takes place when a building is obsolete for any use, and involves replacement of the building by a new construction, for a similar or different purpose, resulting in the start of a new physical life on the site (Lichfield, 1988). There have been many points of criticism regarding this approach (Ohemeng, 1998), not least that the capital and physical resources sunk in buildings are significant, and that simply writing them off should be a last resort (Smith *et al.*, 1998; Rydin, 1992; Freer *et al.*, 1999). Where demolition and redevelopment are precluded or undesirable, renewal will focus on retarding obsolescence and extending a building's service life through refurbishment (Tiesdell *et al.*, 1996).

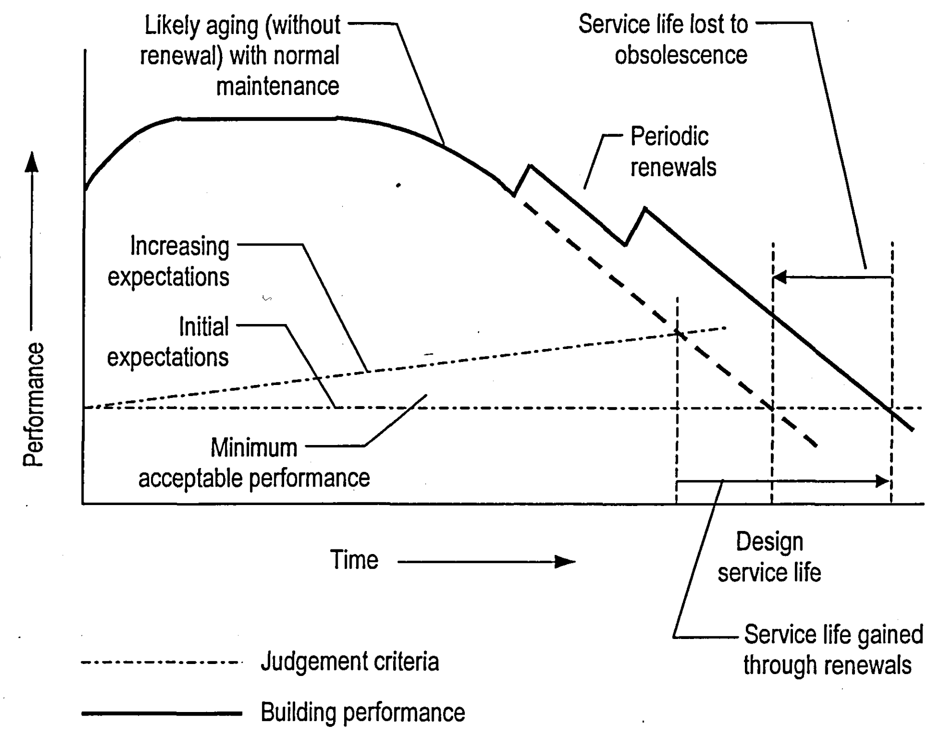

Figure 2.12: Impact of periodic renewals on building service life (adapted from Building Research Board, 1993; p.22)

Refurbishment is the process by which an existing building is substantially upgraded through restoration or improvements, or both. It usually involves work to the fabric and services (Bernard Williams Associates, 1994). Refurbishment provides a positive remedy for the negative processes of physical deterioration and obsolescence (Mansfield, 2000a). The economics of refurbishment activity have become increasingly favourable in the UK because refurbished buildings can offer facilities comparable to new buildings for a fraction of the cost and technological innovation means that many redundant buildings can now be brought back into use (Ohemeng, 1998). As a result, refurbishment has become the principal method for countering obsolescence (BS ISO 15686-1, 2000). This is particularly the case in marginal development locations, where the potential for demolition and redevelopment is lower (Bryson, 1997).

Bryson (1997) suggested that refurbishment offered a number of advantages over redevelopment as a remedy for obsolescence. Refurbishment is normally less expensive than redevelopment. Although the difference may not be significant, it is a critical factor in locations where redevelopment margins are low or non-existent. Planning permission for refurbishment is usually easier and quicker to obtain than for redevelopment, and there are usually fewer planning restrictions on refurbishment projects. Other benefits of refurbishment include energy and resource conservation, preservation of historic fabric and shorter construction periods, which means that a rental stream arrives sooner (Kwakye, 1994). There are, however, drawbacks associated with refurbishment projects. They are often difficult to plan and cost, due to uncertainty about the scope of the works at the design stage. Moreover, refurbishment is unsuitable when the physical constraints imposed by a building mean that it can no longer accommodate existing activities. In these situations, a building will either be demolished and redeveloped or undergo adaptive reuse (Nutt, 1997).

Adaptive reuse is a method by which a building is refurbished and adapted to accommodate a new use (Nutt, 1997). Unless a building was designed for a very specific purpose, it is usually technically feasible to increase its performance by converting it to another use (Williams, 1985; Heath, 2001; Kincaid, 2002). An example of adaptive reuse is the conversion of commercial office buildings into residential accommodation[11] (Gann and Barlow, 1996; Nutt, 1997; Freer *et al.*, 1999). There are, nevertheless, a number of barriers to adaptive reuse. They include the suitability of redundant buildings, the costs of conversation relative to demolition and redevelopment, restrictive planning policies, lack of experience of conversion amongst developers and concern over the level of financial returns from converted buildings (Freer *et al.*, 1999; Heath, 2001).

Determining which form of renewal to use to remedy obsolescence can be a complex decision making process that involves evaluating the costs and benefits of different courses of action (Ohemeng, 1998). The decision making process is dependent on a range of factors, including market conditions, government incentives, planning policies and the physical characteristics of the building in question (Kincaid, 2002). It is also dependent on the objectives of individual stakeholders, such as users (owners, facility managers and

[11] Research by Nutt *et al.* between 1994-1996 suggested this to be the most common form of adaptive reuse (Nutt, 1997). An analysis of planning applications for a sample of London boroughs revealed that office-to-residential conversions accounted for 34 per cent of cases of adaptive reuse.

occupants), investors, producers (architects, engineers and contractors), marketers (property agents), regulators (planners and statutory authorities) and developers[12] (Nutt, 1997).

The decision to renew a building and counteract obsolescence can result in significant capital costs. However, the failure to accommodate changing occupier requirements can be equally as costly. Aside from the costs of depreciation, there is anecdotal evidence to suggest that obsolescence can have an adverse impact on building occupants, for example through reduced productivity or on the job stress, and consequently the operational performance of occupier organisations (Building Research Board, 1993). Obsolete buildings can also blight the urban landscape and become a burden on the natural environmental when demolished (Freer *et al.*, 1999; EKOS Limited and Ryden Property Consultants, 2001). Dealing effectively with obsolescence in buildings therefore has potentially broad benefits (Building Research Board, 1993). It is for this reason that, over the years, a number of studies have sought to develop a better understanding of the causes and consequences of obsolescence in buildings[13]. Grounded primarily in the planning discipline, these studies have, for the most part, examined the impact of changing occupier requirements on the demand for buildings at an urban and regional level. The next section provides a critical review of the key studies.

2.3 Occupier research

Much of the background theory concerning obsolescence can be traced back to the 1960s, when the issues of urban decay and redevelopment came to the fore in the UK (Switzer, 1963; Cowan, 1965; Lichfield & Associates, 1968; Medhurst and Lewis, 1969). However, little of this theory was grounded in empirical evidence, being based instead on anecdotal evidence and conjecture. Cowan *et al.* (1970a) alluded to the fact that while the notion of obsolescence had become established at a conceptual level, there was a lack of operational techniques or research methods to help formalise and extend understanding of the processes involved. Since then, there have been a number of empirical studies on the subject. This section provides a critical review of the key studies.

[12] For example, a survey by Nutt *et al.* between 1994-96 revealed significant variations in the objectives and priorities of different stakeholder groups in relation to adaptive re-use. Investors were primarily concerned with risk (57%), marketers with value (81%) and robustness (71%), regulators with value (79%) and risk (62%), users with cost (84%) and value (65%), developers with risk (61%) and value (55%), and producers with cost (54%) (Nutt, 1997).

[13] A summary of these studies is provided in Appendix A.

2.3.1 Analysis of occupier requirements

Most of the earliest efforts at explaining the causes and consequences of obsolescence were framed within the broader context of urban decay and renewal. Consequently, many studies failed to distinguish between the processes of physical deterioration and obsolescence. Those that did attempted to bring to light the causes of obsolescence by examining the factors influencing occupier behaviour. For example, Medhurst and Lewis' (1969) study involved a survey of occupier organisations to ascertain the reasons behind the decision to vacate a building and move to new premises. The survey revealed that most organisations moved because of rising rents, lack of flexibility, inadequate parking and other traffic problems. However, the usefulness of the results was limited by a small sample size of 24 occupier organisations. Cowan *et al.* (1970b) adopted a similar approach towards occupiers of office buildings. A survey of occupier organisations in London revealed that the principal reasons for moving to new premises were spatial constraints, financial constrains and constraints on organisational change (Table 2.1).

Table 2.1: Factors behind office relocation decisions (from Cowan *et al.*, 1970b; p.7)

Factor	Number of organisations	Percentage
Too small	269	45
Expiry of lease	90	15
Inconveniently located	63	10
Demolished/rebuilding	62	10
Too expensive	50	8
Reorganisation	34	6
Inconvenient layout	21	4
Other	14	2
Total	603	100

Cowan *et al.* (1970b) viewed the measurement of constraints, and occupiers' responses to them, as a potential proxy for obsolescence, arguing that if obsolescence was increasing it could be measured by the tightening of the constraints imposed on occupiers by their accommodation. Equally, if obsolescence was decreasing then it could be measured by the degree of constraint relaxation. The principal objective of Cowan *et al.* (1970b) was to develop techniques for measuring such constraints and occupiers' responses to them. Constraints were classified as either acceptable (no complaints), just tolerable (complaints are voiced but no remedial action taken) or unacceptable (complaints voiced and remedial action taken) (Figure 2.13). Cowan *et al.* (1970b) conducted a case study of an office-based organisation to test the validity of this approach. The authors concluded that constraints could serve as indicators of obsolescence, but that further research was required to refine the data collection techniques. The study served as a pilot for more extensive research by Nutt *et al.* (1976).

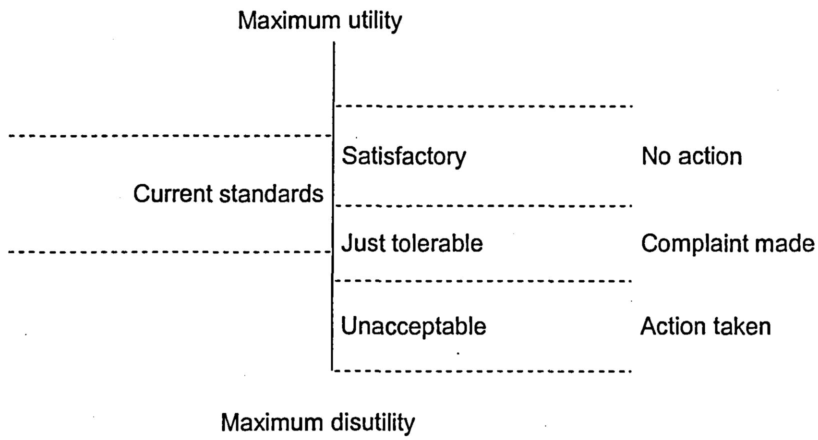

Figure 2.13: Disutility scale
(from Nutt *et al.*, 1976; p.64)

Nutt *et al.* (1976) aimed to develop a method for assessing, simulating and remedying the obsolescence of residential buildings. Based on the theoretical framework developed by Cowan *et al.* (1970b), the central objective of the research was to identify factors, in terms of the physical characteristics of buildings and market conditions, that gave rise to different levels of constraint and dissatisfaction for particular types of households. The theoretical framework was tested using secondary data from more than 10,000 residential buildings and households in London, the West Midlands and Hampshire. These data were supplemented with more detailed data from a questionnaire survey of 600 households and then analysed using multivariate techniques. The research highlighted the thresholds between the different levels of constraint identified by Cowan *et al.* (1970b) and exposed factors that impacted on occupiers' responses to those constraints. These included the age of the building, household size and property values. Nutt *et al.* (1976) concluded that although most of the data had been collected by other researchers for different purposes, the study had been successful in providing an insight into the processes behind obsolescence.

The notion of obsolescence developed by Cowan *et al.* (1970b) and Nutt *et al.* (1976) was that of an increasing misfit between buildings and occupiers. Obsolescence was seen to entail increasing costs and diminishing benefits over time, so that a building would be obsolete when the cost to its occupier exceeded the benefits of occupation. This notion was developed further by Fulcher and Gallagher (1977), in a study of obsolescence in industrial buildings. The authors sought to examine how obsolescence of industrial buildings influenced the operational performance of occupier organisations, measured in terms of the constraints imposed by the layout of the buildings on the production process, the impact of the working environment on employee productivity, and the costs incurred through running and maintaining buildings. Fulcher and Gallagher (1977) surveyed 42 organisations and 87 buildings in Sheffield. The survey revealed that 45% of buildings were perceived to be having an adverse impact on productivity (Table 2.1), but that the costs of relocation were acting as a barrier to moving to new premises. Although the age of buildings increased the probability of an adverse effect on productivity, almost half of buildings constructed before 1914 were perceived to be having no effect.

Table 2.2: Effect of industrial buildings on perceived productivity (from Fulcher and Gallagher, 1977; p.27)

Construction period	Percentage of buildings	Perceived effect on productivity			
		Very serious	Moderately serious	Not serious	None
Pre-1880	31	3	6	13	9
1881-1899	7	1	0	3	2
1900-1914	28	0	1	8	18
1915-1939	10	0	2	3	5
1940+	24	0	1	2	21
Total	100	5	10	30	55

One of the main conclusions to arise from the study was the need to develop more sensitive indicators of obsolescence, rather than simply relying on the age of buildings, and relate these to the operational performance of the occupier organisation (Fulcher and Gallagher, 1977).

Williams' (1985) study of obsolescence also focused on industrial buildings. The aim of the study was to identify the factors that lead to obsolescence in multi-storey industrial buildings and develop a framework within which obsolescence could be remedied through adaptive reuse. This was achieved through the use of case studies of buildings in Leicester and London. The case studies provided an insight into the impact that social and economic changes were having on the utilisation of buildings, but also how buildings with different physical and locational characteristics had accommodated these changes or been converted through adaptive reuse. Although the results of the research, like those of Bryson's (1997) study of Nottingham, were largely anecdotal, they served to highlight the importance of regularly assessing the capacity of buildings to satisfy occupier requirements over time.

In 1993 the United States Building Research Board published the results of its research into obsolescence. The aim of the study was to examine the causes of obsolescence, expose factors that make buildings more susceptible to obsolescence and identify methods of dealing with obsolescence. This was achieved through the use of case studies, and interviews with experts from industry and academia. The principal conclusion arising from the study was that obsolescence should be considered within the context of a building's entire life cycle, from initial planning through to operations and maintenance. The Building Research Board (1993) identified three interrelated strategies for dealing with obsolescence in buildings. These were to minimise the risk of obsolescence through flexible design, avoid or defer obsolescence by monitoring the utilisation of buildings, and remedy obsolescence through renewal.

The Building Research Board (1993) suggested that the flexibility of buildings could be improved by collecting information on the utilisation of buildings and feeding it back into the design process (Figure 2.14). It recommended that post-occupancy evaluations be employed to gain insights into design configurations better suited to avoiding or delaying obsolescence[14]. Building evaluations were seen to offer other benefits. By repeating them at regular intervals it would be possible to monitor trends that could hasten obsolescence. The Building Research Board (1993, p.46) suggested that information from recurring building evaluations be used to develop 'an indicator – a multidimensional 'obsolescence index' – that could alert building owners and managers to approaching problems'. It argued that the development of 'such an index might be a useful target for research' (Building Research Board, 1993; p.46). Applied in practice, such an index would enable obsolescence to be forestalled, if not avoided, and the impact of any changes on the performance of a building to be estimated in advance. A remedial strategy could then be formulated to counteract the obsolescence.

[14] Post-occupancy evaluations are used to evaluate the degree of 'fit' between a building and its occupier. They can be designed by individual researchers and tailored to meet specific circumstances (Becker, 1990; Preiser, 1995). A number of standardised evaluation techniques have also been developed. ORBIT 2.1 (Becker, 1988), Serviceability (Davis *et al.*, 1990), Real Estate Norm (1992), Building Quality Assessment (Isaacs *et al.*, 1993) and Design Quality Indicator (Construction Industry Council, 2002) all enable comparisons between individual buildings and portfolios of buildings (Baird *et al.*, 1996).

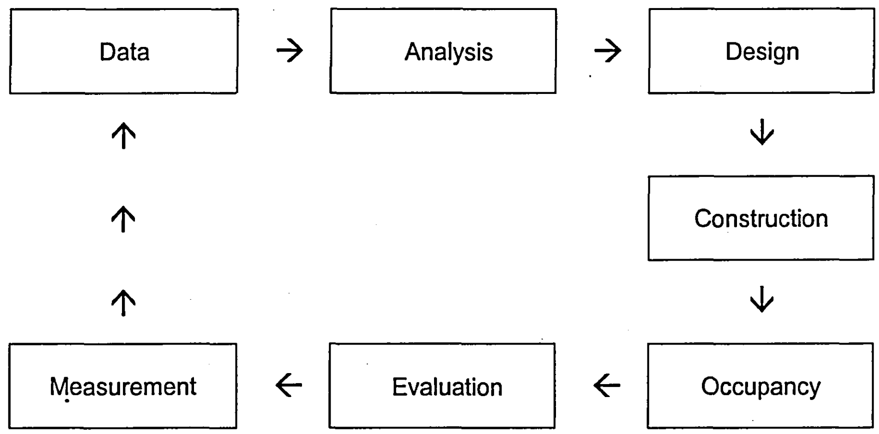

Figure 2.14: Improving flexibility through building design and evaluation

The most recent study of obsolescence in buildings was undertaken on the behalf of the Scottish Executive (EKOS Limited and Ryden Property Consultants, 2001). The aim of the study was to estimate the scale of the obsolescence problem in Scotland and its impact on the economy. This was achieved through consultations with key organisations to establish their views on the scale, nature and causes of obsolescence, together with a quantitative analysis of vacancy rates among older industrial and commercial buildings. The study revealed that obsolescence was not yet putting a significant constraint on the operation of the Scottish economy, but the authors suggested that the situation could change if the property market moved into recession. Nevertheless, the authors acknowledged that the study had been constrained by the absence of a method for analysing the impact of obsolescence on occupier efficiency.

At the outset of the study, the authors noted the paucity of research into obsolescence in buildings, particularly when compared with other issues such as brownfield land and urban regeneration, and suggested that the scale and nature of the issue was neither understood nor appreciated. The literature review in this section has served to confirm this view. When research has been conducted, it has, for the most part, been based on anecdotal evidence derived from descriptive case studies of individual buildings or urban areas. Moreover, the small number of quantitative studies into obsolescence, all of which were undertaken in the 1960s and 1970s, were constrained by a lack of primary data and analytical techniques for measuring obsolescence. This is in contrast to the growing body of research into property depreciation, which has resulted in the development of statistical models for estimating the impact of property depreciation over time. The next section critically reviews this body of research.

2.4 Property research

The first major empirical study of property depreciation in the UK was by Salway (1986). Prior to this the issue was poorly understood (Baum, 1991). It had long been assumed that, given that the loss in the rental or capital value of a building is the result of it losing utility, property depreciation was caused by a combination of physical deterioration and obsolescence (Figure 2.15). However, it was only following Salway's (1986) study that this assumption was tested using empirical data, and the relative impact of obsolescence and physical deterioration on property depreciation established. Since then a number of empirical studies have been undertaken[15]. This section critically reviews the key studies[16].

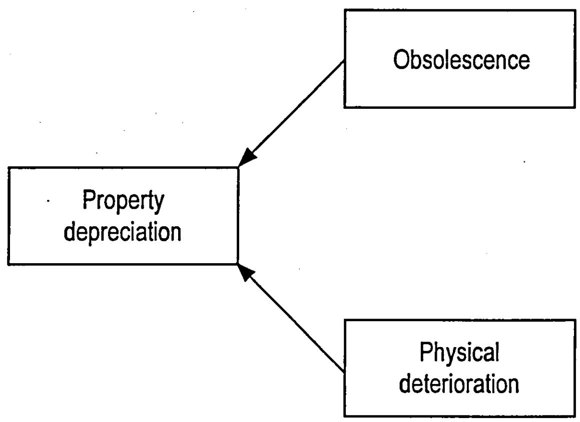

Figure 2.15: Causes of property depreciation

2.4.1 Exposing the factors behind property depreciation

In the UK, property depreciation was first raised as a serious issue by Bowie (1983). At a time when many 1950s and 1960s office buildings were becoming obsolete, Bowie (1983) argued that property depreciation was not well understood by property professionals and

[15] A summary of these studies is provided in Appendix B.

[16] Note that for reasons of brevity this review focuses mainly on studies undertaken in the UK commercial property market. A number of studies of depreciation have been undertaken in the US and elsewhere (See for example: Chinloy, 1977; Leigh, 1979; Chinloy, 1980; Hulten and Wykoff, 1981; Cannaday and Sunderman, 1986; Malpezzi *et al.*, 1987; Baer, 1991; Shinnick, 1997; Smith, 1994; Nelson, 2004) but are excluded from this review because they focus either on economic depreciation or residential property, both of which lie beyond the scope of this study. See Jorgenson (1996), Dixon *et al.* (1999) and Mansfield (2001) for reviews of this literature.

suggested that this could have serious implications for property valuation and management practices. To raise awareness of the issue, Bowie (1983) constructed hypothetical models highlighting the impact of property depreciation on the capital and rental values of office buildings. Acknowledging the limitations of the models, Bowie (1983) recommended further research to refine the models and identify the factors that influence the onset of property deprecation.

This recommendation was the driver behind Salway's (1986) study of depreciation of commercial buildings. Salway (1986) sought to analyse property depreciation and develop techniques that could be used to account for depreciation in property valuations. The underlying premise of Salway's (1986) study was that building age was a primary factor affecting the differential impact of property depreciation, that is to say why some properties experience higher rates of depreciation than others. The age of a building was considered to be a proxy for buildings' physical characteristics. As in subsequent studies, the physical characteristics of buildings, such as layout and construction, were assumed to follow distinct trends over time in line with changes in materials and technology (Dunse and Jones, 2002). Experience had suggested that a building's physical characteristics influence its physical deterioration and obsolescence, and consequently its susceptibility to depreciation (Bowie, 1983).

Table 2.3: Annual rates of property depreciation (Salway, 1986; p.22)

Age of property (years)	Offices (% p.a.)	Industrial (% p.a.)
0 – 5	3.3	3.1
5 – 10	3.4	3.9
10 – 20	2.7	3.2
0 – 20	3.0	3.3

Salway (1986) conducted a cross-sectional analysis of office and industrial buildings at 32 locations across the UK[17]. Property depreciation was measured as the difference between the rental value of each building and the rental value of a new, state of the art building. The analysis revealed that depreciation rates were highest during the early stages of buildings' service lives (Table 2.3). This was surprising because it had been expected that depreciation rates would be lowest during this period and would accelerate thereafter, as the buildings aged. The results suggested that depreciation could have costly implications

[17] Data collected at one point in time had the advantage of eliminating the effects of market fluctuations on rental values over time (Salway, 1986).

for property owners because the early stages of a building's service life is the period during which financial returns are normally greatest. They also raised doubts as to whether the prices being paid for buildings fully reflected the impact of depreciation.

Of equal significance was the fact that there was no direct relationship between building age and property depreciation[18], which implied that there were other, more significant factors affecting the onset of property depreciation. Salway (1986) advocated further research to identify these factors and to develop analytical models that would enable decision makers to take account of them. In doing so, Salway (1986) distinguished between two components of property depreciation (Figure 2.16). These were:

- the depreciation of land (locational depreciation); and
- the depreciation of buildings (building depreciation).

This distinction was considered important, because the factors affecting the depreciation of land were assumed to be different from those affecting the depreciation of buildings. Any analysis of property depreciation must take account of this fact.

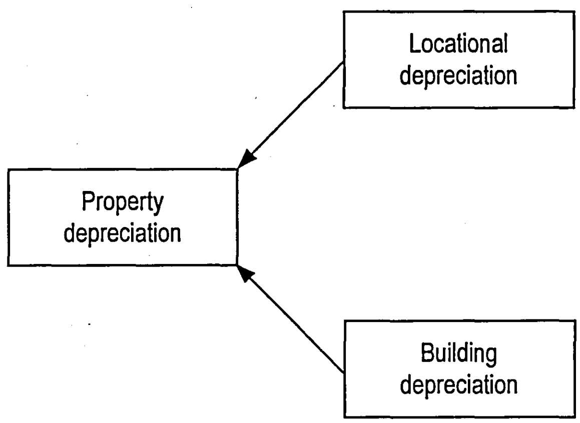

Figure 2.16: Components of property depreciation

2.4.2 Analysis of locational depreciation

Much of the value of a property comes from the location of its site. The value of land is a function of market forces, that is to say the demand for and supply of land for different uses (Hoesli and MacGregor, 2000). At the same time, locational obsolescence can cause the utility of a site to decline and, consequently, its value to depreciate. The result is locational

[18] A major limitation of Salway's (1986) research was that it was based on hypothetical rental data. However, Salway's (1986) findings were later confirmed by Jones Lang Wootton's (1987) and Barras and Clark's (1996) studies, both of which used actual rental data.

depreciation (Figure 2.17). Two recent studies (Dixon *et al.*, 1999; Dunse and Jones, 2002) sought to analyse the causes of locational depreciation.

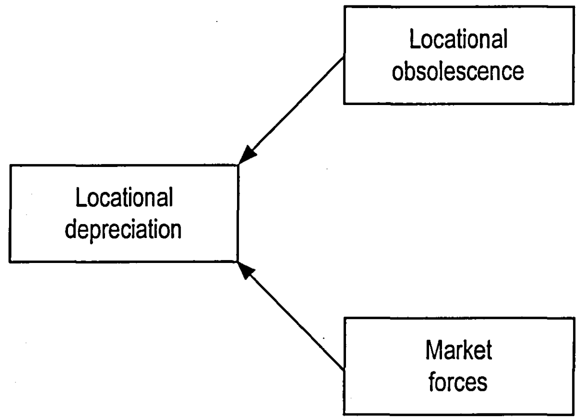

Figure 2.17: Causes of locational depreciation

Dixon *et al.* (1999) conducted a longitudinal analysis of property depreciation using rental data for 728 office, industrial and retail buildings across the UK[19]. Multiple regression analysis was used to estimate the relative impact of building age (construction period) and location on property depreciation rates[20]. Building location was separated into two components:

- geographical location, referring to the type of town in which the building was located, for instance whether it was in a metropolitan area or minor region; and
- locational quality, whether the building was in a prime or non-prime location within a particular town.

The analysis revealed that geographical location was the most significant factor affecting property depreciation, with locational quality and building age having a much smaller impact.

The importance of geographical location as a factor behind property depreciation was confirmed by Dunse and Jones' (2002) research, which focused on industrial buildings in and around Glasgow. Like Dixon *et al.* (1999), Dunse and Jones (2002) conducted a

[19] Longitudinal analysis is when a variable or a group of variables are analysed over time. It has the advantage of being able to identify any changes in individual buildings over time (Dixon *et al.*, 1999).

[20] Multiple regression analysis is a statistical technique 'for evaluating the effects of more than one explanatory variable on a outcome variable' (Vogt, 1999; p.183). In Dixon *et al.* (1999) the outcome variable was property depreciation and the explanatory variables were building age and location.

longitudinal analysis of rental data against building age (date of construction) and geographical location. Hedonic price analysis was used to estimate the impact of the variables on property depreciation[21]. Depreciation rates were again shown to differ systematically according to geographical location.

Dunse and Jones (2002) also included additional variables in the analysis, in order to estimate the impact of building-specific factors on property depreciation. The additional variables related directly to buildings' physical characteristics, for instance whether the buildings were warehouses or factories, in good or poor condition and finished or unfinished internally. Buildings' physical characteristics were shown to have some impact on property depreciation, although there were inconsistencies with the relationship. This was because it was not possible to hold location characteristics constant over time, which obscured the measurement of building depreciation. It is only by removing the depreciating effect of location that the impact of buildings' physical characteristics on property depreciation can be estimated accurately.

2.4.3 Analysis of building depreciation

Building depreciation is the varying impact of depreciation on different types of property (Baum, 1991). In contrast to locational depreciation, building depreciation is a function of a physical deterioration and building obsolescence (Figure 2.18). Following on from Salway's (1986) study, Baum (1991) sought to find out why some buildings experience higher rates of building depreciation than others by:

- exposing the forces behind building depreciation; and
- developing analytical techniques to enable decision makers to account of it.

The underlying premise of Baum's (1991, p.186) study was 'that a model which classifies the causes of depreciation provides a superior explanation of depreciation to one which relates depreciation rate to age alone'. Baum (1991) tested this premise by introducing buildings' physical characteristics into the analysis of building depreciation.

The physical characteristics included in the analysis were selected using a panel of property agents and included an assessment of physical deterioration (Table 2.4). To eliminate the impact of market fluctuations and locational obsolescence, the analysis was based on a cross-sectional survey of 125 office buildings in the City of London and 125 buildings from

[21] Hedonic price analysis is an extension of multiple regression analysis, and involves determining the relative influence that the intrinsic attributes of a product have in determining the value of that product (Khalid, 1994).

an industrial estate near London[22]. The panel of agents assigned a score to the physical characteristics of each building using a five-point scale, ranging from 'poor' to 'excellent'. Depreciation was measured by comparing the rental value of each building to the prime rental values in that location, expressed as a shortfall in rental value. The data were modelled using multiple regression analysis.

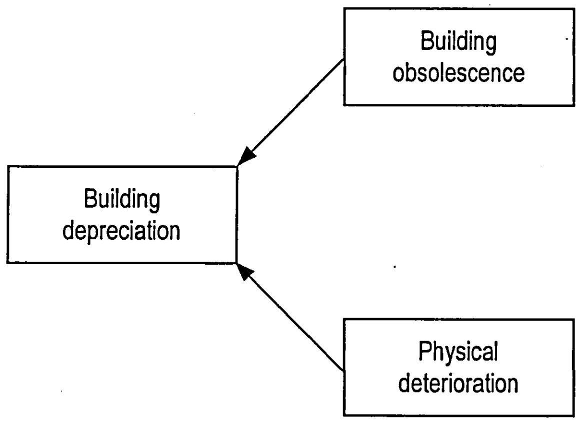

Figure 2.18: Causes of building depreciation

The results of the analysis suggested that the physical characteristics of buildings were superior to age as an explanation of building depreciation. Furthermore, the physical characteristics with the greatest impact on building depreciation were related to configuration, internal specification and external appearance, rather than the durability of materials. This implied that building obsolescence was much more important than physical deterioration as a cause of building depreciation. This was found to be the case for both office and industrial property.

Baum's (1991) research had practical implications for property owners and their advisors. The results suggested that making allowances for building depreciation would depend on forecasting building obsolescence. However, this was considered problematic because the causes of building obsolescence could not be predicted with any degree of confidence. Baum (1991) argued that property owners should look to purchase buildings that were flexible in terms of their physical characteristics. This argument was supported by Baum's (1997) study, which included office buildings from the original research. Building

[22] Although limiting the generalisability of the research, the use of buildings from the same locality enabled Baum (1991) to exclude the effect of site value variations within the value of a particular property and focus solely on building depreciation.

obsolescence was again revealed to be more important than physical deterioration as a cause of building depreciation, but the relative importance of the physical characteristics had changed. For example, internal specification had become more important than configuration. Baum (1997) attributed this to changes in occupier requirements.

Table 2.4: Physical characteristics used to estimate building depreciation (Baum, 1994; p.37)

Category	Characteristic
Configuration	Plan layout
	Floor-to-ceiling height
Internal specification	Services
	Finishes
External appearance	Exterior
	Common parts
Durability of materials	Resistance to external deterioration
	Resistance to internal deterioration

One of the limitations of Baum's (1991) research was the small number of physical characteristics used in the analysis of building depreciation. Baum (1991) suggested that future research could involve a more detailed analysis by breaking the physical characteristics into further sub-categories. This approach was used by Khalid (1994) to estimate the depreciation of office property in Kuala Lumpa, Malaysia. Like Baum (1991), Khalid (1994) used the age and physical characteristics of office buildings to estimate the impact of building obsolescence on building depreciation. Sixty-five physical characteristics were identified from the literature and a questionnaire survey of 100 occupier organisations and property managers. Data on the physical characteristics were then collected for 136 office buildings in Kuala Lumpa and subjected to hedonic price analysis, with rental difference as the outcome variable.

The analysis revealed that 21 of the 65 physical characteristics had a significant impact on building depreciation. These were related to appearance, flexibility and the quality of engineering services (Table 2.5). The impact of age and location on office building depreciation was much lower, which was expected because the analysis focused on a restricted geographical area. Khalid (1994, p.44) concluded that the findings would be of practical use to 'decision-makers during the building design and cost planning stage and property investment appraisals'.

Table 2.5: Physical characteristics used in hedonic analysis of depreciation (Khalid, 1994; p.40)

Category	Characteristic
Flexibility	Bay span
	Building height
	Column free
	Additional space for storage
	Net rentable area
Appearance	Main ceiling finish
	Main floor finish
	Main entrance ceiling finish
	Main entrance finishes
	Main entrance floor finish
	Main entrance wall finish
	Quality of finishes
	Tenant's image is compatible
	High tenant's image
	Tenant's image and its compatibility
	Main wall finish
Quality of engineering	Energy control using building automation
	Capacity of lifts
	Using automated control system
	Lifts landing zone
	Stand-by generator

A common problem in multiple regression analysis and hedonic price analysis is when two or more explanatory variables are highly correlated, making it difficult to determine their separate effects on the outcome variable. This problem is known as multicollinearity (Vogt, 1999). Baum (1991) and Khalid (1994) both overcame the problem of multicollinearity by combining or eliminating offending variables. However, this approach was criticised by Yusof (1999) for being too subjective. Yusof (1999) sought to measure the financial impact of building obsolescence on 100 office buildings in Kuala Lumpa, using a method similar to that employed by Khalid (1994). Yusof's (1999) research was differentiated by the fact that it used principal components analysis to eliminate multicollinearity. Principal components analysis is a statistical technique for transforming a large set of correlated variables into a smaller group of uncorrelated variables (Vogt, 1999). Yusof (1999) justified the use of principal components analysis as means of deriving a more robust and parsimonious analytical model. The principal components analysis resulted in eight physical characteristics being included in the hedonic price analysis (Table 2.6).

Table 2.6: Physical characteristics derived from principal components analysis (Yusof, 1999; p.235)

Characteristic	Typical components
Quality of the building	Building automation systems, floor finishes, lift provision
Size and efficiency	Lift efficiency, floor area
Design and layout	Ceiling height, space utilisation, lobby finishes
Location	Landscaping, parking provision
Appearance	Exterior finishes, floor finishes
Complementary	Common amenities, refreshment facilities
Facilities	Gym, conferences facilities
Parking services	Number of bays, parking-to-floor space ratio

The most comprehensive study of property depreciation to date was by Bottom *et al* (1999). Bottom *et al.* (1999) sought to introduce functional performance into the analysis of property depreciation. The study was based on a theoretical framework derived from the literature, and semi-structured interviews with property owners and advisors (Figure 2.7). The theoretical framework related to the ownership and occupation of investment class office buildings and suggested that:

- for the investment institution the physical characteristics of an office building produce a return determined by market demand (estimated rental value);
- the tenant organisation, with particular organisational characteristics and property requirements, interacts with the building's physical characteristics, the interactive relationship being a measure of functional performance; and
- on the basis that the property requirements of the occupier organisation may change over time, there exists a risk to the investment institution that the functional performance of the office building will decrease and that returns will also decrease.

To model these relationships, Bottom *et al.* (1999) conducted a cross-sectional study of 40 commercial office buildings and 76 occupier organisations in the City of London. The study comprised three parts:

- a questionnaire survey of occupier organisations to elicit data on the functional performance of their office buildings and their organisational characteristics. Functional performance was derived from importance and satisfaction scores, provided by the occupier organisation for 39 separate aspects of their office building. Organisational characteristics included such attributes as number of employees, core business and working practices;

- a walk-through survey of each office building to collect data on 39 different physical characteristics; and
- a questionnaire survey of investment institutions to acquire general information about each office building, including its estimated rental value.

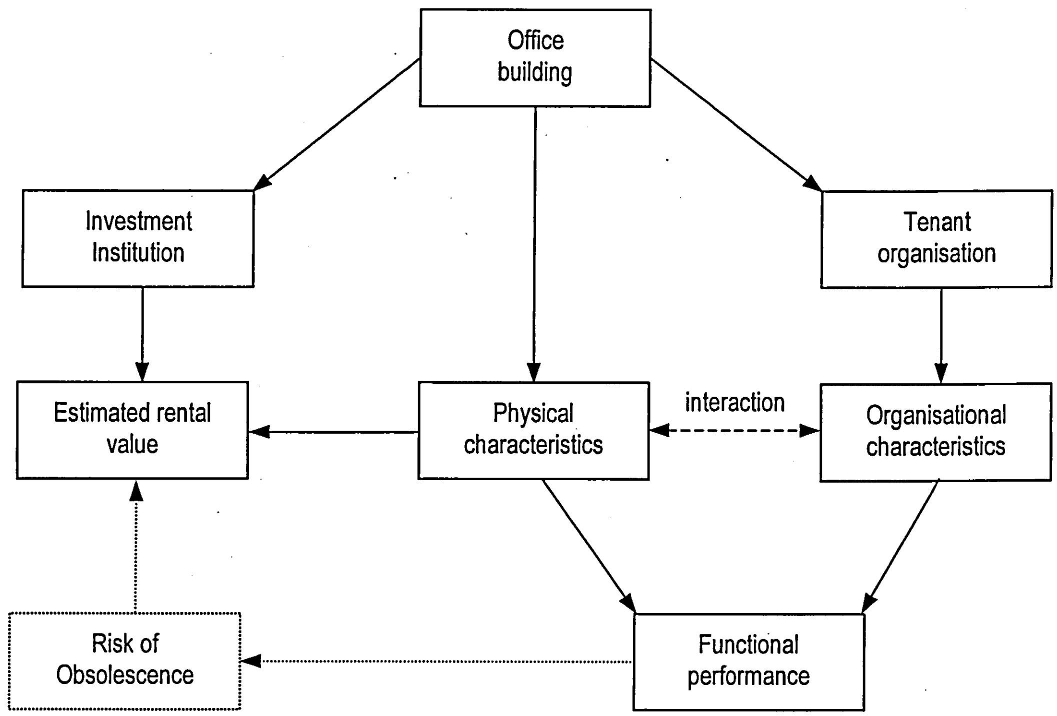

Figure 2.19: Property depreciation and functional performance (adapted from Bottom *et al.*, 1999; p.343)

Data were analysed using multiple regression analysis and neural network analysis[23]. Eight separate models, seven relating to aspects of functional performance and one for property depreciation, were estimated using specific combinations of physical and organisational characteristics. The research represented an important contribution to knowledge because it demonstrated for the first time that functional performance could be incorporated into the analysis of property depreciation. This was considered to be of potential value to property

[23] Neural network analysis replicates the human brain's learning processes (Lenk *et al.*, 1997). It is based on densely interconnected networks of artificial neurons which can learn from experience and be used to make models of the real world (McGreal *et al.*, 1998).

owners and their advisors, but also to those concerned with the design and management of buildings.

2.5 Conclusion

The purpose of this chapter was to discuss the background theory regarding obsolescence in buildings, provide a critical review of key studies of the subject, highlight gaps in the existing body of knowledge and identify areas for further research. Much of the background theory relating to obsolescence has its roots in literature from the 1950s and 1960s, when the issues of urban decay and regeneration came to the fore in the UK. In most of the literature from that time, obsolescence in buildings is considered to be a function of physical deterioration and ageing. It is only in later studies that researchers begin to differentiate obsolescence as a relative decline in performance that is caused primarily by changing occupier requirements, rather than wear and tear arising from physical deterioration, the action of the elements and use. At the same time, there has been growing awareness in the literature about the impact of obsolescence on the depreciation of property values.

Empirical research into property depreciation has primarily been grounded in the real estate discipline. As a result, research has focused on analysing the impact of obsolescence on the values of commercial properties, based on their physical and locational characteristics. A number of studies have estimated locational depreciation using data relating to the geographical location and locational quality of buildings, though the majority of studies have focused on the issue of building depreciation using data relating to the physical characteristics of buildings. These studies have resulted in the development of statistical models for assisting property owners and investors in measuring and estimating the impact of obsolescence on depreciation rates, enabling them to take account of it in their financial decision-making. However, no comparable methods have been developed for use by occupiers.

A review of published literature revealed a general lack of empirical research into the issue of obsolescence from an occupier perspective. The small number of studies that have been undertaken are largely grounded in the planning discipline and have tended to focus on the impact of changing occupier requirements on demand for property at an urban and regional level. Collectively, these studies span a range of property sectors, from residential buildings through to commercial office and industrial buildings. Nevertheless, despite some commonalities, there is little coherence in the methodological approaches employed. A number of studies have focused on the impact of changing occupier requirements on individual buildings; however, these studies are based largely on what Lizieri (2003, p.1165) describes as 'assertion, anecdote, poorly theorised case study work and abstract models untroubled by empirical verification'. Other studies have attempted to move beyond this largely descriptive approach by employing quantitative methods, but have been constrained, either by a lack of suitable data or analytical techniques for measuring obsolescence.

In summary, therefore, previous studies into obsolescence have traditionally focused on either:

- the physical performance of buildings, measured in terms of physical deterioration;
- the impact of changing occupier requirements on the demand for buildings; or
- the financial performance of buildings from the perspective of the property owner, measured in terms of depreciation.

In doing so, previous research has tended to overlook the downstream impact of obsolescence on the workplace, people and the client or customer (Figure 2.20). This is partly because there has traditionally been an absence of techniques for measuring the utility of buildings or their financial performance from an occupier perspective. It is also because the issue of obsolescence has largely been overlooked in the facilities management (FM), workplace and business performance disciplines[24]. This is despite anecdotal evidence which suggests that obsolescence can have an adverse impact on the performance of occupier organisations, for instance through decreased operational efficiency, reduced productivity or declining morale in the workplace.

The aim of this study is to address these gaps in the of existing body knowledge by examining the issue of obsolescence from an occupier perspective (Figure 2.20). In doing so, this study has two objectives. The first is to develop a framework for measuring obsolescence from an occupier perspective. The second objective of this study is to identify factors that affect the differential impact of obsolescence from an occupier perspective, that is to say, why some buildings exhibit lower levels of performance than others. Previous empirical studies of obsolescence have tended to explain such differences through case studies of individual buildings. However, research into property depreciation suggests that variations in building performance might be explained through the use of statistical models comprising the physical characteristics of buildings, together with other explanatory variables. Such models might provide insights into design configurations that are better suited to delaying or avoiding obsolescence. A theoretical framework to underpin this approach is developed in Chapter 3.

[24] A comprehensive review of this literature was undertaken by Haynes *et al.* (2000).

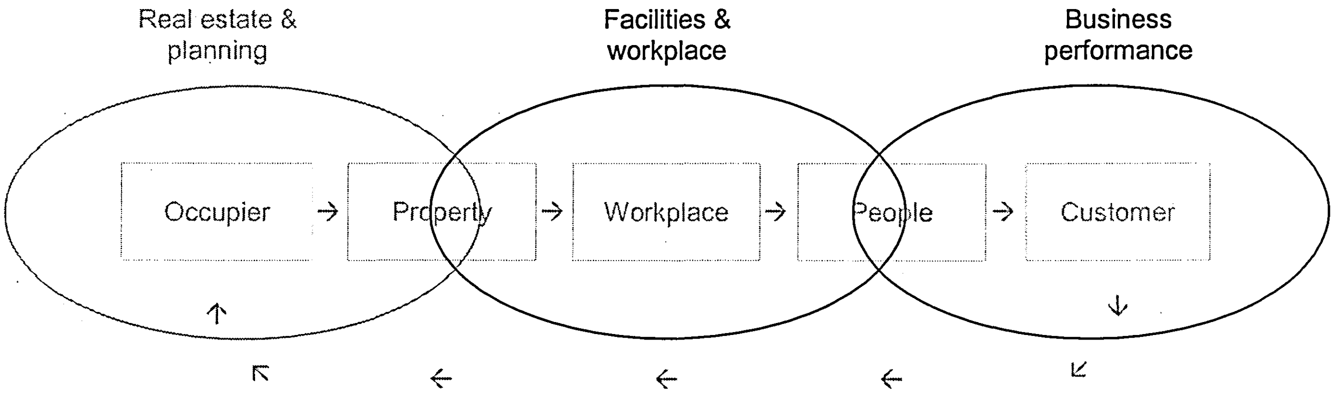

Figure 2.20: Gaps in the existing body of knowledge on obsolescence (adapted from Haynes *et al.*, 2000; p.6 and McLennan, 2000; p.169)

References

Abdellaoui, M., Barrios, C. and Wakker, P.P. (2001) *Ordinal and cardinal utility: experimental arguments based on prospect theory*, Working paper, Department of Economics, University of Amsterdam, Netherlands.

Aronoff, S. and Kaplan, A. (1995) *Total workplace performance*, WDL Publications, Ottawa, Canada.

Ashworth, A. (1997) *Obsolescence in buildings: data for life cycle costing*, Chartered Institute of Building, Report No. 74, London.

Ashworth, A. (1999) *Cost studies of buildings*, Third Edition, Longman, New York.

Baer, W.C. (1991) Housing obsolescence and depreciation, *Journal of Planning Literature*, **5** (4), 323-332.

Baird, G., Gray, J., Isaacs, N., Kernohan, D. and McIndoe, G. (1996) *Building evaluation techniques*, McGraw-Hill, London.

Bannock, G., Baxter, R.E. and Davis, E. (1992) *The penguin dictionary of economics*, Fifth Edition, Penguin Books, London.

Barras, R. and Clark, P. (1996) Obsolescence and performance in the Central London office market, *Journal of Property Valuation and Investment*, **14** (4) 63-78.

Baum, A. (1991) *Property investment depreciation and obsolescence*, Routledge, London.

Baum, A. (1994) Quality and property performance, *Journal of Property Valuation & Investment*, **12** (1), 31-46.

Baum, A. (1997) The causes and effects of depreciation in office buildings: a ten year update, *In proceedings of the Royal Institution of Chartered Surveyors Cutting Edge Conference*, Royal Institution of Chartered Surveyors, London.

Becker, F. (1988) ORBIT 2.1, *Facilities*, **6** (3), 5-7.

Becker, F. (1990) *The total workplace: facilities management and the elastic organization*, Van Nostrand Reinhold, New York.

Bernard Williams Associates (1994) *Facilities Economics*, Building Economics Bureau, Bromley.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999) Appraising the functional performance characteristics of office buildings, *Journal of Property Research*, **16** (4), 339-358.

Bowie, N. (1983) The depreciation of buildings, *Journal of Valuation,* **2** (1), 5-13.

Brand, S. (1994) *How buildings learn*, Phoenix Illustrated, London.

Brill, M., Weidemann and the BOSTI Associates (2001) *Disproving widespread myths about workplace design*, Kimball International, Jasper.

Bryson, J.R. (1997) Obsolescence and the process of creative reconstruction, *Urban Studies*, **34** (9), 1439-1458.

Building Research Board (1993) *The fourth dimension in building: strategies for minimizing obsolescence,* National Academy Press, Washington D.C.

Burton, J.E. (1933) Building obsolescence and the assessor, *The Journal of Land and Public Utility Economics*, **9** (2), 109-120.

BS ISO 15686-1 (2000) *Buildings and constructed assets – service life planning*, British Standards Institution, London.

Cannaday, R.E. and Sunderman, M.A. (1986) Estimation of depreciation for single-family appraisal, *AREUEA Journal*, **14** (2), 255-273.

Chanter, B. and Swallow, P. (1996) *Building maintenance management*, Blackwell Science, Oxford.

Chinloy, P.T. (1977) Hedonic price and depreciation indexes for residential housing: A longitudinal approach, *Journal of Urban Economics*, **4**, 469-482

Chinloy, P.T. (1980) The effect of maintenance expenditures on the measurement of depreciation in housing, *Journal of Urban Economics*, **8** (1), 81-107.

Clift, M:R. and Butler, A. (1995) *The performance and costs-in-use of buildings: a new approach*, Building Research Establishment, Watford.

Clift, M. and Bourke, K. (1999) *Study on whole life costing*, BRE, Watford.

Construction Industry Council (2002) *Design Quality Indicator*, Construction Industry Council, London.

Cook, G.K. and Hinks, A.J. (1992) *Appraising building defects*, Longman Scientific & Technical, Harlow.

Cowan, P. (1965) Depreciation, obsolescence and ageing, *The Architects Journal*, **141**, 1395-1401.

Cowan, P., Nutt, B., Sears, D. and Rawson, L. (1970a) *Obsolescence in the built environment, Report 1: A Feasibility study*, Joint Unit for Planning Research, London.

Cowan, P., Nutt, B., Sears, D. and Rawson, L. (1970b) *Obsolescence in the built environment, Report 2: Some concepts of obsolescence*, Joint Unit for Planning Research, London.

Cowan, P., Nutt, B., Sears, D. and Rawson, L. (1970c) *Obsolescence in the built environment, Report 3: Some empirical studies*, Joint Unit for Planning Research, London.

Davis, G., Gray, J. and Sinclair, D. (1991) *Occupants requirements and the serviceability of office facilities*, International Centre for Facilities, Public Works Canada, Ottawa.

Debenham Tewson & Chinnocks (1985) *Obsolescence - its effect on the valuation of property investments*, Debenham Tewson & Chinnocks, London.

Dixon, T.J., Law, V. and Cooper, J. (1999) *The dynamics and measurement of commercial property depreciation in the UK*, The College of Estate Management, Reading.

Douglas, J. (1992) *Building adaptation*, Butterworth-Heinemann, Oxford.

Dunse, N. and Jones, C. (2002) Rental depreciation, obsolescence and location: the case of industrial properties, *In proceedings of European Real Estate Society Conference*, Glasgow.

EKOS Limited and Ryden Property Consultants (2001) *Obsolete commercial and industrial buildings*, Scottish Executive Central Research Unit, Edinburgh.

Emery, J.S. (1971) *Urban obsolescence and its educational implications with particular reference to selected areas of London*, PhD, University of London.

Freer, N., Lawson, D. and Salter, M. (1999) *Conversion of redundant commercial space to residential use*, British Property Federation, London.

Fulcher, M.N. and Gallagher, R.A. (1977) *Industrial obsolescence: a Sheffield case study*, Occasional paper 77/31, Sheffield Centre for Environmental Research, Sheffield.

Gann, D.M. and Barlow, J. (1996) Flexibility in building use: the technical feasibility of converting redundant offices into flats, *Construction Management and Economics*, **14**, 55-66.

Gibson, V.A. (1994) Strategic property management: how can local authorities develop a property strategy, *Property Management*, **12** (3), 9-14.

Gray, J. and Tippett, H. (1992) *Office space: a primer for managers*, Centre for Building Performance Research, Victoria University of Wellington, New Zealand.

Haynes, B., Matzdorf, F., Nunnington, N., Ogunmakin, C., Pinder, J. and Price, I. (2000) *Does property benefit occupiers? An evaluation of the literature*, Report No. 1, http://www.occupier.org.

Heath, T. (2001) Adaptive re-use of offices for residential use, *Cities*, **18** (3), 173-184.

Hendry, J. (1970) *Obsolescence in housing in the villages of Northern Ireland*, PhD, Queen's University of Belfast.

Hoseli, M. and MacGregor, B.D. (2000) *Property investment*, Pearson Education Limited, Harlow.

Hulten, C.R. and Wykoff, F.C. (1981) The estimation of economic depreciation using vintage price assets, *Journal of Econometrics*, **15**, 367-396.

Isaacs, N., Bruhns, H., Gray, J. and Tippett, H. (1993) *Building Quality Assessment: Research, development and analysis for office and retail buildings*, Centre for Building Performance Research, Victoria University of Wellington, New Zealand.

Jones Lang Wootton (1987) *Obsolescence: The financial impact on property performance*, Jones Lang Wootton, London.

Jorgenson, D. (1996) Empirical studies of depreciation, *Economic Inquiry*, **34**, 24-42.

Khalid, G. (1990) Measuring and managing the impact of obsolescence in commercial buildings, *Surveyor*, **25** (4), 17-27.

Khalid, G. (1992) *Hedonic price estimation of the financial impact of obsolescence on commercial office buildings*, PhD, University of Reading.

Khalid, G. (1994) Obsolescence in hedonic price estimation of the financial impact of commercial office buildings: The case of Kuala Lumpa, *Construction Management and Economics*, **12**, 37-44.

Kincaid, D. (2002) *Adapting buildings for changing uses*, Spon Press, London.

Kirk, S.J. and Dell'Isola, A.J. (1995) *Life cycle costing for design professionals*, Second Edition, McGraw-Hill, London.

Kwakye, A.A. (1994) *Built asset management: Refurbishment and optimum land use*, The Chartered Institute of Building, Ascot.

Leigh, W.A. (1979) The estimation of tenure-specific depreciation/replacement rates using housing quality measures for the US 1950 - 1970, *The Quarterly Review of Economics and Business*, **19**, 45-59.

Lenk, M.M., Worzala, E.M. and Silva, A. (1997) High-tech valuation: should artificial neural networks bypass the human valuer? *Journal of Property Valuation & Investment*, **15** (1), 8-26.

Lichfield, N. (1988) *Economics in urban conversation*, Cambridge University Press, Cambridge.

Lichfield & Associates (1968) *Economics of conservation*, HMSO, London.

Lizieri, C. (2003) Occupier requirements in commercial real estate markets, *Urban Studies*, **40** (5/6), 1151-1169.

Malpezzi, S., Ozanne, L. and Thibodeau, T.G. (1987) Microeconomic estimates of housing depreciation, *Land Economics*, **63** (4), 372-385.

Mansfield, J.R. (2000a) 'Refurbishment' reconsidered: definitional problems in theory and practice, *In proceedings of the Royal Institution of Chartered Surveyors COBRA Conference*, Royal Institution of Chartered Surveyors, London.

Mansfield, J.R. (2000b) Much discussed, much misunderstood: a critical evaluation of the term 'obsolescence', *In proceedings of the Royal Institution of Chartered Surveyors Cutting Edge Conference*, Royal Institution of Chartered Surveyors, London.

Mansfield, J.R. (2001) Property depreciation: unravelling the impact of obsolescence', *In proceedings of the CAST Built Environment Research Conference*, The University of Nottingham, 14 March.

McGreal, S., Adair, A., McBurney, D. and Patterson, D. (1998) Neural networks: the prediction of residential values, *Journal of Property Valuation & Investment*, **16** (1), 57-70.

McKnight, D. (1999) A practical guide to evaluating the functional utility of warehouses, *The Appraisal Journal*, **67** (1), 29-36.

McLennan, P. (2000) Intellectual capital: future competitive advantage for facility management, *Facilities*, **18** (3/4), 168-171.

Medhurst, F. and Lewis, J.P. (1969) *Urban decay: an analysis and a policy*, Macmillan, London.

Nelson, J.P. (2004) Meta-analysis of airport noise and hedonic property values, *Journal of Transport Economics and Policy*, **38** (1), 1-27.

Nutt, B. (1997) Adapting and re-using buildings, *International Journal of Facilities Management*, **1** (3), 113-121.

Nutt, B., Walker, B., Holliday, S., and Sears, D. (1976) Obsolescence in housing: theory and applications, Saxon House, Farnborough.

Ohemeng, F.A. (1998) Rehabilitation versus demolition and redevelopment: a value-based decision framework for private commercial properties, PhD, University of Salford.

Ohemeng, F.A. and Mole, T. (1996) Value-focused approach to built asset renewal and replacement decisions, *In proceedings of the Royal Institution of Chartered Surveyors COBRA Conference*, Royal Institution of Chartered Surveyors, London.

Pearsall, J. (ed) (2001) *Concise Oxford English Dictionary*, Tenth Edition, Oxford University Press, Oxford.

Preiser, W.F.E. (1995) Post-occupancy evaluation: How to make buildings work better, *Facilities*, **13** (11), 19-28.

Raftery, J. (1991) *Principles of building economics: an introduction*, BSP Professional, Oxford.

Real Estate Norm (1992) *Real Estate Norm*, Second Edition, Real Estate Norm Foundation, Netherlands.

Rutherford, D. (1992) The routledge dictionary of economics, Routledge, London.

Rydin, Y. (1992) Environmental impacts and the property market, *In Breheny, M.J. (ed), Sustainable development and urban form*, 217-241, Pion Ltd, London.

Salway, F. (1986) *Depreciation of commercial property,* The College of Estate Management, Reading.

Shinnick, E. (1997) Measuring Irish housing quality, *Journal of Economic Studies*, **24** (1), 95-119.

Slaughter, S.E. (2001) Design strategies to increase building flexibility, *Building Research & Information*, **29** (3), 208-217.

Smith, B.C. (2004) Economic depreciation of residential real estate: Microlevel space and time analysis, *Real Estate Economic*, **32** (1), 161-180.

Smith, M., Whitelegg, J., and Williams, N. (1998) *Greening the built environment*, Earthscan Publications, London.

Switzer, J.F.Q. (1963) The life of buildings in an expanding economy, *The Chartered Surveyor*, August, 70-77.

Tiesdell, S., Tanner, O. and Heath, T. (1996) *Revitalizing historic urban quarters*, Architectural Press, Oxford.

Trowbridge, C.R. (1964) Deterioration, *Appraisal Journal*, January, 91-96.

Vogt, W.P. (1999) *Dictionary of statistics & methodology*, Sage Publications, London.

Weatherhead, M. (1999) *Real estate in corporate strategy*, Macmillan, London.

Williams, A.M. (1985) *Obsolescence and re-use: a study of multi-storey industrial buildings*, School of Land and Building Studies, Leicester Polytechnic.

Williams, B. (2003) *Facilities economics in the UK*, Building Economics Bureau Ltd, Bromley.

Yusof, A.M. (1999) *Modelling the impact of depreciation: a hedonic analysis of offices in the city of Kuala Lumpur, Malaysia*, PhD, University of Aberdeen.

Chapter 3
Research method

Chapter 3 Research method

3.1 Introduction

The previous chapter (Chapter 2) provided a critical review of previous research into obsolescence and highlighted gaps in the existing body of knowledge. One of the principal findings of the literature review was the need to move beyond traditional approaches to obsolescence, which are rooted primarily in the planning and real estate disciplines, and pay heed to the downstream impact of obsolescence on the workplace, people and the client or customer, issues which have largely been overlooked in the facilities management[25] (FM) and business disciplines. Hence, the aim of this study is to examine the impact of obsolescence from the perspective of the building occupier. In doing so this study focuses on the linkages between the occupier, property, workplace and people (Figure 3.1).

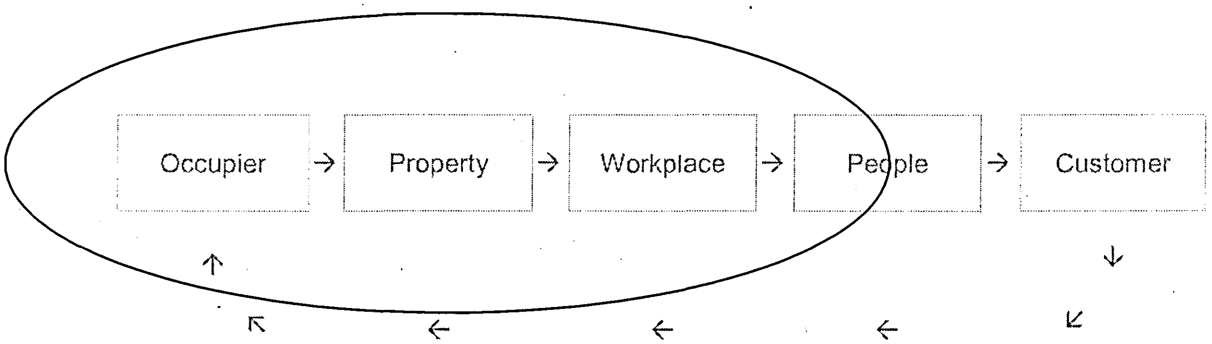

Figure 3.1: Focus of this study
(adapted from Haynes *et al.*, 2000; p.6 and McLennan, 2000; p.169)

This study has two principal objectives. The first is to develop a framework for evaluating obsolescence from an occupier perspective, so that obsolescence can be measured over time. This was deemed necessary because previous studies of obsolescence have been constrained by the absence of such a framework. The second objective of this study is to identify factors that explain variations in building performance and, consequently, the differential impact of obsolescence. Previous research into property depreciation suggests

[25] The term *facility* management is also used extensively in the literature, particularly in North America. Although the origins of these two terms are different (Price, 2002a), in the UK literature they are often used interchangeably.

that such variations might be explained through the use of statistical models. The purpose of this chapter is to present a method for achieving those objectives (Figure 3.2)

Section 3.2 explains the research design underpinning this study. It explains the philosophical foundations and describes a theoretical framework for the collection of empirical data. The data requirements and sample selection are also discussed in Section 3.2. This is followed by Sections 3.3 - 3.5, which describe the collection of empirical data for use in this study. Section 3.5 also describes the development of a technique for evaluating workplace utility. Conclusions from this chapter are discussed in Section 3.6.

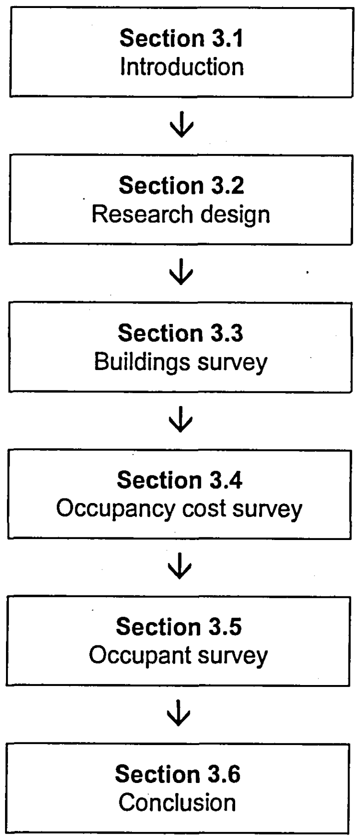

Figure 3.2: Structure of Chapter 3

3.2 Research design

3.2.1 Philosophical foundations

Research design involves establishing a process for carrying out a study. This includes operationalising concepts so that they can be measured, specifying the type of data required and selecting a sample (Kumar, 1999). However, before these design issues can be addressed in further detail it is necessary to explain the philosophical assumptions underpinning this study. This is important because

> *"... how we come to ask particular questions, how we assess the relevance and value of different research methodologies so that we can investigate those questions, how we evaluate the outputs of research, all express and vary according to our underlying epistemological commitments" (Johnson and Duberley, 2000; p.9).*

Epistemology is the theory of knowledge, particularly in relation to its methods, validity and scope (Pearsall, 2001). In any discipline where knowledge claims are routinely made, epistemology contributes by defining the conditions and limits of what is taken as justified knowledge (Johnson and Duberley, 2000).

This study is grounded in the FM discipline, one root of which lies in the early workplace management practices of the 1970s and 1980s (Price, 2002b). FM has since evolved to cover a wide field of activities (Nutt, 1999). Nutt (2000, p.124) describes the objective of FM as the '... effective management of facility resources and services in providing shells of support to us all; support to the operations of organisations, their working groups, project teams and individuals.' However, despite a rapid growth in FM literature over the last decade, the discipline has been criticised for lacking a rigorous body of research (Nutt, 1999; Price, 2002a). Indeed, Cairns (2003, p.96) argued that 'much of what is current held forth as theory in the field of FM is little more than slogans, sound bytes (*sic*) that have little or no empirical or theoretical foundation'. Cairns (2003) went on to suggest that the FM discipline must pay more attention to epistemological issues if it is to develop as a true management discipline.

Despite falling out of favour, at least in the UK, in the 1960s and 1970s, positivist epistemology remains a major influence in the field of management research (Johnson and Duberley, 2000). Positivism is 'the belief that an understanding of phenomena is solely grounded on sense data; what cannot be tested empirically cannot be regarded as proven' (Mayhew, 1997). According to Johnson and Duberley (2000) the central tenets of positivism are that:

- the method of natural sciences, with its focus on internal validity, external validity, reliability and operationalisation, is the only rational source of knowledge and should therefore be applied to the social sciences;
- the purpose of research should be to identify causal explanations and fundamental laws to explain regularities in human behaviour;

- the researcher exists independently of what is being observed, so that social phenomena can be studied objectively;
- the choice of what to study and how to study can be determined objectively, independently of human beliefs and interests; and
- theory can be tested against observable 'facts'.

Positivism can therefore be described as having an objectivistic epistemology and objectivistic ontology[26] (Figure 3.3). The former presupposes that it is possible to observe the external world objectively, the latter that reality exists independently of human cognition (Johnson and Duberley, 2000).

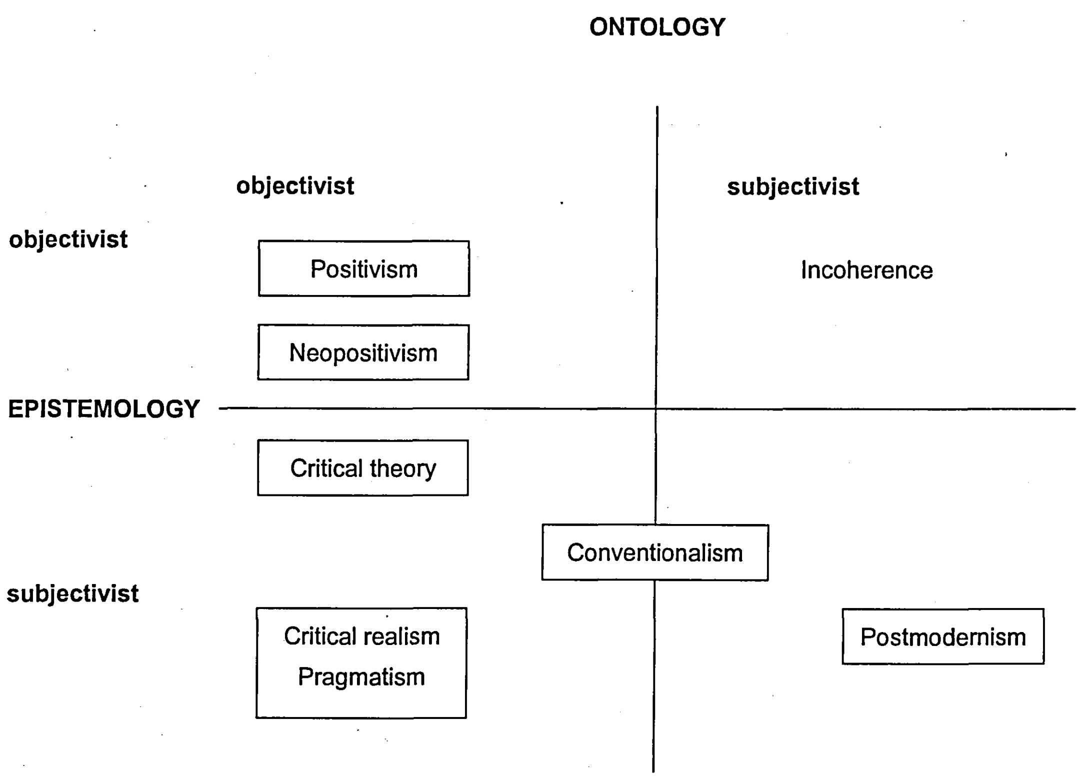

Figure 3.3: Epistemology and management research (from Johnson and Duberley, 2000; p.180)

Critics of positivism argue that, *inter alia*, it is inappropriate to apply natural-scientific methods to the social sciences because of the influence of human attributes, such as consciousness cultural norms and symbolic meaning (Marshall, 1998). A further criticism

[26] Ontology is concerned with the way in which people understand the world and the assumptions about what can or cannot exist (Marshall, 1998).

concerns the positivist notion that empirical regularities[27], that is to say two or more events occurring together in similar conditions, are both necessary and sufficient for establishing a causal law (Lawson, 1997). Critical realists suggest that in the social world empirical regularities between observable events are the exception rather than the rule[28]. For them, the social world is made up of open systems, rather than closed systems, in which individuals respond differently in similar situations and on different occasions (Bache, 2003). Closed systems are conditions where a causal sequence may be observed without interference from extraneous causes (Johnson and Duberley, 2000). Experiments, particularly those in the natural sciences, can therefore be seen as an attempt to close a system by focusing on a limited number of variables and excluding possible disturbing influences (Bache, 2003).

It is evident from the previous chapter that, as a social phenomenon, the process of obsolescence in buildings should be viewed as an open, rather than closed system. Obsolescence is an open system because it is a consequence of social, economic and technological changes, some of which operate at local, national and at times international levels, and are often interactive and self-perpetuating (Williams, 1985). However, according to critical realist epistemology, the existence of open systems in the social world does not preclude the analysis of causal relationships (Bhaskar, 1978). By adopting a critical realist stance in this study, the author presupposes that causation in the social world is not expressed solely through constant event regularities, but partial event regularities which indicate the presence of occasional, but less than universal, mechanisms or structures that govern events and human behaviour. It is therefore assumed that causation can be analysed by subjecting these partial event regularities to statistical modelling (Downward *et al.*, 2002).

The modelling process underpinning this study is depicted in Figure 3.4. The first four stages of the modelling process, involving the development of a conceptual framework, operationalisation of concepts, specification of data requirements and sample selection, are discussed later in this section. Collection of empirical data for use in the modelling process is described in Sections 3.3 - 3.5 of this chapter. Chapters 4, 5 and 6 describe the outcomes of the data analysis and development of the statistical models. Potential applications of the statistical models and reflections on the modelling process are discussed in Chapter 7.

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[27] Also described as constant conjunction of events (Johnson and Duberley, 2000).

[28] In contrast to positivism, critical realism has an subjectivist epistemology which denies the possibility of accessing the external world objectively (Figure 3.3). Critical realist epistemology therefore implies that research should take account of the unobservable structures and subjectively experienced social phenomena that generate human behavioural tendencies (Johnson and Duberley, 2000).

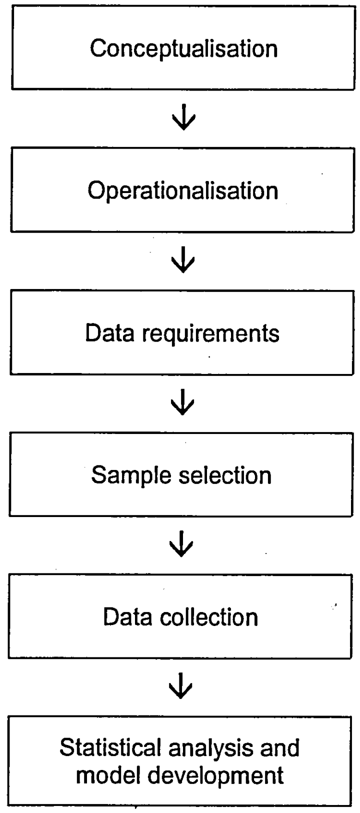


Figure 3.4: Modelling process

3.2.2 Conceptualisation

Statistical models are representations of real world phenomena, created in order to facilitate understanding and explanation (Mayhew, 1997). The development of a model involves making simplifying assumptions by focusing attention on concepts and their interrelationships (Marshall, 1998). The first stage of the modelling process therefore involved establishing a conceptual framework for modelling obsolescence from an occupier perspective (Bradley and Schaefer, 1998; Maki and Thompson, 1973). According to Maki and Thompson (1973) the formulation of the conceptual framework is crucial because it involves deciding whether one formulation is better than another, when the implications of a given form of conceptualisation are difficult to discern so early in the modelling process.

Obsolescence was defined in the previous chapter as a decline in the performance of a building caused by changing occupier requirements. Overall building performance was seen to comprise three interrelated components: physical performance, utility (functional performance) and financial performance. However, previous studies of obsolescence have tended to focus on either the physical performance of buildings, measured in terms of physical deterioration, or the financial performance of buildings from the perspective of the property owner, measured in terms of depreciation. In doing so they have failed to take into account the utility of buildings and their financial performance, as defined by the occupier. From an occupier perspective, the financial performance of a building can be measured in terms of its occupancy costs and contribution to business profitability (Williams, 2003), whereas utility is a measure of the attributes afforded by a building to the benefit, or otherwise, of the people that use it (Aronoff and Kaplan, 1995). The conceptual framework underpinning this study therefore focuses on these aspects of building performance (Figure 3.5). Operationalisation of the conceptual framework is described below.

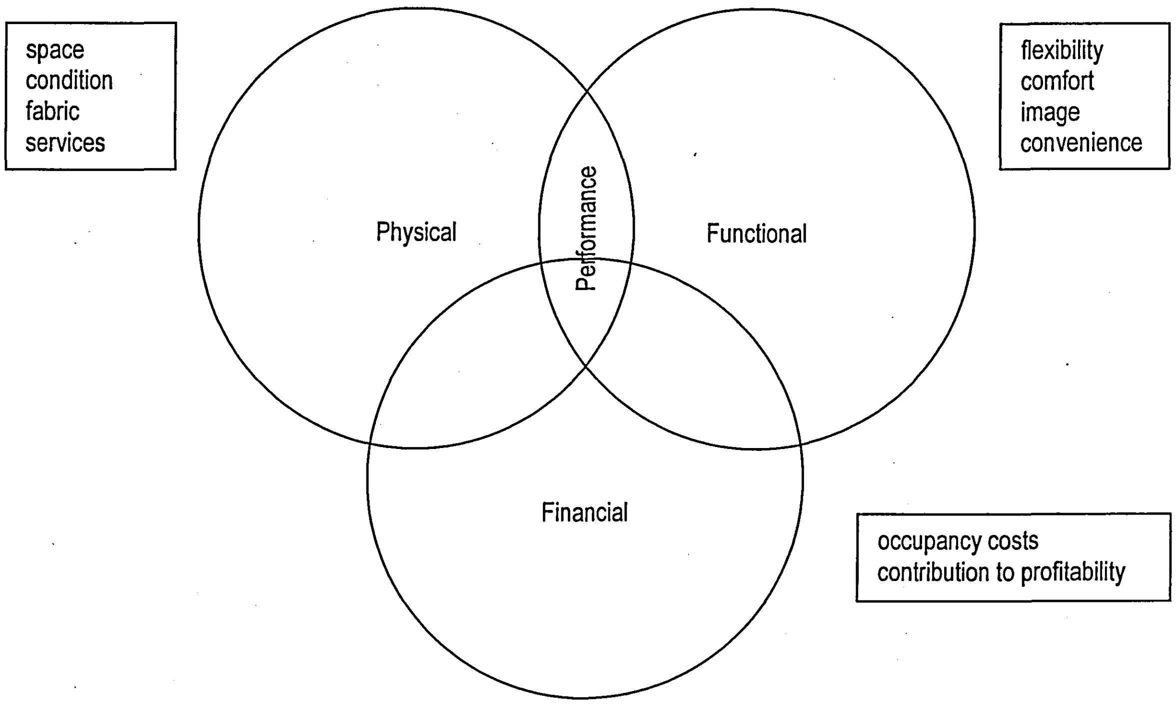


Figure 3.5: Conceptual framework
(adapted from Williams, 2003; p.A-22)

3.2.3 Operationalisation

Operationalisation involves selecting indicators, or variables, to represent abstract concepts (de Vaus, 1996; Vogt, 1999). The indicators employed in this study, and the hypothesised relationships between them, together comprise a theoretical framework (Figure 3.6). The theoretical framework was developed by reference to the literature and is an extension of the occupiers' property chain introduced in the previous chapter (Figure 2.1). The underlying premise of the theoretical framework is that obsolescence can be measured by evaluating the physical performance, utility and financial performance of buildings from an occupier perspective.

The first stage of the theoretical framework addresses the issue of financial performance. Since the contribution that buildings make to profitability is difficult to evaluate (Haynes *et al.*, 2000) this study focuses on occupancy costs as a measure of a building's financial performance. Occupancy costs include all the day-to-day costs associated with meeting occupier requirements, but exclude the costs of business activities conducted within the building because these can be influenced by a wide variety of other factors (Clift and Butler, 1995). Occupancy costs are employed as outcome variables in the theoretical framework because they are assumed to be affected by the occupancy characteristics of the occupier organisation and the physical characteristics of the property that is being occupied (Aronoff and Kaplan, 1995):

> *H_1: There is a significant relationship between the occupancy costs of a building, its physical characteristics and the characteristics of its occupier.*

Occupancy characteristics are the composition and activities of the organisation occupying the property. In combination occupancy characteristics can lead to a requirement for a property with particular physical characteristics (Gray and Tippett, 1993). Occupancy characteristics can change due to technological, legal, aesthetic and functional factors (Chapter 2). Occupancy characteristics are employed as explanatory variables in the theoretical framework because they are assumed to affect the costs of occupying a property (Clift and Butler, 1995):

> *H_2: There is a significant relationship between the occupancy costs of a building and the characteristics of its occupier*

The physical characteristics of a property relates to its spatial attributes, such as floor area. Physical characteristics are employed as explanatory variables in the theoretical framework because they are assumed to affect property occupancy costs (Williams, 1985; Gray and Tippet, 1992; Avis *et al.*, 1993):

> *H_3: There is a significant relationship between the occupancy costs of a building and its physical characteristics.*

The second stage of the theoretical framework addresses the issue of utility (Figure 3.6). Occupier organisations utilise property as workplaces. Workplaces are created to support people in the delivery of goods, services or knowledge to clients and customers, the level of support being a measure of the utility (functional performance) provided by the building.

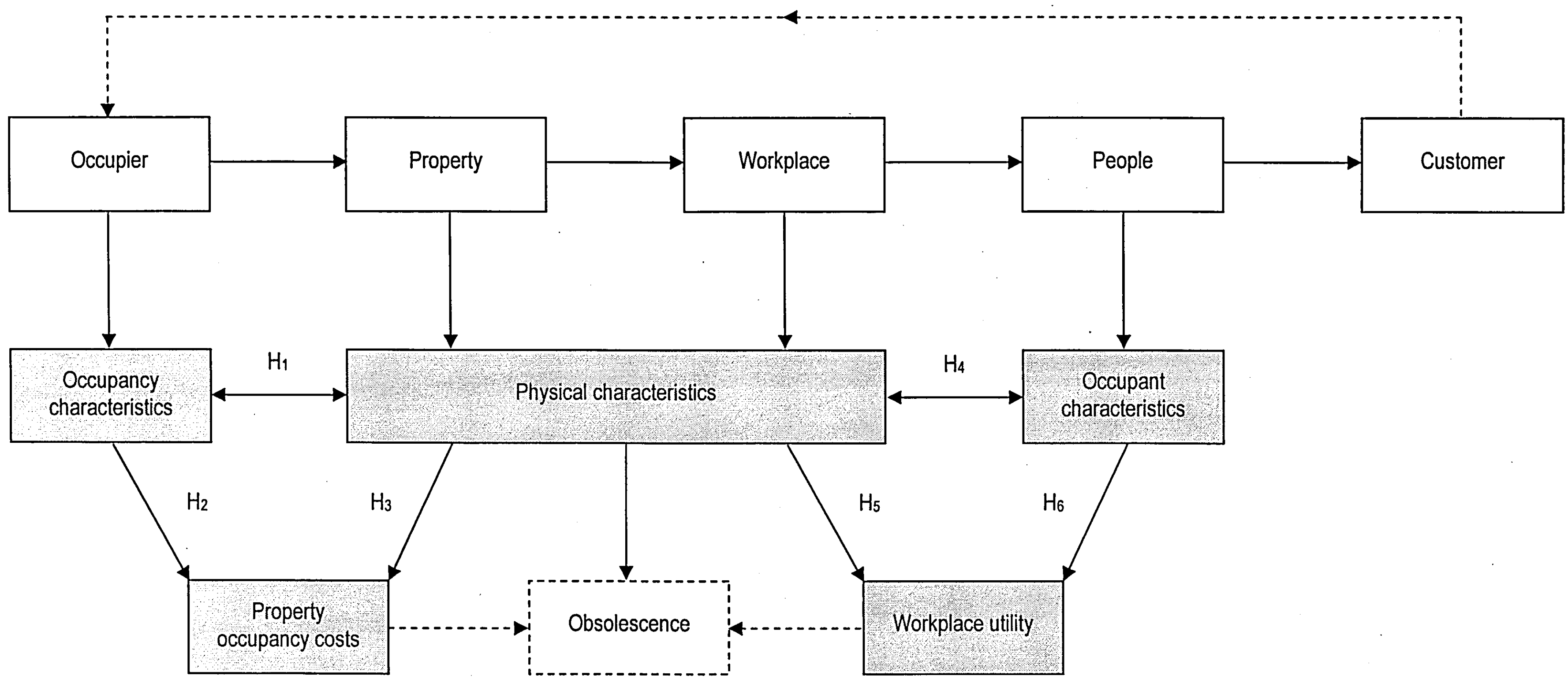


Figure 3.6: Theoretical framework

The utility of a workplace can vary over time due to changes in its physical characteristics or the characteristics of its occupants. Utility is therefore employed as an outcome variable in the model:

> *H_4: There is a significant relationship between the utility of a building and its physical characteristics.*

The physical characteristics of the workplace include its spatial arrangement and the nature and condition of its fabric and services (Williams, 1985). These characteristics may change over time due to physical deterioration or renewal (Chapter 2). Physical characteristics are employed as explanatory variables in the theoretical framework because they are assumed to affect the utility derived by occupants:

> *H_5: There is a significant relationship between the physical characteristics of the workplace and its utility.*

Occupant characteristics refer to the demographics and activities of individual occupants. The use of occupant characteristics as an indicator was based on the assumption that occupants are the principal users of workplaces. In combination occupant characteristics can lead to a requirement for a workplace with particular physical characteristics (Gray and Tippett, 1993). Occupant characteristics can change due to technological, legal, aesthetic and functional factors (Chapter 2). A change in occupant characteristics can affect the utility derived from a workplace (Nutt *et al.*, 1976; Williams, 1985). Occupant characteristics are therefore employed as explanatory variables in the theoretical framework:

> *H_6: There is a significant relationship between the utility of a building and the characteristics of its occupants.*

In order to model these hypothesised relationships it was necessary to collect empirical data to represent each of the indicators. This was the fifth stage of the modelling process (Figure 3.2). The data requirements are explained next.

3.2.4 Data requirements

Obsolescence, like most other processes, can be modelled using either longitudinal or cross-sectional data (Baum, 1991). Longitudinal data are collected from the same cases at two or more points of time (de Vaus, 1996). The advantage of longitudinal data is that it allows the researcher to detect changes in the outcome variable over time (McNeill, 1990). However, collection of longitudinal data tends to be difficult and is demanding in terms of time and resources (Robson, 1993). Longitudinal studies may also suffer from sample attrition and conditioning. Sample attrition is when cases become inaccessible or unavailable (Hakim, 1987; Robson, 1993). Conditioning occurs when participants begin to adjust their responses to what they think is expected, thereby distorting the data over time (Kumar, 1999).

Cross-sectional data are collected from two or more cases at one point in time in order to compare the extent to which the cases differ on the outcome variable (de Vaus, 1996). They are useful for obtaining a snap-shot of a population at a particular point in time (Robson, 1993). Cross-sectional data are usually cheaper to collect and easier to analyse because they involve only one contact with the study population (Kumar, 1999). The principal disadvantage of cross-sectional data is that they do not have a time dimension and cannot be used to measure change (de Vaus, 1996; Kumar, 1999). According to Vogt (1999, p.65) cross-sectional data 'provide only indirect evidence about the effects of time and must be used with great caution when drawing conclusions about change'. This problem is usually overcome by statistically eliminating differences between cases (de Vaus, 1996).

Time and resource constraints precluded the use of longitudinal data in this study. Cross-sectional data were therefore used instead. The use of cross-sectional data was based on the assumption that:

- Buildings of the same type vary in the way they perform basic functions, such as providing security or delivering fresh air to occupants (Gray and Tippet, 1993). Two buildings may therefore have different utility and occupancy costs because of differences between their physical characteristics. One building will be more obsolescent than the other.
- Even for generic activities, such as office work, certain tasks place special demands on the buildings in which they occur (Gray and Tippett, 1993). These differences impact on the costs of occupying a building. Two buildings with the same physical characteristics may therefore have different occupancy costs because of differences in occupancy characteristics.
- Occupants function in ways that are unique in certain respects and set them apart from others (Gray and Tippett, 1993). They may also have different expectations regarding the importance of particular workplace characteristics. Hence, the minimum standard of accommodation may vary with each occupant; one may expect a high level of environmental control and high quality finishes, whereas another may only expect the minimum level of shelter and security. A workplace that is unsuitable for one occupant may therefore yield a high level of utility for another because of differences in occupant characteristics (Williams, 1985).

These assumptions imply that individual buildings, occupiers and occupants provide the basis of modelling obsolescence. These subjects were therefore selected as units of observation and analysis. Units of observation are the subjects from which data were collected (Babbie, 1998). Units of analysis are the subjects about which data were collected (de Vaus, 1996). The units of observation and analysis for this research are summarised in Table 3.1.

Table 3.1: Units of observation and analysis

Unit of observation	Indicator	Unit of analysis
Occupier	Occupancy characteristics	Occupier
Occupier	Occupancy costs	Building
Building	Physical characteristics	Building
Occupant	Utility	Building
Occupant	Occupant characteristics	Occupant

The underlying premise of using cross-sectional data was that the obsolescence of a building could be determined by comparing the building to a sample of similar buildings (Nutt *et al.*, 1976). This was achieved by focusing on portfolios of buildings. A portfolio is a group of buildings owned or occupied by an individual organisation (Baird *et al.*, 1995). The advantage of using portfolios of buildings was that it facilitated data collection. The disadvantage of this approach was that the model would only be applicable to the portfolios from which data were collected. This was not considered problematic, however, since the principal aim of this research was to establish a framework for modelling obsolescence, rather than develop a universally applicable model. The selection of portfolios is discussed next.

3.2.5 Sample selection

The first step in portfolio selection involved identifying a population of occupier organisations. A population is a precisely defined set of subjects (de Vaus, 1996). The population used in this research comprised the 409 local authorities in England and Wales (Table 3.2).

Local authorities in England and Wales are responsible for delivering a wide range of public services and municipal amenities, accounting for approximately 25 per cent of government expenditure. Collectively they employ over 2.6 million people (Kavanagh, 2000). Under the two-tier system of local government in England county councils are responsible for strategic planning, highways, traffic, social services, education, libraries, fire, refuse disposal and consumer protection, and district councils are responsible local planning, housing, environmental health, markets and fairs, refuse collection, cemeteries and crematoria, leisure services and parks, tourism and electoral registration (Municipal Year Book, 2001). English and Welsh unitary councils, together with London and metropolitan borough councils, are responsible for all local government services (Municipal Year Book, 2001).

Table 3.2: Research population (Municipal Year Book, 2001; p.26)

Type of authority	Frequency
English County Council	34
London Borough Council	32
Corporation of London	1
Metropolitan Borough Council	36
English District Council	238
English Unitary Council	46
Welsh Unitary Council	22
Total	409

Local authorities in England and Wales own non-residential property valued in excess of £75 billion. This includes thousands of buildings which they use to deliver front-line services, including 21,000 schools, 3,800 libraries and 1,800 leisure centres (Audit Commission, 2000). Local authorities also occupy a significant number of office buildings, which they use for carrying out administrative activities (Audit Commission, 2000). On average county councils occupy 35,000m^2 of office space, metropolitan councils 22,000m^2 and district councils 5000 m^2 (Audit Commission, 2000). This, together with the fact that their activities are relatively homogeneous, suggested that local authorities would be a suitable research population.

Given the size of the research population it was necessary to select a smaller sample of local authorities from which to collect empirical data (Figure 3.7). There are two main approaches to selecting a sample: probability sampling and non-probability sampling (Babbie, 1998). Probability sampling involves the random selection of cases so that every member of the research population has an equal chance of being selected. Non-probability sampling involves the selection of cases on some basis other than random selection (de Vaus, 1996). Probability samples are more likely to be representative of the research population (Babbie, 1998). It is also possible to estimate how representative a probability sample is, which is critical when making inferences about the research population. If a research problem requires a representative sample some form of probability sampling should be used (Punch, 1998).

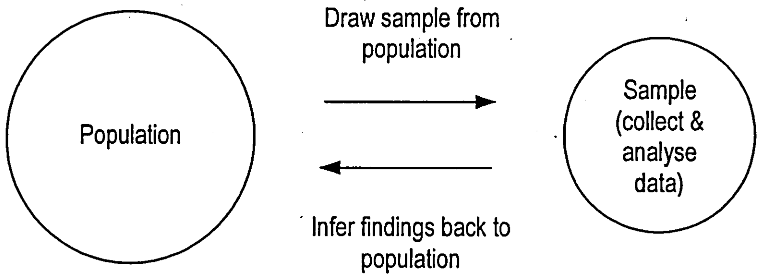


Figure 3.7: Population and sample (from Punch, 1998; p.106)

Two factors precluded the use of probability sampling in this research. The first was that whilst it was possible to randomly select local authorities from the research population, it was assumed that many would be unable to participate in the study because of resource constraints or concerns over confidentiality. This assumption was confirmed through preliminary discussions with several local authorities. Random selection of local authorities would have produced such a bias that the sample would not have been representative despite the use of probability sampling (de Vaus, 1996). The second factor was that since the aim of this study was to develop a framework for modelling obsolescence, rather than to make inferences about the research population, a representative sample was not required. Local authorities were therefore selected using non-probability sampling.

There are three principal methods of non-probability sampling: purposive, quota and availability (Babbie, 1998). Purposive sampling involves selecting cases based on their presumed typicality (de Vaus, 1996). This method can be used to maximise the chance of observing a relationship or phenomenon (Punch, 1998). Quota sampling involves dividing a population into categories and selecting cases within each category. Cases are usually selected on the basis of convenience (Vogt, 1999). As with all non-probability sampling, the disadvantage with quota sampling is that it is not possible to estimate the accuracy of the sample (de Vaus, 1996). Availability sampling is where cases are selected simply because they are available. This method is the least likely to produce representative samples and should therefore be used with caution (de Vaus, 1996).

Despite the drawbacks associated with availability sampling, it was still the most suitable method for this research. Local authorities were selected according to their capacity to provide access to buildings and data, rather than for being representative of the research population. The selection process involved discussions with local authorities to negotiate access to buildings, employees and occupancy cost data. Five local authorities agreed to participate in the research: three unitary councils, one county council and one metropolitan borough council. The next three sections explain the research techniques used to collect data from each of the local authorities.

3.3 Buildings survey

The previous section explained the research design which underpinned the empirical research in this study. The empirical research was designed around the premise that obsolescence of a given building is, amongst other things, a function of its physical characteristics. This section describes the techniques that were employed to collect the physical characteristics data for use in the modelling process. The procedure that was used to design and carry out the data collection is depicted in Figure 3.8.

The first stage of the procedure involved determining the type and number of buildings to survey. This is discussed in Section 3.3.1. The second stage of the procedure entailed the selection of physical characteristics to include in the survey. The selection criteria are described in Section 3.3.2. Since existing survey instruments were unsuitable for the purpose, a new instrument was designed for collecting the empirical data. The design and piloting of the survey instrument are explained in Section 3.3.3. Stages 4, 5 and 6 of the procedure comprised data collection. Data were collected by walk-through building surveys using a handheld computer. Section 3.3.4 explains how the surveys were undertaken. The final stage of the procedure involved analysing the data. The results of the data analysis of discussed in Chapter 4, 5 and 6.

3.3.1 Building type and selection

Local authorities differ from many organisations in that they occupy a wide range of building types, including schools, libraries, offices and leisure centres. Since obsolescence of a given building was to be determined by comparing it with a sample of similar buildings, it was necessary to identify one particular building type as the unit of analysis. To facilitate comparison with previous empirical research (Salway, 1986; Baum, 1991; Khalid, 1992; Bottom *et al.*, 1999), it was decided to focus on office buildings. A secondary factor behind this decision was that office buildings have been shown to be particularly susceptible to obsolescence (Gann and Barlow, 1996; Barras and Clark, 1996; Nutt 1997; Chilton and Baldry, 1997).

Collectively, the five local authorities selected for this research occupied 77 office buildings. The number of office buildings occupied varied between each local authority (Table 3.3). To maximise the size of the dataset, it was decided to survey all available buildings. However, because some were inaccessible, a sample of 64 office buildings was surveyed (Table 3.3).

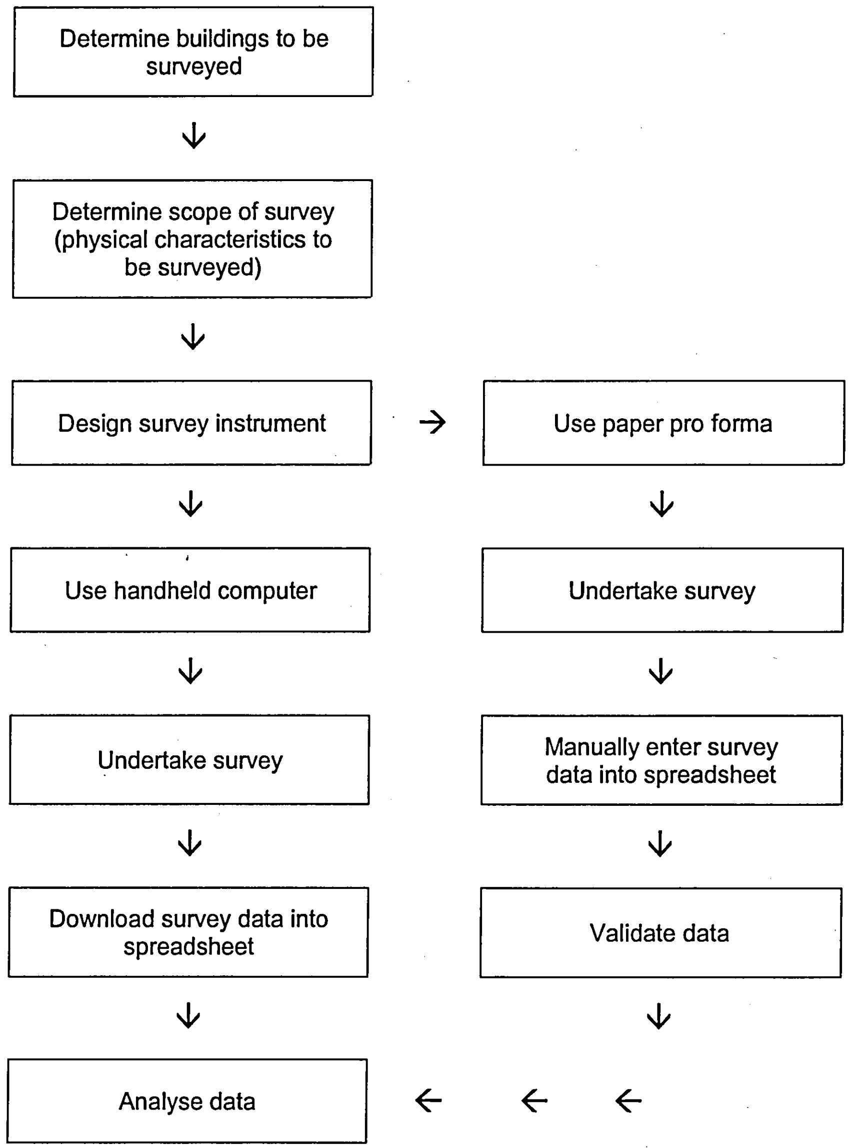


Figure 3.8: Procedure for conducting building surveys (adapted from the RICS, 1997; p.28)

Table 3.3: Number of office buildings per local authority

Local authority	Population	Sample
A	16	16
B	7	5
C	26	22
D	16	16
E	12	5
Total	77	64

3.3.2 Scope of the survey

An office building is a complex assembly of components and sub-components, which together comprise the physical characteristics of the building. The physical characteristics of an office building can be examined at various levels of aggregation. At a basic level, office buildings can be classified according to their site, shell, services, scenery and settings (Duffy *et al.*, 1993). More detailed classifications, such as those used by the RIBA (1976) or ASTM (2000), comprise hundreds of physical characteristics, which are collated in groups. Establishing the scope of the survey was therefore critical, since the collection of excessive data at unnecessary levels of detail would have been wasteful and made subsequent analysis more difficult (RICS, 1997).

The scope of the survey was defined by the number and type of physical characteristics to be surveyed. Physical characteristics were selected on the basis that they were:

- assumed to impact on either the utility or occupancy costs of office buildings;
- accessible and could be subjected to visual inspection; and
- measurable during a walk-through survey.

The selection process was guided by previous empirical studies into property depreciation (Baum, 1991; Khalid, 1992; Bottom *et al.*, 1999). Sixty-seven physical characteristics were selected and arranged under seven headings (Table 3.4). For example, reception and foyer included four characteristics: draught exclusion, disabled accessed, security and reception desk. A complete list of physical characteristics is provided in Appendix C.

3.3.3 Design of the survey instrument

The 76 physical characteristics identified above formed the basis of the instrument used for conducting the building surveys. In order to ensure consistency and validity, and in view of best practice guidance (RICS, 1997; Simpson, 1997) the survey instrument was designed to:

- be highly structured;
- request only relevant data;
- be flexible enough to account for buildings of non-standard construction;
- request data in the same sequence that the buildings would be surveyed; and
- be easy to use, with lists, multiple-choices and blank lines where appropriate.

Table 3.4: Scope of buildings survey

Heading	Number of characteristics
Site and location	10
Building structure	4
Building enclosure	4
Reception and Foyer	4
Common services and amenities	9
Common areas and circulation	14
Working environment	22
Total	67

The survey instrument was structured in accordance with the headings in Table 3.4, with an additional header section containing background information, such as the address of the building and date of the survey. Characteristics were recorded using one of four response formats. Nominal and ordinal data were recorded using yes/no responses, multiple-choice menus and combination lists. Interval and ratio data were recorded using numeric responses. The structure of the survey instrument and the level of measurement of each physical characteristic are summarised in Appendix C.

In addition, condition data were collected for 12 physical characteristics relating to interior and exterior finishes. These data were included to provide an indication as to the physical condition of each building. Condition categories were adopted and clearly defined to ensure data reliability (RICS, 1997). The condition of each characteristic was recorded on a five-point scale, where:

- 1 = Impeccable, new or like new. All surfaces are free from dirt, stains and defects. First class condition, sparkling clean and fresh looking;
- 2 = Above average condition or fairly new. All surfaces are free from marks, stains and defects. Dirty or dusty in places (0-25% of surface area), some areas require additional cleaning;
- 3 = Functional in appearance and image, with no defects. Marks or stains in places (0-25% of surface area), requiring specialist cleaning. Many areas (25-50% of surface area) are dirty or dusty;
- 4 = Damaged or worn, with defects in places (0-25% of surface area). General marks or stains (25-50% of surface area). Most areas are dirty, dusty or streaked (50-75% of surface area); and

- 5 = Extensively worn or badly damaged, with a significant number of defects (25-50% surface area). Most areas have marks or stains (50-75% surface area). Surface is uniformly dirty, dusty, streaked or grimy (75-100% of surface area).

The robustness of these categories was verified by undertaking a pilot study comprising five office buildings. The pilot study was used to test the appropriateness of the survey instrument on different building types prior to data collection (RICS, 1997).

3.3.4 Data collection

The survey instrument was administered using PowerSurvey software and a handheld computer. PowerSurvey enabled the survey instrument to be designed and tested on a PC before being uploaded to a handheld computer. When the survey was complete the data were downloaded to the PC and imported into SPSS. The use of a handheld computer enabled automatic data transfer and eliminated the errors and costs associated with manual data entry (RICS, 1997). An additional advantage of using PowerSurvey was that it allowed verification routines to be included in the survey instrument, reducing the potential for errors during data collection (Then, 1995; RICS, 1997)

Data collection involved conducting a walk-through survey of each office building. The surveys took, on average, an hour to complete, although the duration of each survey varied depending on the size and layout of the building. Additional data were acquired from photographs taken during the survey and as-built drawings provided by the local authority. A decision was taken on-site about what spatial level at which to collect data (RICS, 1997). For instance, some large, complex buildings were sub-divided into a smaller number of spatial units, whereas smaller buildings were usually surveyed at the building level. A balance had to be attained between the quality of data and time available to conduct the surveys (RICS, 1997). The results of the buildings survey are presented in Chapter 4 (Section 4.2). The next section in this chapter describes the collection of occupancy cost data.

3.4 Occupancy cost survey

The purpose of the occupancy cost survey was to collect data relating to the occupancy costs and occupancy characteristics of the sample of local authority office buildings. Occupancy characteristics were employed as explanatory variables in this study and occupancy costs were used as outcome variables. Traditionally, the collection of occupancy cost data has been fraught with problems because:

- in many organisations responsibility for occupancy costs is dispersed across different departments; and

- there is a lack of a universally applicable data structure (Tomlinson *et al.*, 1996).

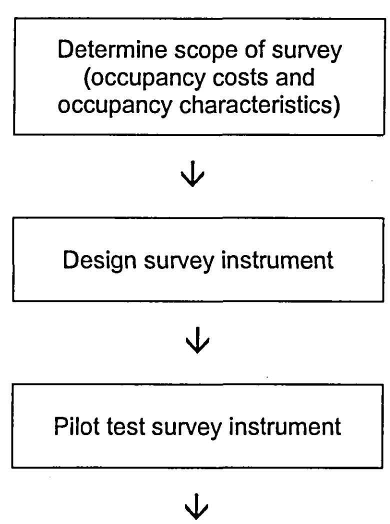
Before occupancy costs could be modelled it was necessary to overcome these problems and collect data in a consistent manner (Tomlinson *et al.*, 1996). This section describes the procedure that was used to accomplish the data collection. The stages of the procedure are depicted in Figure 3.9.

3.4.1 Scope of the survey

The first stage of the procedure (Figure 3.9) involved defining the scope of the occupancy cost survey by selecting which occupancy costs to collect data on. Occupancy costs can be broken down into individual cost components. Various systems have been developed for classifying these components, each comprising different cost headings and different cost components. These classification systems have been developed to enable more consistent data collection, facilitate meaningful cost comparisons and benchmarking, and assist in the construction of other tools and techniques (Tomlinson *et al.,* 1996).

The classification systems examined in this research were:

- *Facilities Costs and Trends Survey* (CFM, 1992). This was designed for collecting data on the cost of occupying and running office buildings. Occupancy costs were defined narrowly as the 'sum of rents, uniform business rates, premises and contents insurance and service charges' (CFM, 1992; p.7). Running costs were classified separately as the sum of expenditure on building maintenance and utilities. In total, the survey covered seven cost headings and 35 cost components. The principal drawback with this system was that it lacked definitions of cost components.



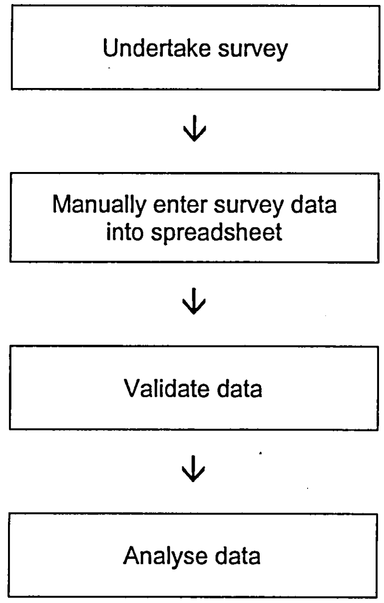


Figure 3.9: Stages in the occupancy cost survey

- *Performance and Cost Managed Building* (Clift and Butler, 1995). This system was developed to provide a framework for collecting detailed information on the performance and costs of buildings in use. Occupancy costs were divided into property costs (rent and rates), operating costs (cleaning, inspection, maintenance and repair), consumption costs (utilities and other services) and administration costs (building management and security). The classification system was designed to be applicable to all building types.
- *Standard Form of Occupancy Cost Analysis* (BMI, 1998). The purpose of this system was to facilitate comparison between the cost of carrying out specific property-related functions and maintenance activities by standardising data collection and analysis. Occupancy costs were classified under nine defined elements and 30 defined sub-elements. The system was designed to be applied to all building types, irrespective of form or use.
- *OPD Total occupancy cost code* (OPD, 1999). This system was designed to provide a common standard for helping occupiers and their advisors to compare cost outcomes. Occupancy costs were broken down into five cost headings (occupational, adaptation, operational, support and management costs) and 39 cost components. Detailed definitions are provided for each component. The system is applicable to most standard property types.

In defining the scope of the occupancy cost survey it was necessary to select one of the above classification systems as the basis of the survey instrument. The *OPD Total* *occupancy cost code* was selected for use in this research because it was the most up-to-date, comprehensive and rigorous classification system. Its application in the survey instrument is described below.

3.4.2 Design of the survey instrument

The survey instrument employed in the occupancy cost survey was designed to be completed by the participating local authorities. A copy of the survey instrument is included in Appendix D. The survey instrument comprised four sections:

- Section A, in which local authorities were asked to provide general information about the building, such as its address.
- Section B, in which local authorities were asked to provide data about the physical characteristics of the building, such as its gross internal area. These additional physical characteristics were required to supplement data from the buildings survey described in Section 3.3.
- Section C, in which local authorities were asked to provide occupancy cost data under the cost headings and cost components taken from the *OPD Total occupancy cost code* (Table 3.5) for the previous financial year (2000-2001). An additional category was also included for net income received, for example from sub-let space.
- Section D, in which local authorities were asked to provide information about the occupancy characteristics of each building, such as whether it was owned or leased by the local authority.

Table 3.5: Scope of occupancy cost survey

Cost heading	Number of components
Property occupation	6
Adaptation and equipment	2
Building operation	17
Business support	5
Management	2
Net income received	4
Total	36

A glossary of terms was also included in the survey instrument to ensure that local authorities were providing data based on a common set of definitions. Definitions were taken from the *OPD Total occupancy cost code* and the *RICS Code of Measuring Practice*

(RICS, 2001). The survey instrument was issued to each of the participating local authorities for consultation prior to data collection.

3.4.3 Data collection

All five local authorities participated in the occupancy cost survey. Collectively, the local authorities provided building-level occupancy cost data for 53 office buildings. Occupancy cost data were unavailable for 11 office buildings (Table 3.6). Data received from the local authorities were manually input into SPSS prior to analysis. The results of the data analysis are presented in Chapter 4 (Section 4.3). The next section in this chapter describes the collection of data relating to workplace utility and occupant characteristics.

Table 3.6: Buildings covered by occupancy cost survey

Local authority	Population	Sample
A	16	13
B	5	5
C	22	21
D	16	10
E	5	4
Total	64	53

3.5 Occupant survey

Occupant surveys are designed to elicit occupants' perceptions of buildings (Aronoff and Kaplan, 1995). The use of occupant surveys for evaluating buildings has become increasingly common in the last two decades (Aronoff and Kaplan, 1995; Baird *et al.*, 1996). A number of standardised instruments have been developed to provide valid and reliable comparisons between buildings, organisations and time periods (Becker, 1990), the most recent example being *Design Quality Indicator* (Construction Industry Council, 2002). These instruments have principally been designed for the purpose of post-occupancy evaluation, that is to say the 'formal evaluation of a building by its occupants after it is completed' (Becker, 1990; p.267). Bespoke instruments have also been developed by individual researchers and tailored to the specific circumstances of a building and its occupants (Becker, 1990).

In this study the purpose of the occupant survey was to collect data on the utility of the sample buildings and the characteristics of the buildings' occupants. A new survey instrument was therefore developed for this purpose[29]. This section describes the stages involved in developing and administering the survey instrument (Figure 3.10).

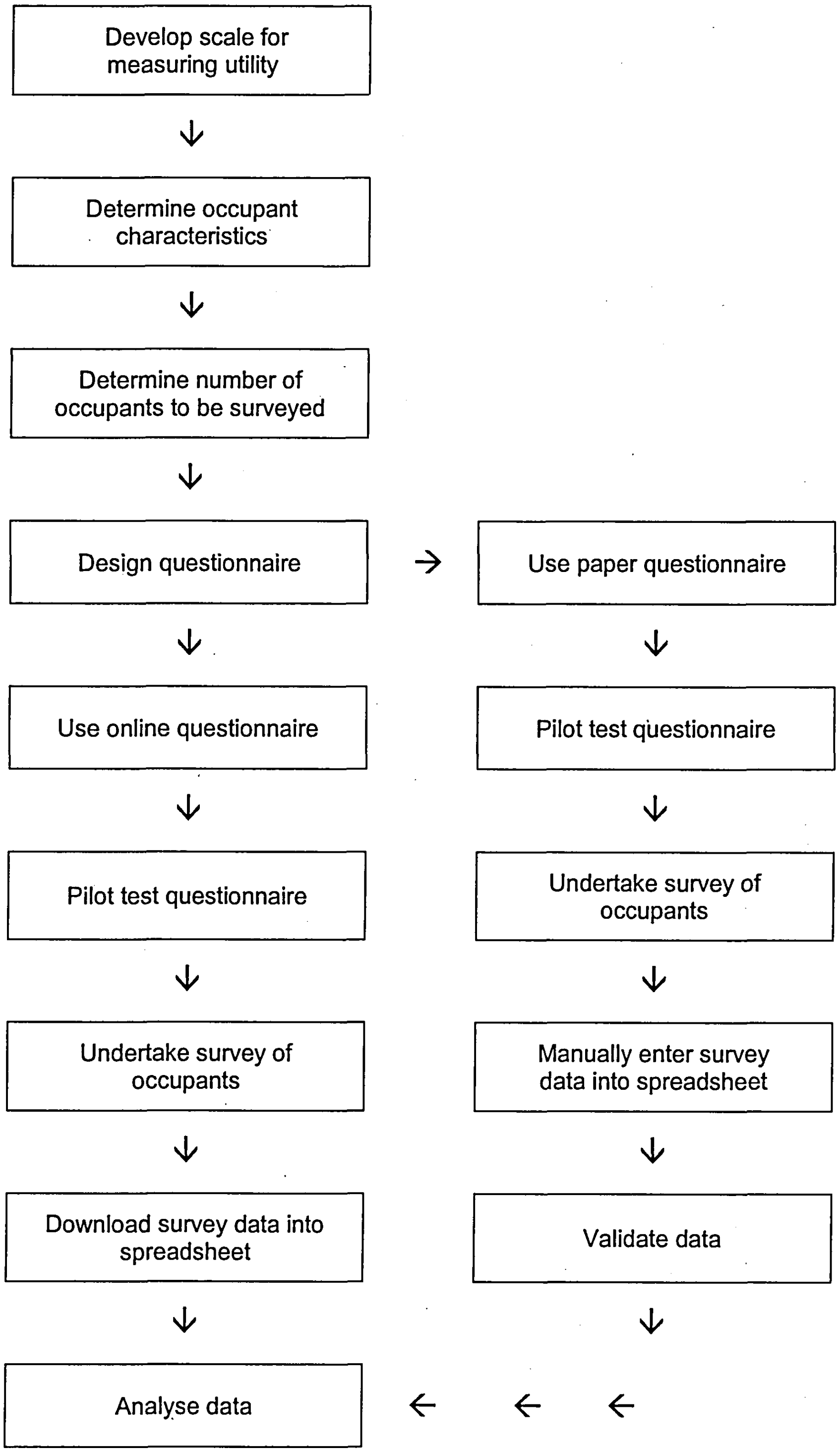


Figure 3.10: Stages in the occupant survey

[29] The preliminary study that was conducted to develop the scale was subsequently endorsed through peer reviewed publication (Appendix P).

3.5.1 Scale development

The first stage of the occupant survey (Figure 3.10) involved developing a scale for measuring workplace utility. In Chapter 2 utility was defined as a measure of the attributes afforded by a building to the benefit, or otherwise, of the people that use it. Utility is a subjective concept (Vogt, 1999). According to Williams (1985) occupants form an opinion about the utility of their workplace based on their:

- Expectations of what they think their workplace should be like. Occupants usually have different priorities with regard to workplace attributes. This means that the minimum standard of accommodation will vary with each occupant; one occupant may expect a high level of environmental control and high quality finishes, whereas others may only expect the minimum level of shelter and security.

Table 3.7: Factors influencing occupant perceptions (adapted from Williams, 1985; p.13-15)

Factor	Effect
Relativity	Relative conditions are easier to perceive than absolute conditions, this being in direct proportion to the magnitude of the relative difference. For instance, it is easier to judge that one building is in better condition than another than it is to judge the condition of a building in isolation.
Significant aspects	Some aspects of a building are easier to perceive than others. For example, the decorative state of repair and the internal thermal environment are easier to perceive than structural performance or the adequate provision of fire exits. These aspects may have a disproportionate influence on the overall assessment of utility
Knowledge and past experience	These are important where the occupant has particular knowledge relating to the building itself or the activity in question. Occupants' experience of other buildings will also influence their perceptions.
Level of involvement	Occupants who use the building infrequently are likely to perceive change as being at a higher rate due to their discontinuous view of the building. Occupants who use the building frequently may overlook lesser changes that would be perceptible to infrequent users. They are also likely to perceive different aspects of the building;
Social context	Where judgements are made by an occupant, either as part of a group or individually, but with knowledge of the group consensus, then the occupant's perception will tend to concur with that consensus more than if the occupant's perceptual judgement was formed in isolation. Hence, if a building has a poor reputation, it is likely to be perpetuated.
Tastes and fashions	Fashion permeates all facets of life and experience suggests that whatever the long term view about a particular style, it will invariably fall out of favour in the medium term; changes in fashion provoke an adverse reaction against styles that characterised the preceding era (Salway, 1986).

- Perceptions of their workplace. Occupants' perceptions relate to all aspects of their workplace and are affected by their individual characteristics, including knowledge and past experience, time spent in the building, personal tastes and social context (Table 3.7).

Since the interaction of these two factors may differ for each occupant, a workplace that is unsuitable for one occupant may yield a high level of utility for another (Williams, 1985).

The utility of the sample buildings was measured using a multi-item scale. Multi-item scales are composite measures where individual measures are used to tap an underlying concept (de Vaus, 1996). A multi-item scale was developed to:

- Improve validity. A single measure of a concept can be misleading. Multi-item scales assist in conducting more valid measurements (Oshagbemi, 1999).
- Increase clarity. Utility is difficult to define explicitly. A multi-item scale helped to unravel the complexity of the concept (de Vaus, 1996).
- Improve reliability. The use of a multi-item scale is better than relying on a single indicator of a concept (Loo, 2002).
- Enhance precision. The use of multiple indicators assists in differentiating between individual cases (de Vaus, 1996).

The scale was devised using Churchill's (1979) procedure for developing multi-item measures of concepts (Table 3.8). This procedure is well established and has been employed in previous empirical research, for example in the measurement of service quality (Parasuraman *et al.*, 1988).

Table 3.8: Procedure for developing multi-item scales (adapted from Churchill, 1979; p.463)

Stage	Description	Technique or coefficient
1	Generate scale items	Focus groups with building occupants
2	Collect data	Survey of building occupants
3	Purify scale	Cronbach's alpha, factor analysis
4	Assess scale reliability	Cronbach's alpha
5	Assess scale validity	Split/multiple samples

3.5.2 Generation of scale items

The first step in Churchill's (1979) procedure (Table 3.8) involved generating a set of items to tap into each aspect of the concept. Item generation is an important part of scale development (Nassar-McMillan and Borders, 2002). Techniques that are typically used to generate scale items include literature searches, interviews, experience surveys, critical incidents and focus groups (Churchill, 1999). In this research, focus groups were used to generate the scale items, the objective being to identify the criteria by which occupants evaluate the utility of their workplace.

Focus groups are a qualitative research technique in which a small number of participants discuss elected topics as a group for approximately one or two hours, whilst the moderator focuses the discussion onto relevant subjects in a non-directive manner (Tynan and Drayton, 1986). The technique is based on the premise that individuals' attitudes and beliefs do not form in isolation, and that people need to hear other opinions before forming their own (Marshall and Rossman, 1999). Focus groups have the advantage of allowing large amounts of data to be collected in a limited time period (Morgan, 1997). They are also a highly effective technique for generating scale items (Nassar-McMillan and Borders, 2002).

Following best practice guidance (Morgan, 1998), three focus groups, comprising a total of 20 people, were conducted with occupants of a public sector office building. Participants were self-selecting, in that they had responded to an invitation that had been sent to all occupants of the building. The focus groups were conducted in the office building and an interview guide, containing ten questions, was used to direct the discussion. Each focus group lasted approximately one hour. The focus groups were recorded, transcribed, coded and analysed. Collectively, the focus groups generated 87 items. A copy of the interview guide and list of items are in Appendix E and F, respectively.

3.5.3 Data collection

The second stage of the procedure (Table 3.8) involved collecting data with which to purify or refine the scale. Data were collected using a questionnaire comprised of the 87 items. Each item was recast into two statements: one for occupants' expectations and the other for occupants' perceptions. A seven-point scale accompanied each statement, ranging from 'Strongly Agree' (7) to 'Strongly Disagree' (1), with no verbal labels for scale points 2 through 6. An additional category, 'Not Applicable' (0), was also included. The expectation statements were grouped together and formed the first part of the questionnaire, whilst the corresponding perception statements formed the second half. A pilot study suggested the number of statements be reduced from 174 to 110 by eliminating and combining items.

A revised 55-item questionnaire was developed for collecting data from building occupants. The revised questionnaire was designed to be administered online. This had the advantage of:

- avoiding the distribution and printing costs associated with paper-based surveys;

- eliminating the time, resources and human error involved in inputting data into a spreadsheet; and
- reducing the potential for respondent error.

An HTML[30] version of the questionnaire was placed on the intranet of the participating organisation. A copy of the questionnaire is included in Appendix G. The URL[31] of the questionnaire was then e-mailed to the 1,800 occupants of a public sector office building. The e-mail also served to explain the rationale and background to the research. Recipients were given two weeks in which to complete the survey instrument. Of the 1,800 recipients, 355 people responded within the specified time period, a 20% response rate. This could be regarded as 'low'. However, when placed into context with response rates from comparable data collection techniques, for example the postal survey, it is to be expected. Factors believed to have had an impact on the response rate include the length and repetitive nature of the survey instrument and the inability to personalise the e-mail inviting recipients to participate.

3.5.4 Scale purification

The objective of scale purification was to produce a more valid, reliable and parsimonious scale. Scale purification involved examining the dimensionality of the 55-item scale using factor analysis. Factor analysis is a statistical technique for condensing many variables (items) into a few underlying factors or dimensions (Figure 3.11). This is achieved by generating artificial dimensions that correlate highly with several of the variables, but are independent of one another (Babbie, 1998). Raw data used in the factor analysis were in the form of difference scores, with values ranging from 6 to -6. For each of the 55 items a difference score U was defined as $U = P - E$, where P and E were the ratings on the corresponding perception and expectation statements, respectively. The idea of using difference scores to purify a multiple-item scale is not new and has been used in previous empirical research (Ford *et al.*, 1975; Parasuraman *et al.*, 1988; Hoxley, 2000).

Missing data[32] were recoded and a missing value analysis was conducted in SPSS, which revealed that missing data were randomly distributed across the data matrix. Mean series values were then calculated and used to replace missing data, thereby maximising the

[30] Hypertext Markup Language. HTML is a document format widely used to create Web pages on the Internet and intranets (Howe, 1993).

[31] Uniform Resource Locator. URLs are the standard way of specifying the location of a web page on the Internet and the form of address used on the World Wide Web (Howe, 1993).

[32] Values of 0, representing 'not applicable', were recoded as 'system missing' to prevent extreme scores skewing the results.

number of valid cases (Hair *et al.*, 1995). The replacement of missing data had the effect of 'smoothing' individual variables so that the influence of extreme values was diminished. This approach could be regarded as 'conservative', but given the potential drastic decline in cases due to the combined impact of missing values it was regarded as justifiable.

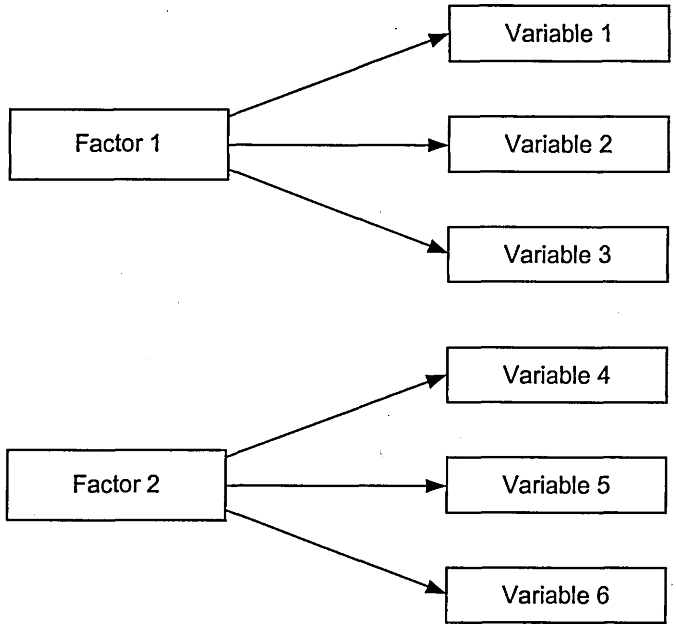


Figure 3.11: Graphical representation of factor analysis (adapted from de Vaus, 1996; p.260)

Prior to conducting the factor analysis it was necessary to test the reliability or internal consistency of the set of items using Cronbach's alpha. Values of Cronbach's alpha range from 0 to 1.0, with higher figures indicating greater scale reliability. Scores higher than 0.7 suggest that the items in a scale are internally consistent, or measuring the same thing (Vogt, 1999). A total scale Cronbach's alpha of 0.96 indicated that the scale had very good reliability. However, values of Cronbach's alpha across the 55 items ranged from 0.35 to 0.66, suggesting that deletion of certain items could improve alpha values. Corrected item-to-item correlations were used to decide whether to delete an item (Churchill, 1979). Corrected item-to-item correlations were plotted in decreasing order of magnitude (Figure 3.12). None of the items had very low correlations (near zero), nor did they produce a substantial or sudden drop in the plotted pattern (Churchill, 1979). All 55 variables were therefore included in the factor analysis.

The suitability of the data had to be determined before factor analysis could be used. Inspection of the correlation matrix, which shows the correlations between the variables, revealed a considerable number of correlations exceeding 0.30, suggesting that the matrix was suitable for factoring (Hair *et al.*, 1995). The anti-image correlation matrix was also examined, indicating that all measures of sampling adequacy were well above the acceptable level of 0.50 (Coakes and Steed, 2001). Finally, the Bartlett test of sphericity, a statistical test for the presence of correlations between variables, was significant and the Kaiser-Meyer Olkin measure of sampling adequacy was 0.93, well above the acceptable level of 0.50 (Coakes and Steed, 2001). These measures all indicated that factor analysis was appropriate.

Factor analysis of the 55 variables, using principal axis factoring and oblique rotation, revealed 32 variables loaded across 8 factors, representing 62% of the total variance. All 32 variables had a communality of 0.50 or more and a factor loading of 0.25 or more; variables with factor loadings less than 0.25 were considered insignificant and were removed from the scale. Interpretation of the pattern matrix resulting from the factor rotation revealed four definable factors, representing 22 variables (Table 3.9). This suggested that workplace utility could be measured along four dimensions:

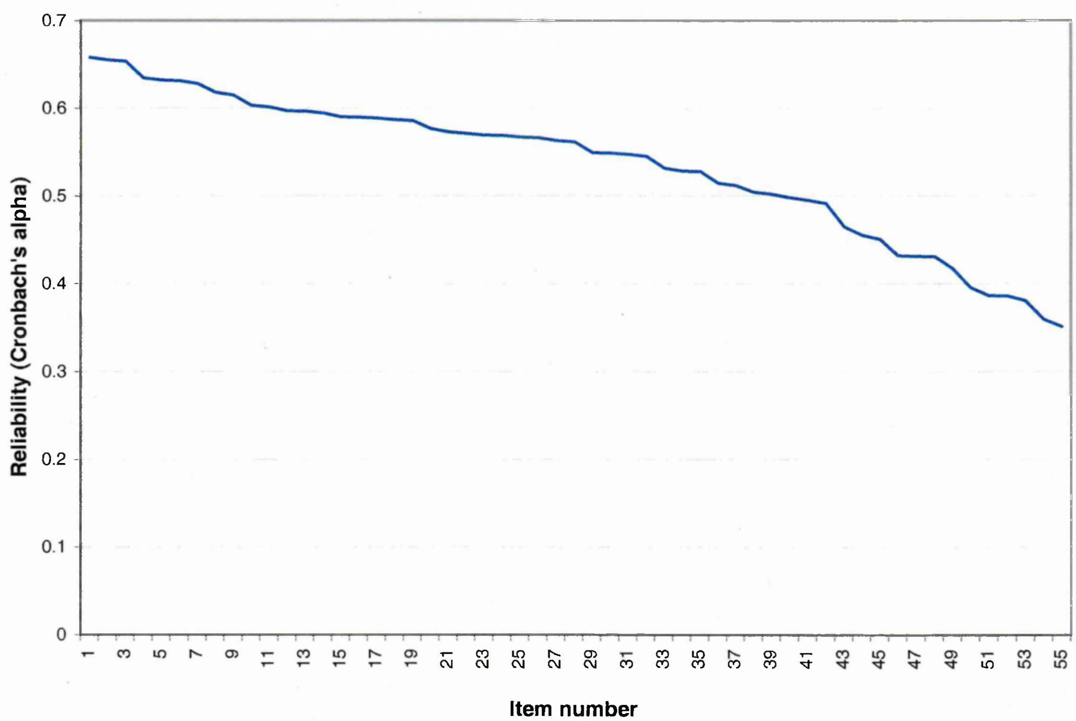


Figure 3.12: Cronbach's alpha corrected item-to-item correlations, decreasing order of magnitude

- Factor 1 was concerned with space 'configuration' attributes, such as the amount of informal meeting space, potential for chance interaction and ease of circulation.
- Factor 2 was loaded with six 'environment' related attributes, such as adequacy of ventilation, degree of individual control of temperature and responsiveness to changes in temperature. This grouping was not surprising, since previous research (Leaman and Bordass, 2000) identified these as being key variables in the evaluation of offices.
- Factor 3 was concerned with the 'appearance' of the office building, and includes attributes such as the modernity of interior areas, exterior appearance and tidiness.
- Factor 4 was comprised of six attributes that relate to the 'functionality' of the building, including the level of conversational privacy, adequacy of workspace and potential to work free from distraction. Again, many of these variables have also been shown to be of importance in previous office workplace evaluation studies (Sundstrom, 1994; Kupritz, 1998; Brill *et al.*, 2001; Nathan, 2002).

Table 3.9: Factor loadings of variables

Variable (attribute)	Factor 1	Factor 2	Factor 3	Factor 4
Access to informal meeting space	0.555			
Amount of informal meeting space	0.552			
Amount of space for team projects	0.437			
Common areas allow chance interaction	0.384			
Layout enables circulation movement	0.261			
Comfortable temperature		-0.884		
Comfortable humidity		-0.813		
Well ventilated		-0.795		
Responsive to changes in temperature		-0.775		
Control over temperature		-0.692		
Control over ventilation		-0.631		
Modern from the outside			0.816	
Modern appearance			0.791	
Visually appealing from the outside			0.732	
Visually appealing			0.696	
Tidy appearance			0.423	
Conversational privacy				0.708
A place to work free from distraction				0.638
Visual privacy				0.638
Accessible storage space				0.452
Amount of storage space				0.377
Amount of workspace				0.367

3.5.5 Reliability and validity of the scale

The final part of the scale development (Table 3.8) involved assessing the validity and reliability of the 22-item scale prior to its use in the occupant survey. Reliability was evaluated by calculating Cronbach's alpha for each of the four dimensions and for the scale as a whole (Table 3.10). These figures were all high and comparable to those of other scales developed using this procedure (Parasuraman *et al.*, 1988; Nelson and Nelson, 1995; Hoxley, 2000). The total scale alpha of 0.93 indicated that the scale had very good reliability. Validation of the scale involved splitting the sample into two sub-samples and re-estimating the factor models to test for comparability and generalisability. The two factors solutions were by and large comparable across the four dimensions, boosting confidence in the validity of the scale.

Table 3.10: Scale reliability

Dimension	Factor	Number of items	Cronbach's alpha
Configuration	1	5	0.83
Environment	2	6	0.90
Appearance	3	5	0.87
Functionality	4	6	0.87
Entire scale	All	22	0.93

3.5.6 Occupant characteristics

The refined 22-item scale formed the basis of a revised questionnaire that was employed in the occupant survey. A copy of the questionnaire is included in Appendix H. The questionnaire comprised three sections:

- Section A, containing 22 perception statements, each accompanied by a seven-point scale. An additional category, 'Not Applicable', was also included.
- Section B, consisting of 20 questions designed to elicit data about occupant characteristics.
- Section C, comprising 22 expectation statements, each accompanied by a seven-point scale. Recipients were also asked to indicate what they considered to be the most important and least important items.

As explanatory variables in the model, occupant characteristics were selected on the assumption that they would influence occupants' perceptions and expectations, and hence workplace utility. The first set of questions were concerned with occupants' demographics, such as their age, sex, pay scale, and the length of time that they had worked for the local authority, in the same office building and at the same desk position. A second group of questions focused on occupants' working practices. Occupants were asked to indicate, based on the their previous working day, the proportion of time spent doing various activities, such as repetitive and routine tasks, working in groups, or using a telephone. To validate responses to these questions, occupants were asked whether the previous working day had been typical or not.

A customised version of the questionnaire was constructed for each of the participating local authorities, containing the local authority's logo and a list of the buildings covered by the survey. Occupants were asked to indicate which building they worked in so that their responses could be correlated with the physical characteristics of that building.

3.5.7 Sample selection

Three of the five local authorities agreed to participate in the occupant survey. The research population comprised 5172 occupants in 43 office buildings (Table 3.11). A census was undertaken to ensure as large a dataset as possible. In local authorities A and C the questionnaire was administered online, which involved placing an HTML version of the questionnaire on the local authorities' intranets and sending an e-mail to building occupants inviting them to participate in the survey. Local authority B was unable to administer the questionnaire online. A paper version of the questionnaire was therefore distributed instead, together with a letter of explanation and an envelope for returning the questionnaire. Occupants were given two weeks in which to complete the questionnaire. The results of the occupant survey are presented in Section 4.3.

Table 3.11: Research population for occupant survey

Local authority	Number of buildings	Number of occupants
A	16	1839
B	5	821
C	22	2512
Total	43	5172

3.6 Conclusion

The purpose of this chapter was to establish a method for measuring obsolescence from an occupier perspective and establish a framework for explaining the differential impact of obsolescence, that is to say why some buildings exhibit higher or lower levels of performance than others. This was achieved by developing a theoretical framework incorporating the three aspects of building performance described in Chapter 2, namely: physical performance; utility; and financial performance. The principal conclusions arising from this chapter concern the epistemological assumptions on which this theoretical framework is founded, the selection of indicators of building performance and the techniques used to collect empirical data.

Empirical studies into building performance measurement have traditionally been rooted in the positivist epistemology, with its focus on the application of the scientific method and causal explanation based on a closed-system ontology. However, whilst these principles are compatible with measuring the physical performance of buildings, it is questionable as to whether it is valid to adopt the same approach towards the measurement of utility and financial performance, both of which are essentially social phenomenon operating in open-systems. This study therefore adopts a critical realist stance, which presupposes that the social world is made up of open-systems in which individuals respond differently in similar situations and on different occasions. A key assumption underpinning this study is that the interrelationships between the different aspects of building performance can be modelled based on occasional, but less than universal, linkages that exist between the occupiers, property, workplaces and people. The implications of the critical realist stance for the findings of this study are discussed in Chapter 7.

In seeking to model obsolescence from an occupier perspective it was necessary to make a series of simplifying assumptions by constructing a theoretical framework and focusing attention on particular variables and their interrelationships. One such assumption was that occupancy costs could be used as an indicator of a building's financial performance. This was justified by the fact that alternative indicators of financial performance, such as contribution to business profitability, were considered to be difficult to measure empirically. The indicators selected for inclusion in the theoretical framework were building characteristics, occupant characteristics and occupier characteristics, as explanatory variables, and workplace utility and property occupancy costs, as outcome variables. The hypothesised relationships between these groups of explanatory and outcome variables are explored in Chapters 4, 5 and 6 through the statistical analysis of empirical data.

Empirical data used in this study were collected using a cross-sectional research design, thereby reflecting the approach used in previous studies of property depreciation and obsolescence (Chapter 2). The research design was based on the premise that obsolescence can be determined by comparing the physical performance, financial performance and utility of a group of similar buildings. Empirical data were collected from a sample of local authority office buildings, selected on the basis of availability and ease of access to data. Despite the limitations of availability sampling, particularly in terms of producing representative samples, it was deemed to be the most suitable method because it took into consideration the capability of participating occupier organisations to provide the required property data. This was critical since many occupier organisations are still found wanting when it comes to collecting property occupancy cost data, whilst missing data can serve to undermine the validity and reliability of any statistical models. The treatment of missing data is discussed in Chapter 4.

By using office buildings as units of observation and analysis, the results of this study can be discussed in the context of previous studies of property depreciation, the majority of which focused on the office sector, as well as the wider body of literature on office workplace evaluation. This chapter has revealed, through exhaustive focus group research and subsequent statistical analysis, that while the utility of office buildings spans a multitude of different attributes, significant correlations between groups of these attributes means that workplace utility can be evaluated along four dimensions and 22 attributes. Moreover, the four dimensions appear to be theoretically meaningful, in that the importance of many of the 22 attributes has been confirmed in previous office workplace evaluation studies. The next chapter (Chapter 4) describes the performance of the sample of local authority office buildings along each of these dimensions, using data from the occupant survey. It also presents the results of the occupancy cost and building surveys.

References

Aronoff, S. and Kaplan, A. (1995) *Total workplace performance*, WDL Publications, Ottawa, Canada.

ASTM (2000) *ASTM standards on whole building functionality and serviceability*, Second Edition, International Centre for Facilities, Ottawa, Canada.

Audit Commission (2000) *Hot property: getting the best from local authority assets*, Audit Commission, London.

Avis, M., Braham, R., Crosby, N., French, N., Gane, D., Gibson, V.A., Temple, M., and Whitman, A. (1993) *Property management performance monitoring*, GTI and Oxford Brookes University, Oxford.

Babbie, E. (1998) *The Practice of Social Research*, Eighth Edition, Wadsworth, London.

Bache, I.W. (2003) *Critical realism and econometrics*, Working paper 4/2003, Central Bank of Norway, Oslo.

Baird, G., Gray, J., Isaacs, N., Kernohan, D. and McIndoe, G. (1996) *Building evaluation techniques*, McGraw-Hill, London.

Barras, R. and Clark, P. (1996) Obsolescence and performance in the Central London office market, *Journal of Property Valuation and Investment*, **14** (4) 63-78.

Baum, A. (1991) *Property investment depreciation and obsolescence,* Routledge, London.

Becker, F. (1990) *The total workplace: facilities management and the elastic organization*, Van Nostrand Reinhold, New York.

Bhaskar, R. (1978) *A realist theory of science*, Longman.

BMI (1998) *Standard form: Property occupancy cost analysis*, The Royal Institution of Chartered Surveyors, London.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999) Appraising the functional performance characteristics of office buildings, *Journal of Property Research*, **16** (4), 339-358.

Bradley, W.J. and Schaefer, K.C. (1998) *The Uses and Misuses of Data and Models*, Sage Publications, London.

Brill, M., Weidemann and the BOSTI Associates (2001) *Disproving widespread myths about workplace design*, Kimball International, Jasper.

Cairns, G. (2003) Seeking a facilities management philosophy for the changing workplace, *Facilities*, **21**, (5/6), 95-105.

CFM (1992) *Facilities Costs and Trends Survey 1992*, Centre for Facilities Management, University of Strathclyde.

Chilton, J.J. and Baldry, D. (1997) The effects of integrated workplaces strategies on commercial office space, *Facilities*, **15** (7/8), 187-194.

Churchill, G.A. (1979) A paradigm for developing better marketing constructs, *Journal of Marketing Research*, 16, February, 64-73.

Churchill, G.A. (1999) *Marketing research: methodological foundations*, Seventh Edition, Dryden Press.

Clift, M.R. and Butler, A. (1995) *The performance and costs-in-use of buildings: a new approach*, Building Research Establishment, Watford.

Coakes, S.J. and Steed, L.G (2001) *SPSS without anguish*, John Wiley and Sons, Chichester.

Construction Industry Council (2002) *Design Quality Indicator*, Construction Industry Council, London.

de Vaus, D.A. (1996) *Surveys in social research*, Fourth Edition, UCL Press, London.

Downward, P., Finch, J.H. and Ramsay, J. (2002) Critical realism, empirical methods and inference: a critical discussion, *Cambridge Journal of Economics*, **26**, 481-500.

Duffy, F., Laing, A. and Crisp, V. (eds) (1993) *The responsible workplace*, Butterworth, Oxford.

Ford, N.M., Walker, O.C. and Churchill, G.A. (1975) Expectations specific measures of the intersender conflict and role ambiguity experienced by industrial salesmen, *Journal of Business Research*, 3 (April), 95-112.

Gann, D.M. and Barlow, J. (1996) Flexibility in building use: the technical feasibility of converting redundant offices into flats, *Construction Management and Economics*, **14**, 55-66.

Gray, J. and Tippett, H. (1992) *Office space: a primer for managers*, Centre for Building Performance Research, Victoria University of Wellington, New Zealand.

Gray, J. and Tippett, H. (1993) *Building quality assessment: a prerequisite to economic analysis*, Center for Building Performance Research, Victoria University of Wellington, New Zealand.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C (1995) *Multivariate data analysis with readings*, Fourth Edition, Prentice Hall, London.

Hakim, C. (1987) *Research design: strategies and choices in the design of social research*, Allen & Unwin, London.

Haynes, B., Matzdorf, F., Nunnington, N., Ogunmakin, C., Pinder, J. and Price, I. (2000) *Does property benefit occupiers? An evaluation of the literature*, Report No. 1, http://www.occupier.org.

Howe, D. (1993) *Free on-line dictionary of computing*, http://www.foldoc.org.

Hoxley, M. (2000) Measuring UK construction professional service quality: the what, how, when and who, *International Journal of Quality and Reliability Management*, **17** (4/5), 511-526.

Johnson, P. and Duberley, J. (2000) *Understanding management research: An introduction to epistemology*, Sage Publications, London.

Kavanagh, D. (2000) *British politics: continuities and change*, Fourth Edition, Oxford University Press, Oxford.

Khalid, G. (1992) *Hedonic price estimation of the financial impact of obsolescence on commercial office buildings*, PhD, University of Reading.

Kumar, R. (1999) *Research methodology: A step-by-step guide for beginners*, Sage Publications, London.

Kupritz, V.W. (1998) Privacy in the workplace: The Impact of building design, *Journal of Environmental Psychology*, **18**, 341-356.

Lawson, T. (1997) *Economics and reality*, Routledge, London.

Leaman, A. and Bordass, W. (2000) Productivity in buildings: the 'killer' variables, *In Clements-Croome, D. (ed), Creating the productive workplace*, E & FN Spon, London.

Loo, R. (2002) A caveat on using single-item versus multiple-item scales, *Journal of Managerial Psychology*, **17** (1), 68-75.

Maki, D.P. and Thompson, M. (1973) *Mathematical models and applications*, Prentice-Hall.

Marshall, C. and Rossman, G.B. (1999) *Designing qualitative research*, Third Edition, Sage Publications, London.

Marshall, G. (ed) (1998) *A Dictionary of Sociology*, Oxford University Press, University Press, Oxford Press. Accessed 16 November 2003, http://www.oxfordreference.com/

Mayhew, S. (ed) (1997) *A Dictionary of Geography*, Oxford University Press, University Press, Oxford Press. Accessed 16 November 2003, http://www.oxfordreference.com/

McLennan, P. (2000) Intellectual capital: future competitive advantage for facility management, *Facilities*, **18** (3/4), 168-171.

McNeill, P. (1990) *Research Methods*, Second Edition, Routledge, London.

Morgan, D.L. (1997) *Focus Groups as Qualitative Research*, Second Edition, Sage Publications, London.

Morgan, D.L. (1998) *The Focus Group Kit*, Sage Publications, London.

Municipal Year Book (2001) *Municipal year book and public services directory*, Hemming Information Services, London.

Nassar-McMillan, S.C. and Borders, L.D. (1992) Use of focus groups in survey item development, *The Qualitative Report*, **7** (1), http://www.nova.edu/ssss/QR

Nathan, M. (2002) *The state of the office*, The Industrial Society, London.

Nelson, S.L. and Nelson, T.R. (1995) RESERV: an instrument for measuring real estate brokerage quality, *The Journal of Real Estate Research*, **10** (1), 99-114.

Nutt, B. (2000) Four competing futures for facility management, *Facilities*, **18** (3/4), 124-132.

Nutt, B. (1999) Linking FM practice and research, *Facilities*, **17** (1/2), 11-17.

Nutt, B. (1997) Adapting and re-using buildings, *International Journal of Facilities Management*, **1** (3), 113-121.

Nutt, B., Walker, B., Holliday, S., and Sears, D. (1976) *Obsolescence in housing: theory and applications*, Saxon House, Farnborough.

OPD (1999) *OPD total occupancy cost code,* IPD Occupiers Property Databank, London.

Oshagbemi, T. (1999) Overall job satisfaction: How good are single versus multiple-item measures? *Journal of Managerial Psychology*, **14** (5), 388-403.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1988) SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality, *Journal of Retailing*, **64** (1), 12-40.

Pearsall, J. (ed) (2001) *Concise Oxford English Dictionary*, Tenth Edition, Oxford University Press, Oxford.

Price, I. (2002a) Can FM evolve? If not, what future? *Journal of Facilities Management*, **1** (1), 55-69.

Price, I. (2002b) The history of facility and facilities management, *In Best, R., Di Valence, G. and Langston, C. (ed) Building in value: Workplace strategies and facility management*, Butterworth-Heinemann, Sydney.

Punch, K.F. (1998) *Introduction to social research*, Sage Publications, London.

RIBA (1976) CI/SfB construction indexing manual, RIBA Publication, London.

RICS (1997) *Stock condition surveys: A guidance note*, RICS Business Services, London.

RICS (2001) *Code of Measuring Practice: A Guide for Surveyors and Valuers*, Fifth Edition, RICS Books, London.

Robson, C. (1993) *Real World Research*, Blackwell, Oxford.

Salway, F. (1986) *Depreciation of commercial property*, Centre for Advanced Land Use Studies, The The College of Estate Management, Reading.

Simpson, J.A. (1997) *Property inspection: An appraiser's guide*, Appraisal Institute, Chicago.

Sundstrom, E., Town, J.P., Rice, R.W., Osborn, D.P. and Brill, M. (1994) Office noise, satisfaction and performance, *Environment and Behavior*, **26** (2), 195-222.

Then, D.S. (1995) Computer-aided building condition survey, *Facilities*, **13** (7), 23-27.

Tomlinson, J., Lewis, J. and Kaka, A. (1996) Premises occupancy cost analysis – current practice and developments towards a universal taxonomy, *In proceedings of the RICS COBRA Conference*, Royal Institution of Chartered Surveyors, London.

Tynan, A.C. and Drayton, J.L. (1986) *Conducting focus groups: a guide for first-time users*, Working Paper No. 86/20, Department of Business Studies, University of Edinburgh.

Vogt, W.P. (1999) *Dictionary of statistics & methodology*, Sage Publications, London.

Williams, A.M. (1985) *Obsolescence and re-use: a study of multi-storey industrial buildings*, School of Land and Building Studies, Leicester Polytechnic.

Williams, B. (2003) *Facilities economics in the UK*, Building Economics Bureau Ltd, Bromley.

Chapter 4 Survey results

4.1 Introduction

Following on from previous empirical studies (Chapter 2), the overall aim of this study was to establish a framework for modelling obsolescence from an occupier perspective. A theoretical framework for achieving this was established in Chapter 3. In order to be able to model the hypothesised relationships in the theoretical framework, it was necessary to collect empirical data for a sample of buildings. The data collection comprised three separate, but interrelated surveys (Chapter 3). The first was a walk-through survey of a sample of local authority office buildings to collect information about their physical characteristics. This was followed by a questionnaire survey of facility managers to ascertain the occupancy costs of each building and occupancy characteristics. Finally, a questionnaire survey of the buildings' occupants was used to elicit information about the occupants' working practices, as well as their perceptions and expectations of their workplace. This chapter (Figure 4.1) presents the results of each survey, a prerequisite to further bivariate and multivariate analysis in Chapters 5 and 6, respectively.

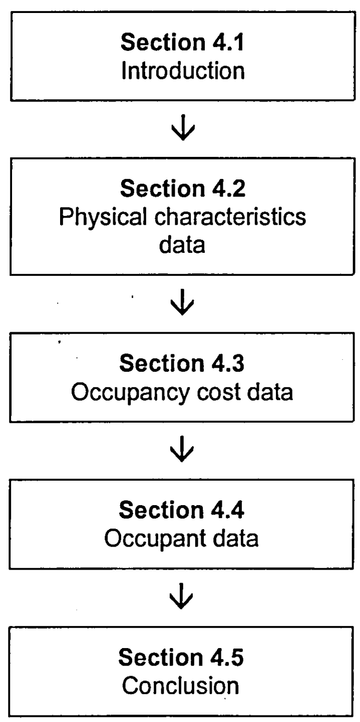


Figure 4.1: Structure of Chapter 4

The next section in this chapter (Section 4.2) presents data from the buildings survey. It provides a profile of the sample buildings, focusing in particular on their size, construction and condition. Section 4.3 examines the data from the occupancy cost survey and the occupancy characteristics of the sample buildings. The fourth section of this chapter (Section 4.4) presents data from the occupant survey. It provides a profile of the occupants, their perceptions and expectations of their workplace, and the utility of the sample buildings. A summary of the statistical tests used in this chapter are included in Appendix J.

4.2 Physical characteristics data

The purpose of the buildings survey was to collect data on the location, physical characteristics and condition of the sample buildings (Chapter 3). These characteristics are employed as explanatory variables in Chapters 5 and 6, in that they are used to explain variations in the occupancy costs and utility of the sample buildings. Additional physical characteristics data were collected in the occupancy cost survey (Chapter 3). The sample comprised 64 office buildings from five local authorities (Table 3.3). The highest number of buildings (22) was from local authority C, comprising more than a third (34%) of the sample, and the lowest numbers (5) were from local authorities B and E, together comprising only 16% of the sample. A profile of the sample buildings is presented below.

4.2.1 Site and location characteristics

The sample office buildings were mainly located in town centres and urban areas, close to public amenities. All but one of the 64 buildings were located within 200 metres of public car parking (Figure 4.2). More than 60% of buildings were within 200 metres of a bus stop, shops and park or open space. However, 12% of buildings were sited more than 1000 metres from shops and 44% more than 1000 metres from a train station. This reflects the fact that these were predominantly buildings from local authorities A and C, the county and metropolitan borough councils, and were therefore more likely to be geographically dispersed. Only 6% of the sample buildings were located within 200 metres of a train station.

More than half of buildings (70%) lacked any form of soft landscaping or had only minimal provision, although 55% of these were sited within 200 metres of a public park or open space (Figure 4.2). The other 30% of buildings had either a moderate amount of landscaping (19%) or extensive grounds (11%). A majority (52%) of buildings had a site and surroundings that were clean and tidy, with paved areas and exterior furniture in good condition and no litter or graffiti. More than a third (36%) of sites were very clean and tidy, with paved areas and exterior furniture in as-new condition. None of the sites were very dirty and untidy, although 13% had paved areas and exterior furniture that were in poor condition, with some litter or graffiti. These were predominantly town centre sites.

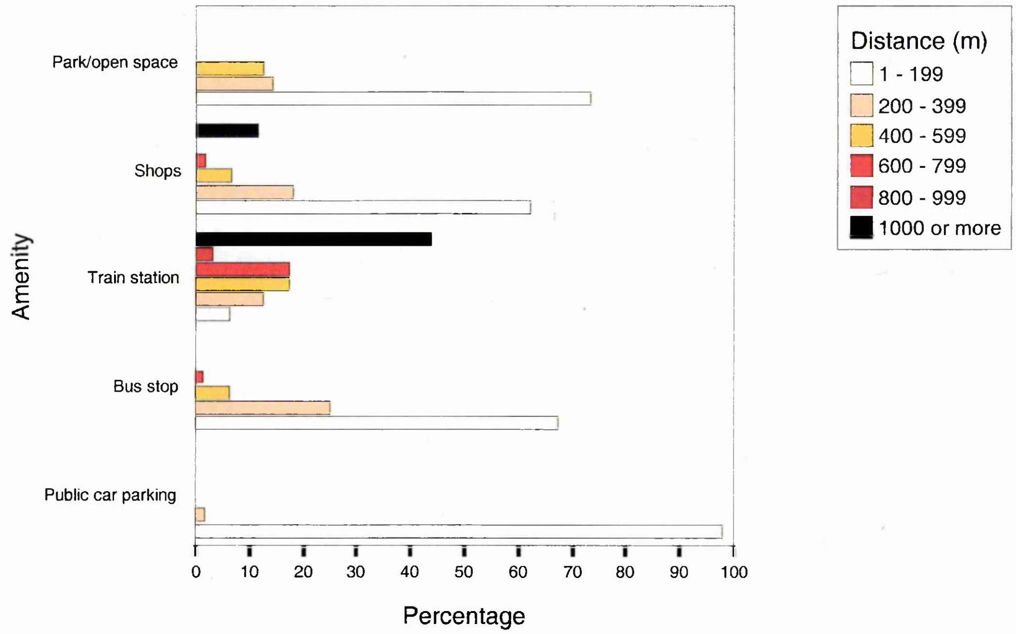


Figure 4.2: Distance to public amenities

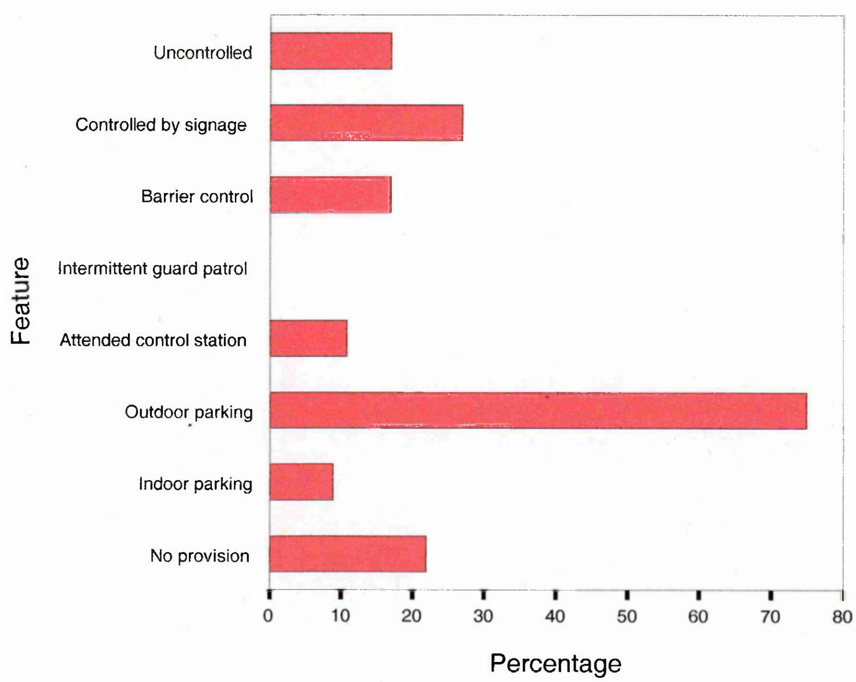


Figure 4.3: Car parking facilities

One fifth of buildings had no on-site car parking provision (Figure 4.3), although a high proportion of these buildings were located within 200 metres of public car parking (80%) or a bus stop (55%). Nearly half (46%) of buildings had between 1-20 car parking spaces and only 10% had more than 50 car parking spaces. Of the 50 buildings that had on-site car parking, the majority (75%) had outdoor car parking provision and only 9% had indoor car parking. A small proportion of buildings had either an attendant (11%) or automatic barrier (17%) to control car parking.

4.2.2 Construction characteristics

The majority of office buildings in the sample were constructed either before 1900 (34%) or between 1900 and 1939 (28%). Only four of the buildings were constructed in the 1980s and none were constructed in the last decade. This may reflect the traditional under-investment in local authority capital stock (Clark *et al.*, 2002), but also the fact that local authorities tend to have historical public buildings in their property portfolios, such as Victorian town halls (Audit Commission, 2000). Even so, the age profile of the sample buildings was found to be consistent with the UK's office building stock as a whole, boosting confidence in the validity of the sample data. Data published by the Office of the Deputy Prime Minister (ODPM, 2002) reveal that 60% of office space in the UK was constructed before 1939, with 39% having been constructed before 1900.

There were two main forms of construction in the sample. More than half (53%) of the buildings were constructed from loadbearing walls and a further 44% used steel or concrete frame. The remaining buildings were timber framed. A high proportion (59%) of buildings had shallow depth floorplates, with an average distance of 4-5 metres between perimeter and circulation space, and a quarter of the buildings had medium depth floorplates (6-10 metres between perimeter and circulation space). The remaining buildings had either a deep plan (11-19 metres between perimeter and circulation) (1), atrium (2) or central courtyard (11%).

Collectively the sample buildings represented 158,700m^2 of floor space[33] (Table 4.1). The highest proportion of floor space was from local authority C, comprising almost half (47%) of the sample, and the smallest proportion was from local authority E, forming just 5% of the sample. These proportions reflected the number of buildings covered by the survey at each local authority. The size of the local authorities' office portfolios also varied considerably (Table 4.1). The largest portfolio belonged to local authority C (86,600m^2) and the smallest

[33] Floor space data were unavailable for 11 of the buildings. The treatment of missing data from the occupancy cost survey is discussed in Section 4.3.

to local authorities B and E (12,600m^2 and 12,400m^2, respectively). A high proportion of each portfolio was represented in the sample, with values ranging from 69% to 100%.

Table 4.1: Number and net internal area of buildings, by local authority

Local authority	Frequency	NIA$^{(a)}$ (m^2)	Mean NIA$^{(a)}$ (m^2)	Percentage sample	NIA$^{(a)}$ portfolio (m^2)	Percentage portfolio
A	13	24,600	1892	16	24,600	100
B	5	10,500	2100	7	12,600	83
C	21	75,000	3571	47	86,600	87
D	10	40,000	4000	25	39,900	100
E	4	8,600	2150	5	12,400	69
Total	53	158,700	2994	100	176,100	

[a] Net internal area

There was considerable variation in the size of the sample buildings, with floor areas ranging from 239m^2 to 14,700m^2. A majority of buildings had floor areas in the 1-5000m^2 range (83%). The mean net internal area[34] (NIA) of the sample buildings was 2994m^2, although this figure varied by local authority (Table 4.1). For instance, the mean NIA of buildings from local authority D was 4000m^2, where as for local authority A this figure was much lower at 1892 m^2. Floor plate efficiency, taken as the ratio of NIA to gross internal area (GIA), also varied across the sample from 47% to 92%. The majority of buildings for which data were available had efficient floor plate ratios of 80% of more (Figure 4.4), the mean value being 81%.

As was expected, there was a moderate positive correlation between the NIA of the sample buildings and the travel distances between workspaces and circulation routes (Spearman rho, $p < 0.05$). This indicated that as the NIA of a building increased, so did travel distances. Half of the buildings had travel distances of between 1-20 metres, with the average distance in the sample being 25 metres and the longest 70 metres. The average number of direction changes between workspaces and circulation routes was three and the most was eight. Only 6% of buildings in the sample were single storey, with the majority (84%) having between two and four floors. The remaining 10% of buildings had between five and 13 floors.

A large proportion (58%) of buildings had masonry exterior walls and a further 29% had either stone or stone and masonry walls. Other exterior wall types found in the sample included timber cladding (5%), curtain wall systems (2%) or composite cladding panels

[34] Refer to occupancy costs survey instrument in Appendix D for a glossary of terms used in this chapter.

(6%). The condition of exterior walls was generally good (Figure 4.5). More than half (52%) of the buildings had exterior walls that were in impeccable or fairly new condition, free from marks stains or defects. A third of the sample were functional in appearance, with minor defects or marks or stains in places. Only 13% of buildings had exterior walls that were damaged or badly worn.

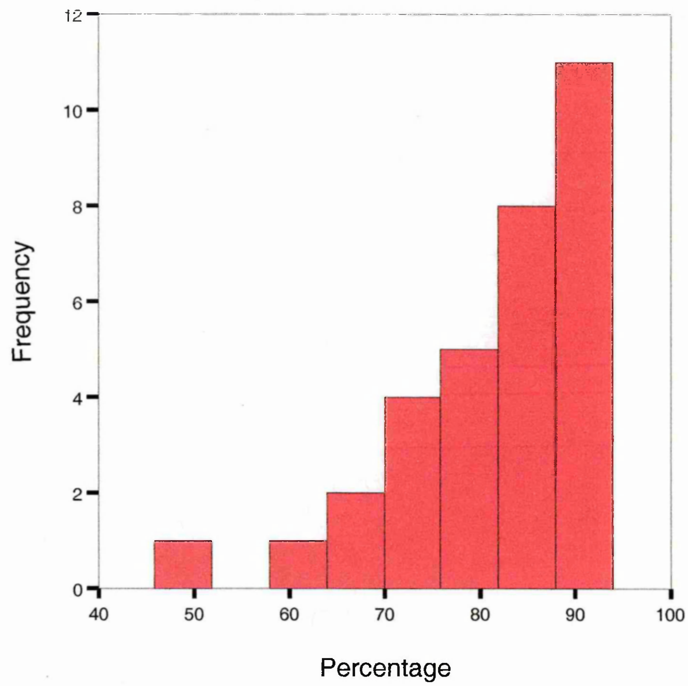


Figure 4.4: Floor plate efficiency

The majority of buildings in the sample had either timber (52%) or aluminium window frames (39%). The remaining buildings had either PVCu (3%) or cast iron window frames (6%). Only 28% of buildings had double glazing. The condition of exterior windows frames was generally poor (Figure 4.5). Less than a third of buildings had windows frames that were in impeccable or fairly new condition, with a further 28% being functional in appearance. The remaining 42% of buildings had window frames that were damaged or extensively worn, with a considerable number of defects and marks. However, there were highly significant differences between the condition of the four types of window frame (Kruskal-Wallis, $p < 0.01$). The values of the mean rankings indicated that PVCu and aluminium window frames were in significantly better condition than timber or cast iron window frames, most probably because the former were newer replacements.

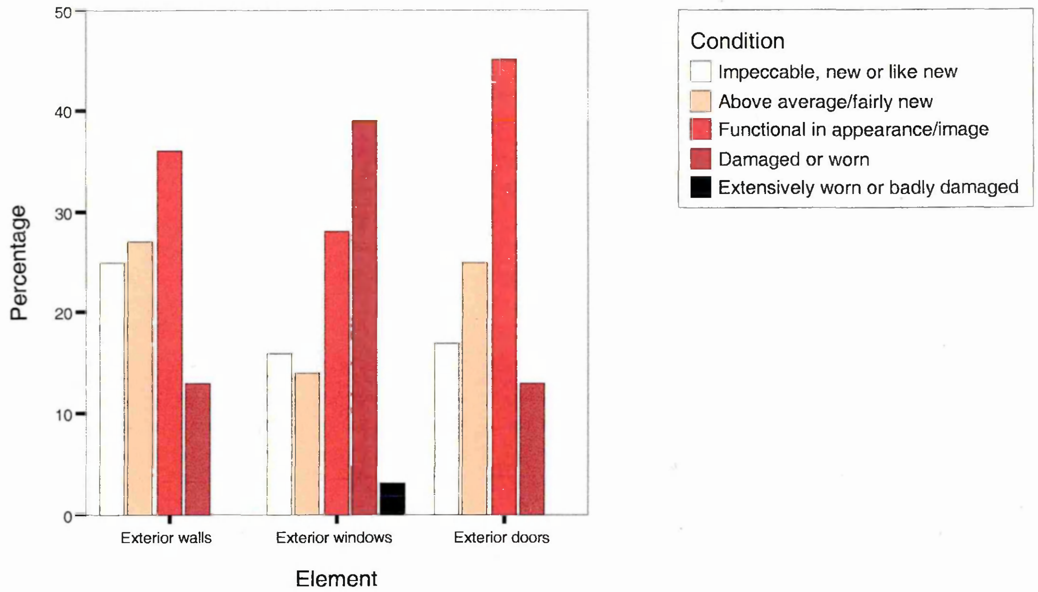


Figure 4.5: Condition of exterior elements

Exterior doors were predominantly timber (39%) or aluminium (24%). More than a third of buildings had exterior doors that were in impeccable or fairly new condition (42%), and 35% had exterior doors that were functional in appearance (Figure 4.5). Only 13% of buildings had exterior doors that were damaged or worn. A third of buildings had no draught exclusion provision at entrances. However, the majority of buildings had some form of draught exclusion, whether it be double doors (65%) or revolving doors (2%).

A third of buildings had stone, masonry or concrete walls separating interior areas and circulation routes. A further 33% of buildings had stone, masonry or concrete walls, together with lightweight demountable or stud partitions. The remaining 34% had either lightweight demountable partitions, stud partitions or a combination of both. The majority (87%) of buildings had wall surfaces that were plastered and finished, with the remainder being exposed masonry, stone or concrete (3%) or covered with decorative paper (10%). Wall finishes in common areas were generally in good condition (Figure 4.6). More than half of buildings (55%) had wall finishes that looked new or fairly new, free from marks, stains or defects. Only 17% of buildings had wall finishes that were damaged or worn.

A high proportion (78%) of buildings had floors that were covered with carpet or carpet tiles. The remaining buildings had either granolithic, linoleum or parquet floor finishes in common areas. Floor finishes tended to be in poor condition, particularly in circulation routes where levels of traffic are likely to be higher (Figure 4.6). More than half (52%) of buildings had floor finishes that were functional in appearance, with some marks and stains, and 10% were found to be damaged or extensively worn. There were significant differences between the condition of the different floor coverings (Kruskal-Wallis, $p < 0.05$). The values of the mean rankings indicated that floors that were covered with carpet or linoleum were in significantly better condition than floors with granolithic or parquet finishes.

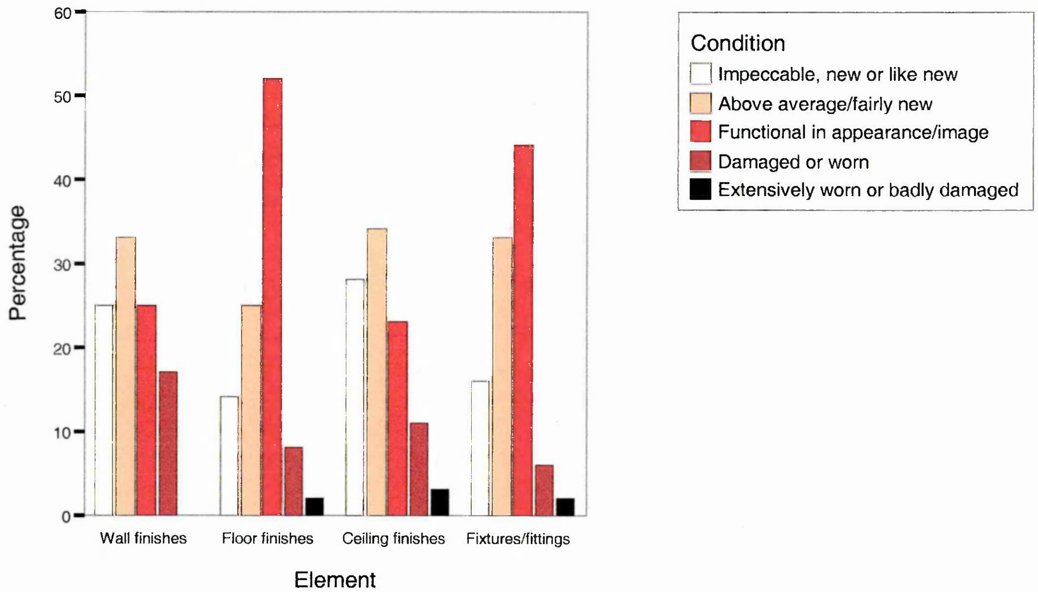


Figure 4.6: Condition of elements in common areas

Ceilings in common areas were predominantly plastered and finished (53%) or suspended plaster or PVC tiles (34%). The remaining 13% of buildings had ceilings covered with either metals tiles, mineral fibre tiles or decorative paper. Ceiling finishes were in good condition, the majority (62%) looking impeccable or fairly new, free from marks, stains or defects (Figure 4.6). Only 14% of buildings had ceiling finishes that were damaged or worn. Fixtures and fittings in common areas were also in good condition (Figure 4.6). Almost half (49%) of buildings had fixtures and fittings that looked new or fairly new, and a similar proportion were functional in appearance (44%). Less than 10% of buildings had fixtures and fittings that were damaged or extensively worn.

4.2.3 Building services and common amenities

The majority (86%) of buildings had a wet heating system, typically low pressure central heating (Figure 4.7). Of these, 80% were ventilated via openable windows. The remainder were ventilated using either mechanical systems or split air-conditioning units, comprising compressors and ceiling-mounted cassettes. A small proportion of buildings had either a dry heating system (9%), such as electric convector heaters, or a full, centralised air-conditioning system with humidity control (3%). In most buildings heating control was localised, at medium (40–150 m^2) or small (<40 m^2) spaces (86%), using wall stats and thermostatic radiator valves. Heating control in the remaining buildings was either centralised (13%) or on a floor-by-floor basis (2%).

In those buildings with natural ventilation, the level of control was dependent on the type and number of openable windows. In 17% of buildings window units were either non-openable (sealed or locked) or ventilation was heavily restricted due to the use of secondary glazing. A further 23% of buildings had less than 50% openable windows. However, the majority (60%) of buildings had between 50% and 100% openable windows, some of which were fully adjustable. In buildings with mechanical ventilation, control was either localised using wall-mounted controllers or on a floor-by-floor basis.

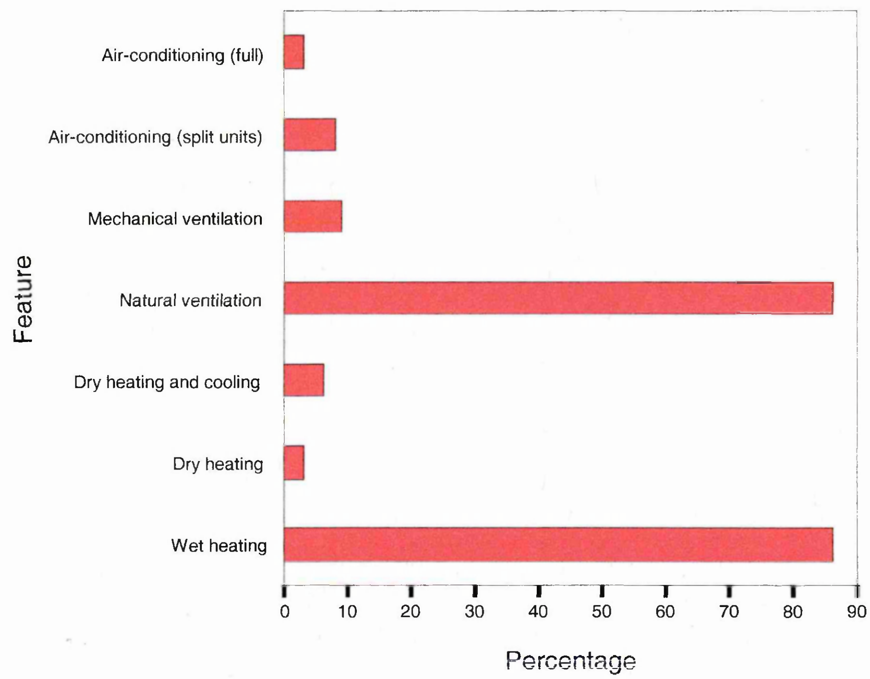


Figure 4.7: Building services provision

The majority of buildings had some form of access control, whether it be a combination or key lock (49%), swipe card system (29%) or intercom (22%). Visual access control was provided via closed-circuit television (CCTV) (15%) or security guards (55%). Almost three-quarters of buildings had a reception desk (72%). In terms of wheelchair access (Figure

4.8), more than two-thirds (69%) of buildings had an entrance wider than 810mm, the minimum width required by wheelchair users (Rostron and Fordham, 1996). A similar proportion had either level access at ground level (37%), a purpose-built access ramp suitable for use by wheelchair users (42%) or special lift facilities (8%). More than a quarter of buildings had manually opening and closing entrance doors, and a further 45% of buildings had manually opening doors with automatic closers. The remaining buildings had fully automatic doors, with either hands free (26%) or signal operation (3%).

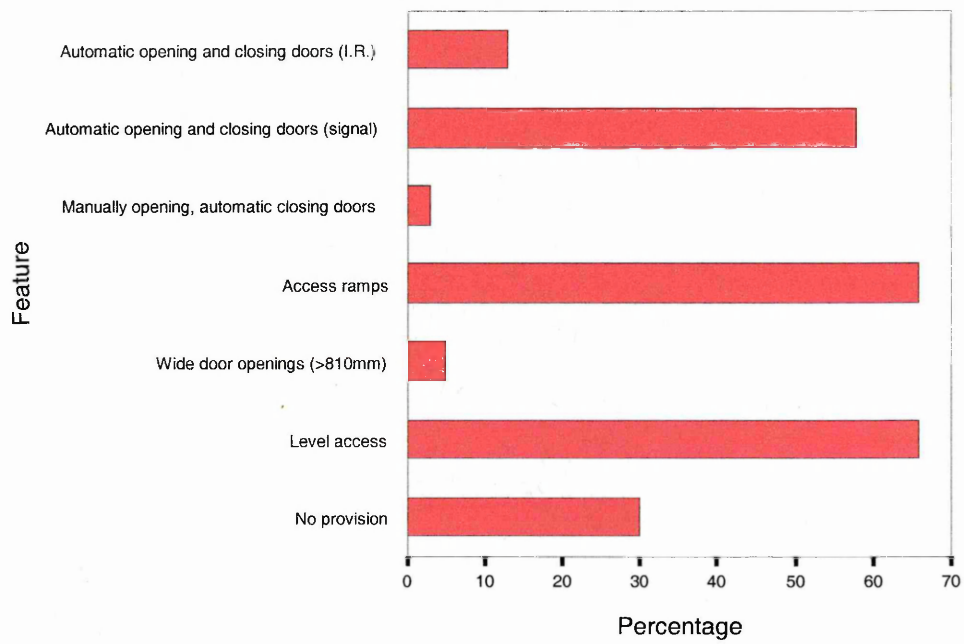


Figure 4.8: Disabled access provisions

Almost a third (30%) of buildings lacked provisions to facilitate movement of wheelchair users around interior spaces and in only 44% of buildings were all interior spaces accessible to wheelchair users (Figure 4.9). A moderate positive correlation between accessibility and NIA suggests that the larger buildings were less accessible to wheelchair users (Spearman rho, $p < 0.05$). Only a small proportion (5%) of buildings had wide door openings suitable for wheelchair users. More than two thirds of buildings had doors that opened and closed automatically, either by signal control, such as a button (58%), or infra-red (13%). A similar proportion had level access throughout or access ramps to facilitate movement between levels. None of the buildings had special lift provisions for wheelchair users, although 48% were found to have standard lift facilities. Three-quarters of the buildings had disabled toilet facilities (74%).

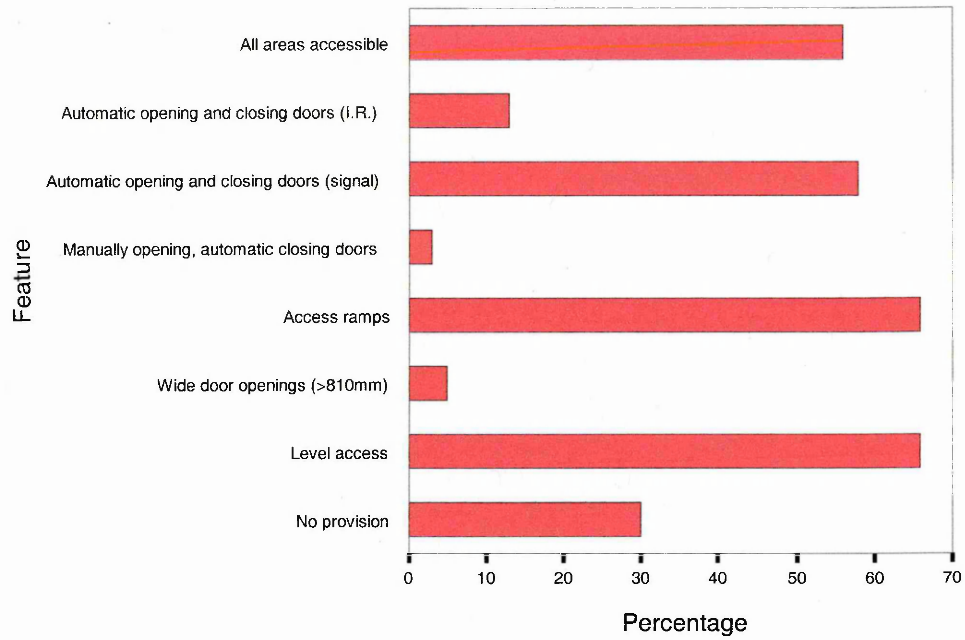


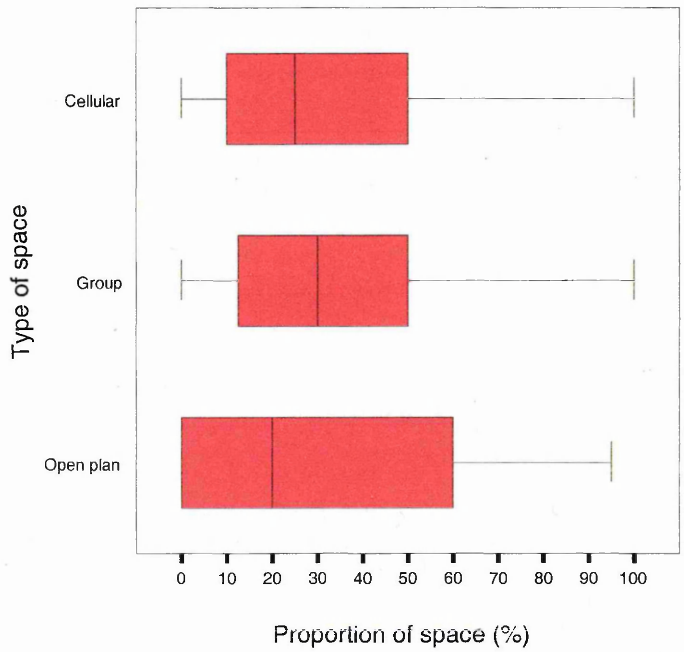
Figure 4.9: Disabled circulation provisions

None of the buildings had crèche or gym facilities, although 11% had shower or changing facilities. A third of buildings had multiple kitchens and staff rooms. The same proportion of buildings had smaller multiple kitchenette facilities. Vending machines were provided in 17% of buildings and a further 13% had some form of staff restaurant or cafeteria. Only 9% of buildings lacked any catering facilities. The quality of finishes and fittings employed in these facilities varied considerably. A small proportion (8%) of buildings were found to have basic non-resistant finishes and fittings, with 42% having floor tiles or similar purpose finishes. The same proportion of buildings had floor and wall tiles, with either partial (22%) or complete coverage (20%). A small percentage (8%) of buildings had complete tiling cover together with integrated furniture and fittings.

The majority (77%) of buildings lacked any form of informal seating facilities away from work areas. Only 14% of buildings had a staff lounge or break-out area. An even smaller proportion of buildings had informal seating in common areas (9%) or outdoor seating facilities (3%). This was surprising, in view of the fact that space for relaxation has been rated as the second most important workplace characteristic, after private workspace (Nathan, 2002). The workspace characteristics of the sample buildings are examined below.

4.2.4 Workspace characteristics

The type of workspace in each building was characterised as either cellular (1-3 workstations), group (4-12 workstations) or open plan (13 or more workstations). The mean proportion of each type across the sample of buildings was 31%, 35% and 34%, respectively (Figure 4.10).



Statistics	Type of space		
	Open plan	Group	Cellular
Mean	31	35	34
Median	20	30	25
Std. Deviation	35	28	28
Minimum	0	0	0
Maximum	95	100	100
Lower quartile	0	11	10
Upper quartile	60	50	50

Figure 4.10: Relative proportions of open plan, group and cellular workspace

There was, however, considerable variation between individual buildings. Nearly half (47%) of the buildings had no open plan space and a third had more than 50% open plan space. None of the buildings had 100% open plan space. A high proportion of the sample buildings had less than 50% group space, with only 2% having 100% group space. Only a small proportion (2%) of buildings had no cellular space, with most (72%) having between 10% and 50% cellular space (Figure 4.10). There were also significant differences between the proportion of open plan space across the five local authorities (Kruskal-Wallis, $p < 0.05$). The values of the mean rankings indicated that buildings from local authorities B, D and E had a significantly higher proportion of open plan space than local authorities A and C.

There was a moderate positive correlation between building age and proportion of open plan space and a moderate negative correlation between building age and proportion of cellular space (Spearman's rho, $p < 0.05$). This suggests that newer buildings had more open plan space and less cellular space. There were also significant differences between the proportions of each type of space for different types and arrangements of building structure (Kruskal-Wallis, $p < 0.05$). The proportion of open plan space was significantly higher in buildings with either framed or shallow depth construction. Conversely, the proportion of group and cellular space was significantly higher in buildings with loadbearing walls or shallow depth construction. This was to be expected given that buildings with framed construction and deeper floor plates can more easily accommodate the large, unobstructed, work areas that characterise open plan space.

Inevitably, open plan workspace was found to provide greater levels of flexibility and accessibility. There were significant differences between the method of internal sub-division in open plan areas (Kruskal-Wallis, $p < 0.05$). The values of the mean rankings indicated that buildings with more open plan space were more likely to be sub-divided by easily demountable lightweight partitions or stud and sheet systems, rather than stone, masonry or concrete walls. A moderate positive correlation between wheelchair access and the proportion of open plan space suggests that accessibility increased significantly the higher the proportion of open plan space (Spearman's rho, $p < 0.05$). This may be explained by the fact that the majority (69%) of open plan space was free from screens and partitions, with the remainder being divided by either moveable low-level partitions (8%) or moveable and reusable lightweight screens (23%).

There were moderate positive correlations between the provision of wet heating and natural ventilation and the proportion of cellular space (Spearman's rho, $p < 0.05$). The converse was found for open plan workspace. This indicates that buildings with larger proportions of cellular space and smaller proportions of open plan workspace were more likely to be naturally ventilated and employ wet heating systems. Moreover, a positive correlation between the level of heating control and cellular space suggests that control over heating was significantly higher in cellular workspace (Spearman's rho, $p < 0.05$).

In the majority (75%) of buildings, workspace areas had plastered and finished wall surfaces, the remainder being decorative paper (23%) or timber cladding (2%). Wall finishes were in good condition (Figure 4.11). More than half of buildings (61%) had wall finishes that looked new or fairly new, free from marks, stains or defects. Only 13% of buildings had wall finishes that were damaged or worn. Workspace areas in all buildings were covered with carpet or carpet tiles. Floor finishes were also in good condition (Figure 4.11). More than two-thirds (68%) of buildings had floor finishes that were impeccable or fairly new. No buildings had floor finishes that were damaged or worn.

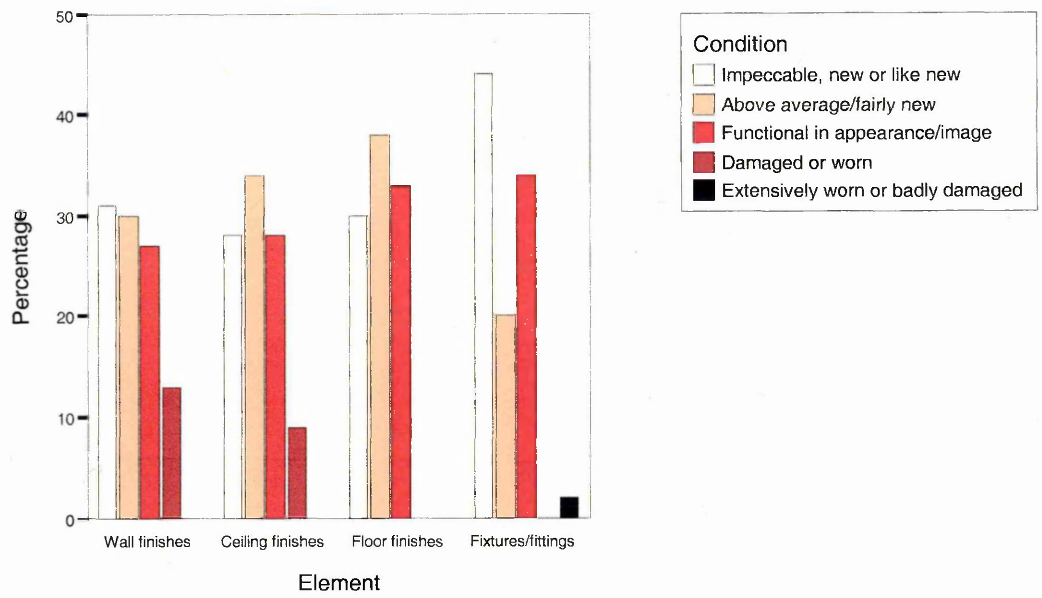


Figure 4.11: Condition of elements in workspace areas

Ceilings in workspace areas were predominantly plastered and finished (91%). The remaining 13% of buildings had ceilings covered with either plaster or PVC tiles, metals tiles, mineral fibre tiles or decorative paper. Ceiling finishes were in reasonable condition, the majority (62%) looking impeccable or fairly new, free from marks, stains or defects (Figure 4.11). Only 9% of buildings had ceiling finishes that were damaged or worn. Fixtures and fittings in workspace areas were in very good condition (Figure 4.11). Almost two-thirds (64%) of buildings had fixtures and fittings that looked new or fairly new, and more than a third were functional in appearance (34%). Only 2% of buildings had fixtures and fittings that were damaged or extensively worn. There were, however, significant differences between the condition of fixtures and fittings in workspace areas across the five local authorities (Kruskal-Wallis, $p < 0.05$). The values of the mean rankings indicated that fixtures and fittings in local authorities B and C were in significantly better condition than those in local authority A.

4.2.5 Summary

This section has examined physical characteristics data from a sample of 64 local authority buildings. The data cover 67 different physical characteristics, relating to aspects such as building location, construction type and physical condition. The data were used to develop a profile of the sample buildings. The next section examines occupancy data from the sample buildings.

4.3 Occupancy cost data

The purpose of the occupancy cost survey was to collect data on the occupancy costs and occupancy characteristics of the sample buildings (Chapter 3). Occupancy costs are employed as outcome variables and occupancy characteristics as explanatory variables in Chapters 5 and 6. The survey covered a sample of 53 buildings from five local authorities (Table 4.1). However, preliminary data analysis revealed a high number of missing values across the data matrix. This was to be expected given the difficulties associated with the collection and analysis of such data, as discussed in Chapter 3.

In order to overcome the problem of missing values and maintain data quality, variables with less than 50% (27) valid cases were excluded from the analysis. This approach had the advantage of avoiding cases being lost from the analysis whilst leading to the elimination of unreliable variables (de Vaus, 1996). Of the 86 variables included in the occupancy cost survey, 53 were excluded from the analysis. These primarily related to building operation costs (12 variables), business support and management costs (10 variables) and occupancy characteristics (13 variables). A list of the variables excluded from the analysis is included in Appendix I and data for the 33 remaining variables are analysed below.

4.3.1 Occupancy characteristics

A majority of the sample buildings were occupied on a freehold basis (35) and only 12 were leased. Although this is consistent with the figures reported by the Audit Commission (2000) for local authorities, the level of freehold ownership is very high in comparison to the private sector and central government (Audit Commission, 2000; Bootle and Kaylan, 2002; Bonn *et al.*, 2003). This is significant because leasehold property occupation has tended to be associated with lower occupancy costs per occupant (Bootle and Kaylan, 2002), a finding reflected in this study (See section 4.3.2 below). None of the buildings for which data were available had been procured using the Private Finance Initiative (PFI) or were leased from a serviced office provider.

Most of the sample buildings were described as either back or satellite offices (21), the remainder being frontline (5) or head offices (8). Some form of internal rent mechanism was employed in 48 of the buildings, with charges being made on the basis of either area occupied (35) or overhead contribution (12). Other occupancy costs, for instance for car parking, were charged out to space users in 39 buildings. The use of internal charging reflects the growth in popularity of this approach in property and facilities management over the last decade (Bonn *et al.*, 2003).

The number of full-time equivalent (FTE) staff accommodated in the buildings varied between 9 and 613, the average number being 159 (Figure 4.12). Most buildings accommodated less than 100 FTE staff (28) and only three buildings accommodated in excess of 500. The occupant densities[35] of the sample buildings are shown in Figure 4.13. Only 10 of the sample buildings had occupant densities in line with the current UK good practice of 12-17m^2 per person (BCO, 2000; Gerald Eve, 2000; Bootle and Kaylan, 2002). The same number of buildings had occupant densities of less than 11m^2 per person (10). However, the highest number of buildings had occupant densities in excess of 18m^2 per person (28).

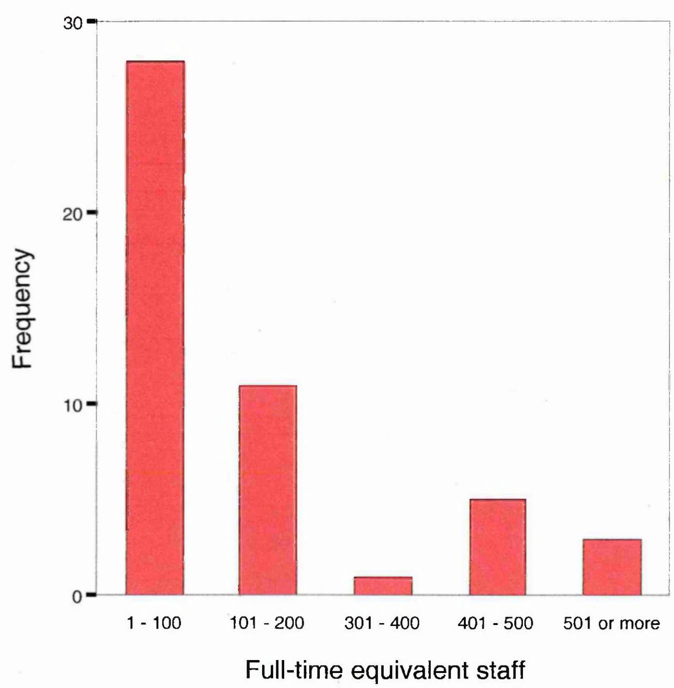


Figure 4.12: Occupancy levels

There were significant differences in occupant densities across the five local authorities (Kruskal-Wallis, $p < 0.01$). The values of the mean rankings indicated that occupant densities of buildings at local authorities C and D were significantly lower than those at local authority E. A moderate negative correlation between occupant density and open plan space suggests that the greater the proportion of open plan space the higher the occupant density. Conversely, a moderate positive correlation between occupant density and cellular space suggests that the greater the proportion of cellular space the lower the occupant density.

[35] Occupant density is the ratio of NIA to FTE staff (BCO, 2000).

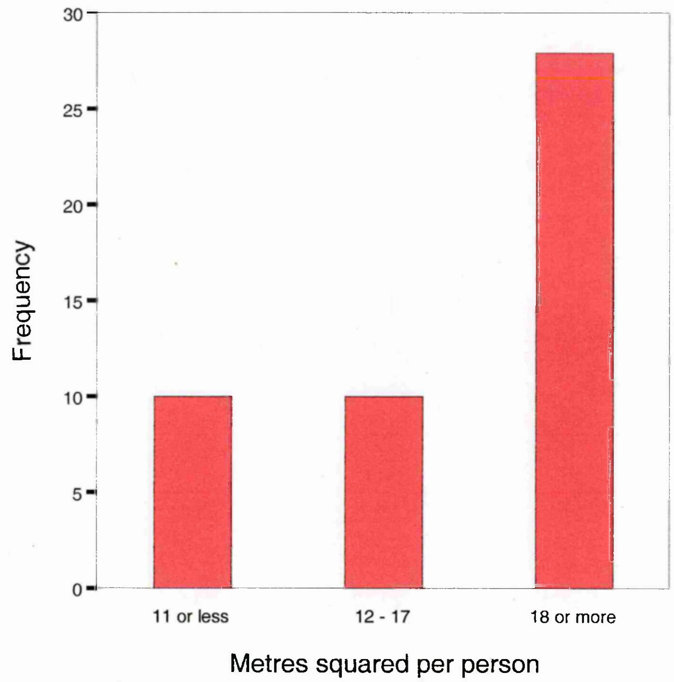


Figure 4.13: Occupant density

4.3.2 Occupancy costs

Constraints arising from missing values meant that the analysis of data from the occupancy cost survey focused solely on the operation costs of the sample buildings. Building operation costs relate to expenditure on minor improvements, cleaning, maintenance security and utilities. Table 4.2 suggests that the operation costs of the sample buildings varied considerably between £4137 and £319,205 per annum. On average, the highest costs were for cleaning (£27,925 p.a), electricity (£15,172 p.a) and security (£13,764 p.a). Aside from expenditure on heating oil, the lowest cost items were grounds maintenance (£1052 p.a) and building insurance (£2786 p.a).

The cost efficiency of the sample buildings is shown in Figure 4.14 and Figure 4.15. The cost per m^2 of NIA is a reliable measure of the efficiency of providing usable floor space (BCO, 2000). Figure 4.14 suggests that the cost efficiency of the sample buildings ranged between £3/m^2 and £53/m^2, the average value being £17/m^2. The majority of buildings had values between £10/m^2 and £40/m^2. There were, however, significant differences in building cost efficiency across the five local authorities (Kruskal-Wallis, $p < 0.01$). The values of the mean rankings indicated that building operation costs per floor area were significantly higher for local authorities B and E than for local authority C.

Table 4.2: Building operation costs

Item	Frequency	Cost (£ per annum)		
		Minimum	Maximum	Mean
Insurance	40	0	17,783	2,786
Minor improvements	35	0	6,6351	9,045
Cleaning	47	0	116,971	27,925
Security	30	0	112,350	13,764
Waste disposal	43	0	66,643	3,599
Grounds maintenance	34	0	12,577	1,052
Water and sewerage	47	0	18,160	2,489
Electricity	47	0	74,150	15,172
Gas	44	0	20,000	4,178
Oil	29	0	3,280	273
Total operation costs	47	4,137	319,205	70,853

Operation cost per FTE staff was also used as a measure of the efficiency of usable floor space in the sample buildings (Figure 4.15). The majority of buildings had operation costs per occupant of between £147 and £910 per person, the mean value being £481 per person. Only a small number of buildings had very high operation costs per occupant in excess of £1000 per FTE staff (2) or very low costs below £100 per FTE staff (1). Analysis of occupancy type revealed significant differences in building cost efficiency between freehold and leasehold properties (Mann-Whitney, $p < 0.05$). The values of the mean rankings indicated that building operation costs per occupant area were significantly higher for freehold properties, thereby reflecting the findings of previous research (Bootle and Kaylan, 2002).

4.3.3 Summary

This section has examined occupancy cost and occupancy characteristics data from the sample of 53 local authority office buildings. Problems arising from missing values resulted in 53 of the original 86 variables being excluded from the analysis on the grounds of poor reliability. This section has therefore focused on providing a profile of the occupancy characteristics and operation costs of the sample buildings. The next section examines data from the occupant survey.

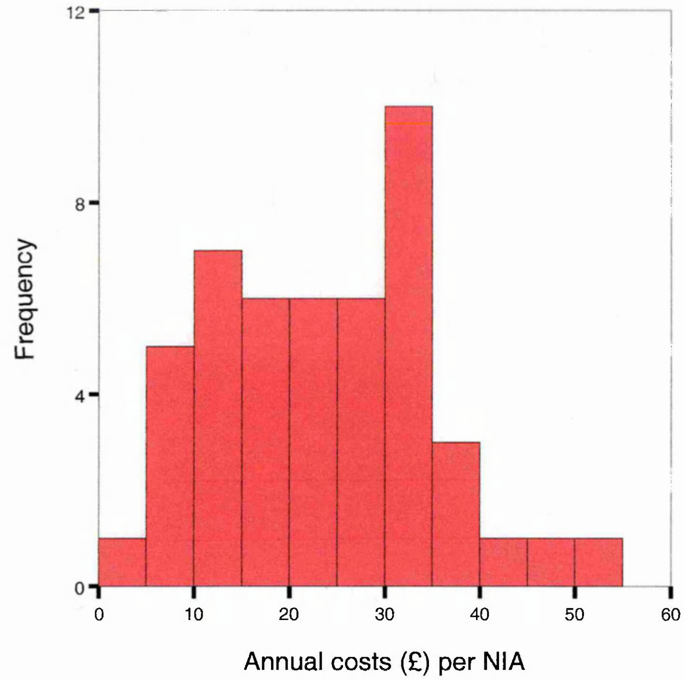


Figure 4.14: Building operation costs per floor area

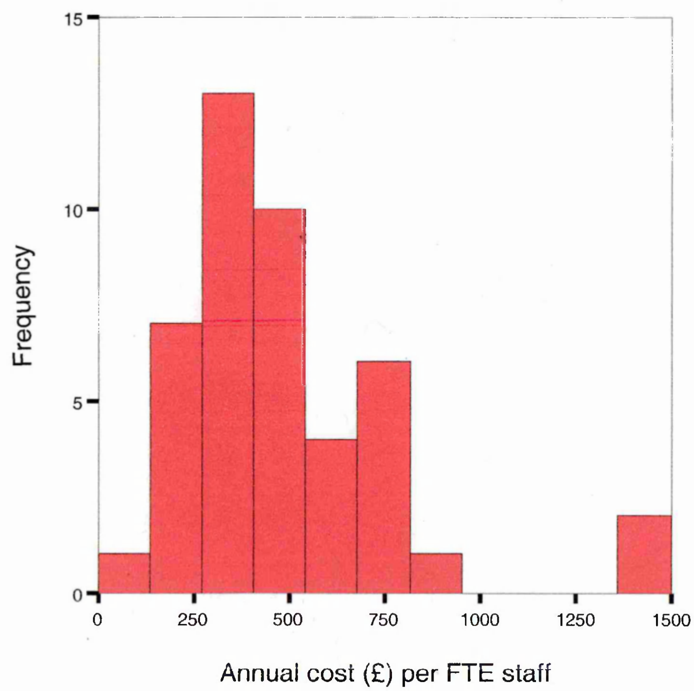


Figure 4.15: Building operation costs per occupant

4.4 Occupant data

The purpose of the occupant survey was to collect data on occupants' perceptions and expectations of the sample buildings, as well as data about their demographics and working practices (Chapter 3). Three of the five local authorities participated in the occupant survey. The questionnaire was sent to over 5000 recipients in 43 office buildings. A total of 940 recipients completed the questionnaire, an 18% response rate. Whilst an 18% response rate could be regarded as low, it is in line with other questionnaire surveys (Kumar, 1999).

Table 4.3 provides a breakdown of the number of responses from each local authority. The highest number of responses (424) was from local authority B, comprising almost half (45%) of the sample. Local authority C yielded the lowest number of responses (206), constituting less than a quarter (22%) of the sample. These differences were reflected in the estimated response rates for the two local authorities. Estimated response rates were calculated by dividing the number of responses by the number of full-time equivalent staff, with the quotient expressed as a percentage (Table 4.3). Local authority B had the highest estimated response rate (52%) and local authority C the lowest (8%).

Table 4.3: Number of responses per local authority

Local authority	Frequency	Percentage	Full time equivalent staff[a]	Estimated response rate (%)
A	310	33	1839	17
B	424	45	821	52
C	206	22	2512	8
Total	940	100	5172	

[a] Figures taken from occupancy cost survey

There was also considerable variation in the number of responses from individual buildings (Table 4.4). Five buildings (C7, C14, C16 and C21) yielded no responses. A further eight buildings yielded just one response. The highest number of responses (258) was from building B3, comprising more than a quarter (27%) of the sample. Indeed, the responses from five buildings (B3, A2, A8, C2 and C11) comprise more than half (58%) of the sample. Estimated response rates also varied considerably, from the lowest of 1% (Building C6) to the highest of 71% (Building B4). Of the 940 responses, 35 were from buildings outside of the sample. Further analysis revealed that all 35 responses were from local authorities A and C, both of which used the online questionnaire. This implied that the respondents had received the email inadvertently; their responses were therefore excluded from the analysis.

Table 4.4: Number of responses per building

Building	Frequency	Percentage	Full time equivalent staff[a]	Estimated response rate (%)
A11	1	0	35	3
A12	1	0	-	-
A14	2	0	-	-
A16	2	0	-	-
A5	3	0	-	-
A10	3	0	61	5
A15	3	0	-	-
A3	5	1	57	9
A7	6	1	74	8
A6	7	1	72	10
A4	10	1	71	14
A9	17	2	-	-
A13	17	2	142	12
A1	28	3	126	22
A8	80	9	397	20
A2	104	11	524	20
B5	15	2	49	31
B4	30	3	42	71
B1	34	4	60	57
B2	87	9	178	49
B3	258	27	492	52
C1	1	0	11	9
C6	1	0	100	1
C17	1	0	-	-
C18	1	0	60	2
C19	1	0	50	2
C20	1	0	20	5
C5	2	0	50	4
C9	4	0	134	3
C12	4	0	16	25
C15	4	0	10	40
C22	4	0	34	12
C4	9	1	100	9
C10	10	1	25	40
C8	11	1	93	12
C13	12	1	450	3
C3	26	3	450	6
C2	50	5	500	10
C11	50	5	172	29
Other	35	4	-	-
Total	940	100	4655	-

[a] Figures taken from occupancy cost survey

4.4.1 Occupant demographics

The survey revealed that the majority (63%) of occupants were female. The largest proportion of occupants (58%) were in the 31-40 and 41-50 age groups, and only a small proportion (5%) were aged under 20 or over 60 years of age (Table 4.5). Administrative, professional, technical and clerical (APT&C) staff comprised the highest proportion (55%) of occupants, with senior officers and management staff comprising 18% and 24% of the sample, respectively. As was expected, only a small number of responses (26) were from senior management (Table 4.6).

Table 4.5: Age of occupants

Years	Frequency	Percentage
20 or under	30	3
21-30	180	20
31-40	263	29
41-50	259	29
51-60	157	17
Over 60	15	2
Total	904	100

There was a weak positive correlation between age and grade, indicating that occupants in older age groups tended to be at higher grades (Spearman's rho, $p < 0.01$). However, there were weak negative correlations between age and gender and gender and grade (Spearman's rho, $p < 0.01$). This suggests that females were more likely to be in lower age groups and at lower grades than males. The latter result is unsurprising, since it reflects the fact that women continue to be under-represented in managerial positions in the workplace (Savery, 1990). For instance, research by Dench *et al.* (2002) suggested that only 8% of employed females occupy managerial positions, compared with 18% of males.

Table 4.6: Occupant pay scales

Pay scale	Frequency	Percentage
APT&C 1-6	491	55
Senior Officer 1-2	159	18
Management 1-4	219	24
Senior Manager 1-4	26	3
Total	895	100

There were also significant differences between the relative proportions of each grade across the three local authorities (Kruskal-Wallis, $p < 0.01$). The values of the mean rankings indicates that a larger proportion of responses from local authorities A and B were from occupants at a higher grade than those from local authority C.

Figure 4.16 shows the length of time that occupants had worked for the same local authority, in the same office building and at the same desk position. The chart indicates that while a high proportion of occupants (39%) had worked for the same local authority for more than 10 years, only 14% of occupants had worked in the same office building for that length of time.

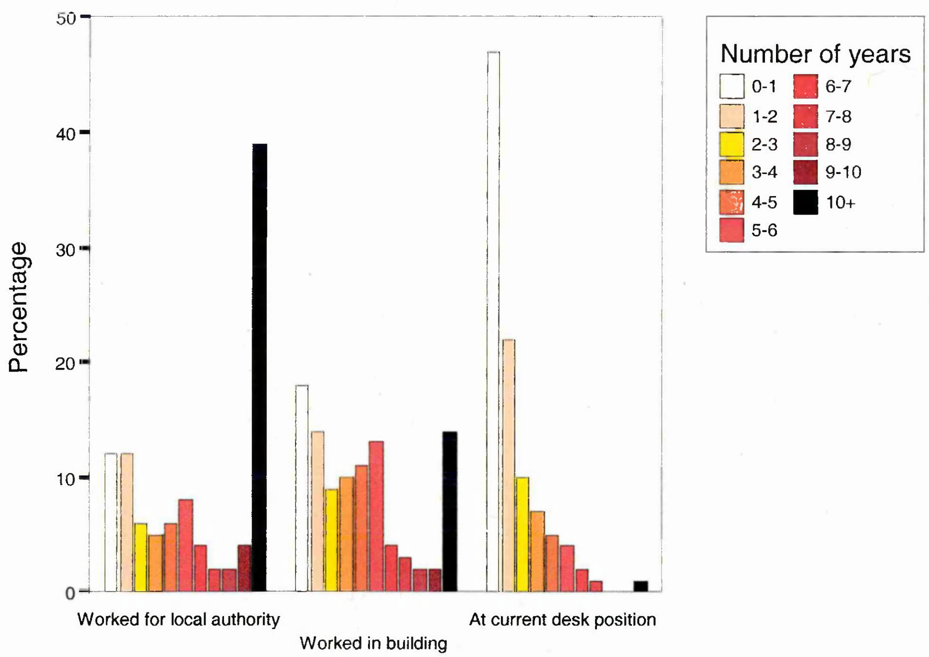


Figure 4.16: Background of occupants

More than half (51%) of occupants had worked in the same building for less than four years. The median length of time that occupants had worked in the same office building was 3-4 years. In contrast, the median length of time that occupants had occupied the same desk position was lower, at 1-2 years. Almost half (47%) of occupants had occupied the same desk for less than one year and more than three-quarters (79%) for three years or less, indicating a high rate of churn[36].

Inevitably, there was a strong positive correlation between the number of years that occupants had worked for the same local authority and the number of years they had worked in the same building (Spearman's, rho, $p < 0.01$). There were also moderate

[36] Churn is the 'percentage of an office's population that changes location in a year' (Brand, 1994; p.168).

positive correlations between the number years that occupants had worked for the same local authority or in the same building and the number of years that they had spent at their current desk position (Spearman's, rho, $p < 0.01$). Age and grade were also positively correlated with each of the three variables, indicating that occupants in older age groups and at higher grades had worked for a longer period of time at the same local authority, in the same office building and at the same desk position (Spearman's, rho, $p < 0.01$).

There were significant differences between the background of occupants across the three local authorities. The values of the mean rankings indicate that occupants at local authority C had worked for the organisation for a significantly longer period of time than those at local authorities A and B (Kruskal-Wallis, $p < 0.05$). Those at local authorities C had worked in the same office building and at the desk for a significantly number of years longer than those at local authorities A and B (Kruskal-Wallis, $p < 0.01$), suggesting that local authority C had experienced a lower rate of churn.

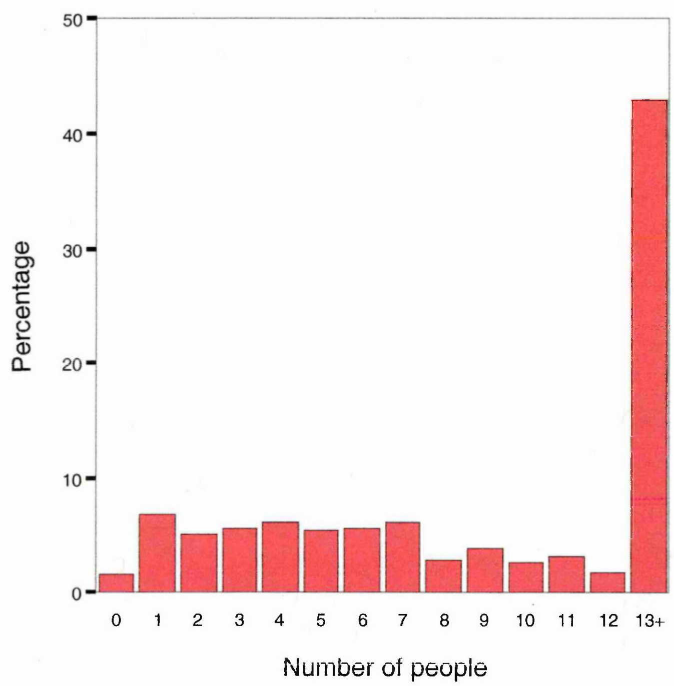


Figure 4.17: Average number of people occupants shared their workspace with

Figure 4.17 shows the average number of people that occupants shared their workspace with[37]. Only 2% of occupants worked alone. This figure is low compared with the results of

[37] Workspace is defined in this study as the space in which an occupant sits mostly when in the office (Brill *et al.*, 2001).

other office workplace surveys. For example, Olson's (2002) analysis of 13,000 US office workers revealed that 25% worked alone in private offices. In this study, however, nearly half (44%) of occupants shared a workspace with 13 or more people. The median number of people that occupants shared their workspace with was between seven and eight. There was a weak negative correlation between grade and the number of people that occupants shared their office with (Spearman's rho, $p < 0.01$), suggesting that the higher a persons grade, the fewer people they shared their office with. This is unsurprising, since the prevailing culture in many office-based organisations means that middle and senior managers tend to work separately from their colleagues at lower grades.

4.4.2 Occupant working practices

Occupants were asked a series of questions about their working practices, based on their activities the previous day. To validate their responses, occupants were asked whether the previous day had been a 'typical' working day. For the majority of occupants the previous day had been typical (84%). However, before occupant working practices could be subjected to further analysis it was necessary to test for significant differences between the working practices of occupants based on whether their previous working day had been 'typical' or not. Analysis of the two groups revealed significant differences on five variables (Mann-Whitney, $p < 0.05$). The values of the mean rankings indicated that occupants whose previous working day had not been typical had shared their office with more people, spent fewer hours in their office and at their desk, and less time doing repetitive and routine tasks (Table 4.7). The 16% of occupants who had indicated that their previous working day had not been typical were therefore excluded from the analysis on these five variables in order to ensure that their responses did not affect the validity of the results.

Table 4.7: Differences in working practices between typical and untypical days

Working practice	Mean rank	
	Typical	Untypical
No. people shared workspace with**	424	469
Hours in office*	468	357
Hours at desk*	462	389
Repetitive & routine tasks*	459	389
Work out of office*	415	500

* Mann-Whitney, $p < 0.01$
** Mann-Whitney, $p < 0.05$

Figure 4.18 shows the number of hours that occupants spent in their office and at their desk. The distribution of data for time spent in the office is negatively skewed, with a majority (55%) of occupants having spent more than seven hours a day in their office. Only a small proportion (20%) of occupants had spent less than five hours a day in their office. The median length of time that occupants spent in their office was 7-8 hours. This may reflect the high proportion of responses from administrative grades (Table 4.6). However, less than a quarter (24%) of occupants had spent more than seven hours at their desk. The majority of occupants (59%) had spent between four and seven hours at their desk, the median time being 5-6 hours. A small proportion (17%) of occupants had spent less than four hours at their desk.

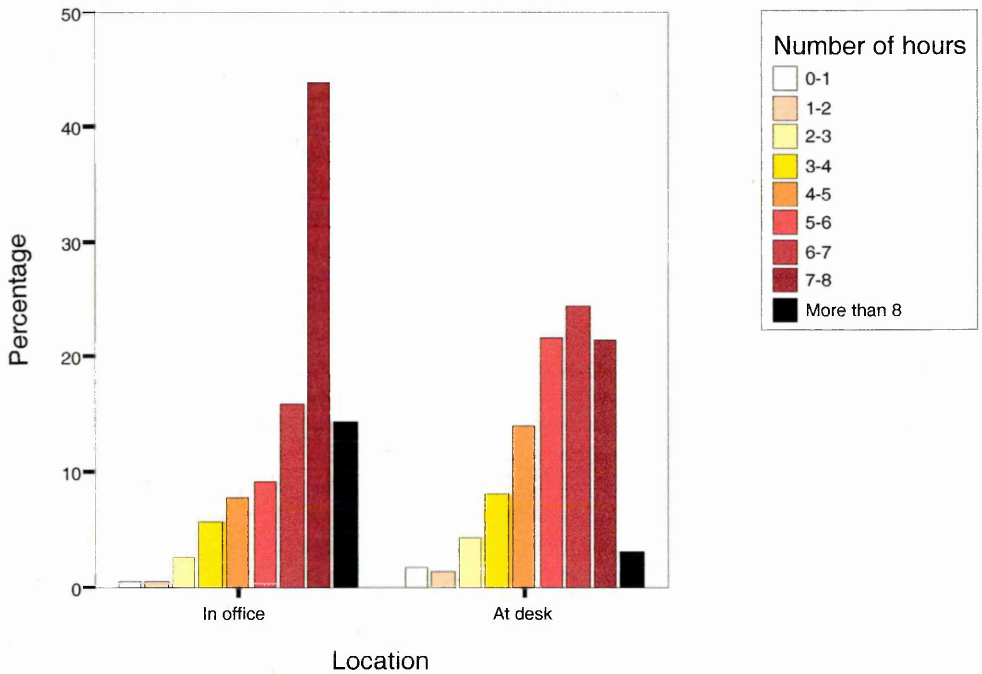
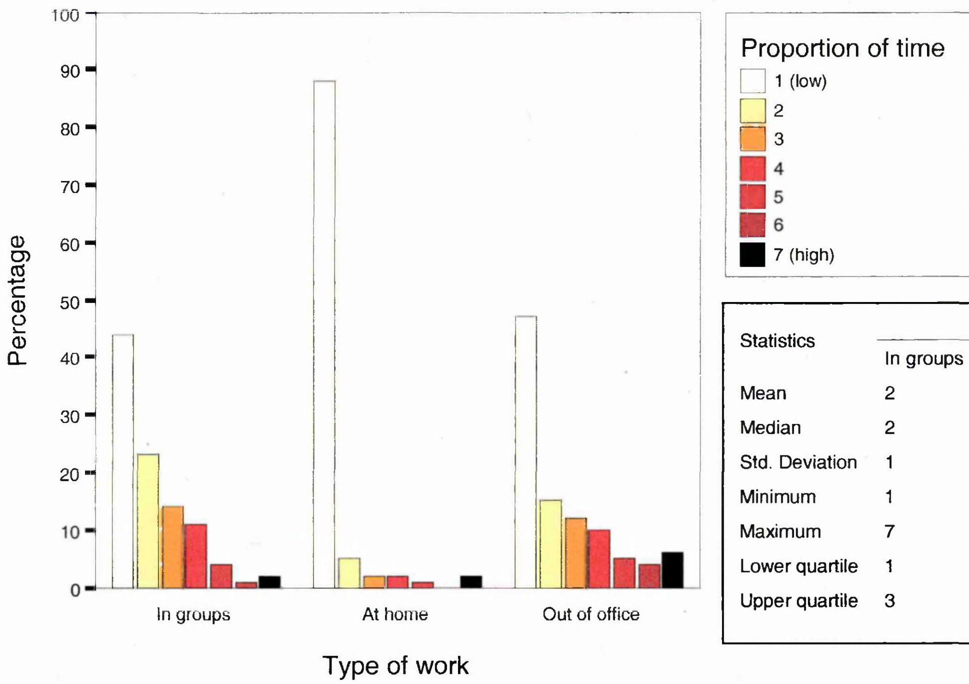


Figure 4.18: Location of occupants at work

There were weak negative correlations between gender and the time that occupants spent in the office and at their desk, suggesting that females spent significantly more time in the office and at their desk than males (Spearman's rho, $p < 0.05$). This was partly explained by the weak negative correlation between grade and the number of hours occupants spent at their desk, which indicates that more senior members of staff spent less time at their desks than those at lower grades (Spearman's rho, $p < 0.05$). The number of hours that occupants spent in the office and at their desk differed significantly across the three local authorities (Kruskal-Wallis, $p < 0.01$). The values of the mean rankings indicate that occupants from local authority B spent significantly less time in the office and at their desk than those from local authorities A and C.

Figure 4.19 shows the proportion of time that occupants spent working in groups, at home or out of the office. The chart suggests that a large percentage (63%) of occupants had spent a low proportion of their time working in groups. Only 3% of occupants had spent a high proportion of their time working in groups. This is reflected in Figure 4.20, which shows the average size of work groups. More than a quarter (27%) of occupants replied 'not applicable' to this question, indicative of the fact that they had not worked in groups.



Statistics	Type of work		
	In groups	At home	Out of office
Mean	2	1	2
Median	2	1	2
Std. Deviation	1	1	2
Minimum	1	1	1
Maximum	7	7	7
Lower quartile	1	1	1
Upper quartile	3	1	4

Figure 4.19: Occupant work activities

For those occupants that had worked in groups, the majority (69%) had operated in small groups of between 2 and 4 people. Only 7% of occupants had worked in larger groups of 10 or more people.

There was a weak positive correlation between grade and the proportion of time occupants spent in groups, suggesting that occupants at higher grades spent more time working in groups than those at lower grades (Spearman's rho, $p < 0.01$). This statistic may reflect the fact that managers tend to spend more time in meetings than their colleagues at administrative and technical grades. For instance, Olson's (2002) survey of office workers revealed that managers spend twice as much time in meetings than technical staff, and three times as much time as administrative staff. A weak positive correlation between grade and average group size suggests that the size of work groups increased as occupants' grade increased (Spearman's rho, $p < 0.01$). There were also significant differences in average group sizes across the three local authorities (Kruskal-Wallis, $p < 0.01$). The values of the mean rankings indicate that average work group sizes in local authority B were significantly larger than those in local authorities A and C.

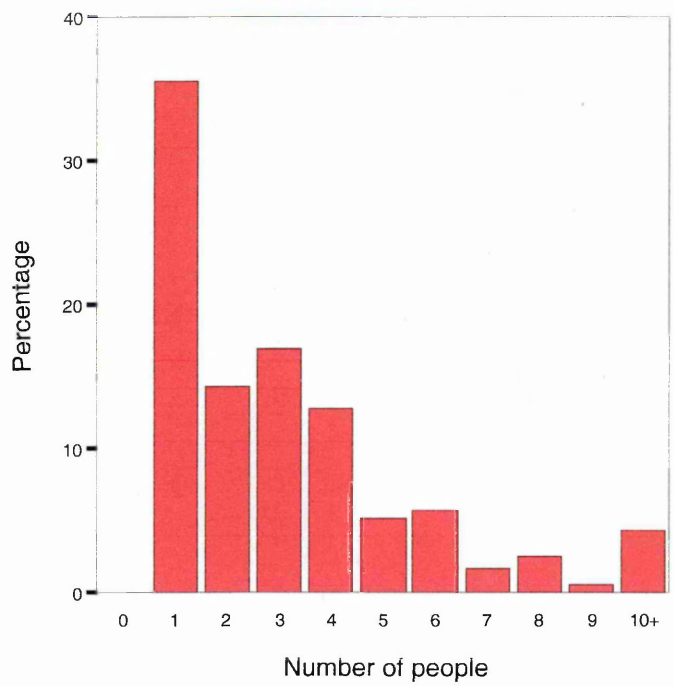
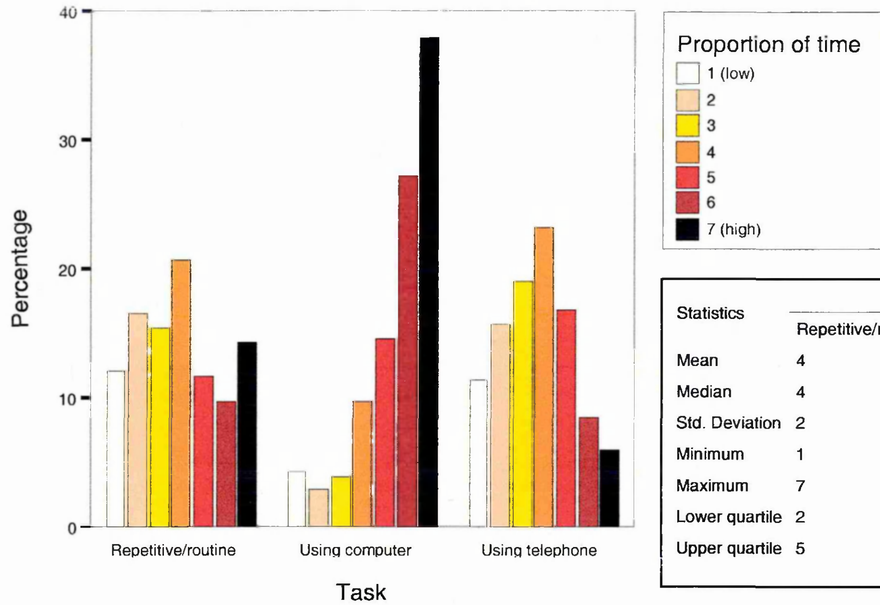


Figure 4.20: Average size of work groups

The majority (93%) of occupants had spent a low proportion of their time working from home (Figure 4.19). This is reflected in a mean score of one. Only a small percentage (2%) of occupants had spent a high proportion of their time working from home. This was not surprising, given that working from home is still not common practice in local government. Price's (2001) survey revealed that 53% of local authorities did not permit working from home and that in cases where it was allowed the number of employees involved was still relatively small. Figure 4.19 suggests that a small percentage (10%) of occupants had spent a large proportion of their time working out of the office. A mean score of three suggests that, on average, occupants spent most of their time in the office, thereby substantiating the results described earlier in Figure 4.18. There were weak positive correlations between an occupant's grade and the proportion of time they spent working at home or out of the office (Spearman's rho, $p < 0.01$), suggesting that occupants at a higher grade spent more time working at home or away from the office than those at lower grades.

Figure 4.21 shows the proportion of time that occupants spent conducting repetitive or routine tasks, working at a computer or using a telephone. The scores for repetitive and routine tasks have a fairly even distribution, with similar percentages of occupants having spent a low (30%) and high (23%) proportion of their time on this activity. A mean score of four suggests that, on average, occupants had spent a moderate amount of their time doing repetitive and routine tasks.



Statistics	Task		
	Repetitive/routine	Using computer	Using telephone
Mean	4	6	4
Median	4	6	4
Std. Deviation	2	2	2
Minimum	1	1	1
Maximum	7	7	7
Lower quartile	2	5	2
Upper quartile	5	7	5

Figure 4.21: Tasks carried out by occupants

The scores for using a telephone have a more normal, bell-shaped distribution, with an average score of four suggesting that occupants had spent a moderate amount of their time using a telephone (Figure 4.21). In contrast, a majority (65%) of respondents had spent a high proportion of their time using a computer. The mean score for this activity was six. This was unsurprising given that IT is an essential part of most office-based activities (Aronoff and Kaplan, 1995). It also reflects the findings of Olson's (2002) research, which suggested that, on average, office workers spend 59% of their time working at a computer.

There was a strong negative correlation between grade and repetitive and routine tasks, suggesting that occupants at a higher grade spent a significantly smaller proportion of their working day on repetitive and routine tasks (Spearman's rho, $p < 0.01$). Conversely, a weak positive correlation between gender grade and repetitive and routine tasks suggests that females spent more time doing repetitive and routine tasks than males (Spearman's rho, p

< 0.05). There were also weak negative correlations between age and grade and time spent working at a computer (Spearman's rho, $p < 0.01$), indicating that occupants in older age groups and at higher grades spent a smaller proportion of their working day using a computer. In contrast, weak positive correlations between gender and time spent using a telephone and working at a computer suggests that females spent a larger proportion of their working day on these tasks than males. This reflects the fact that females are more likely to be at administrative grades than males.

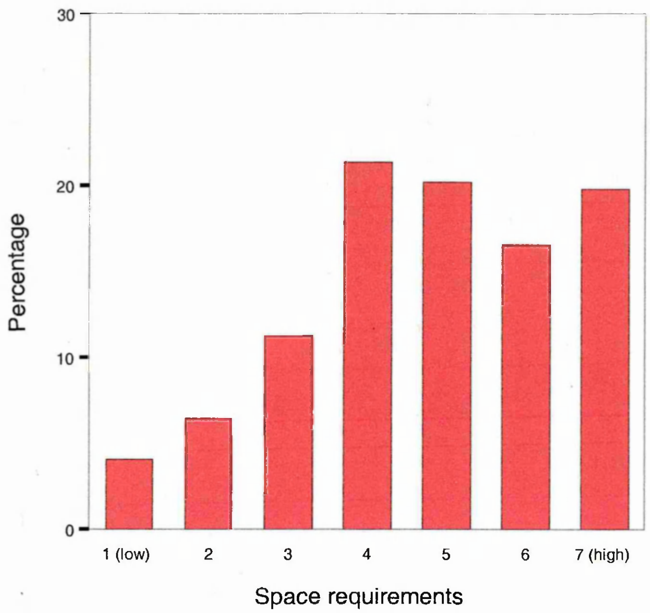
There were also significant differences between the tasks carried out by occupants across the three local authorities. The values of the mean rankings indicate that occupants at local authority A spent a significantly smaller proportion of their working day on repetitive and routine tasks than those at local authorities B and C (Kruskal-Wallis, $p < 0.05$). Instead, occupants at local authority A spent a larger proportion of their time working at a computer (Kruskal-Wallis, $p < 0.01$). Occupants at local authority B spent a larger proportion of their time using a telephone than those at local authorities A and C (Kruskal-Wallis, $p < 0.01$).

4.4.3 Attitudes to the workplace

Occupants were asked about their need for workspace, the importance of interacting with colleagues and their satisfaction with their job. Attitudes to each of these issues were measured on a seven-point scale, ranging from 'High' (7) to 'Low' (1), with no verbal labels for scale points 2 through 6.

Figure 4.22 shows the scores for occupants' perceived workspace requirements for paper, personal storage and filing. The chart indicates that more than a third (37%) of occupants had high perceived workspace requirements. However, a mean score of five suggests that, on average, occupants' had moderate perceived workspace requirements. There were weak positive correlations between workspace requirements and repetitive and routine tasks and telephone usage (Spearman's rho, $p < 0.05$), indicating that occupants that had spent a higher proportion of their time on these tasks had a greater perceived need for workspace.

There was also a weak positive correlation between perceived workspace requirements and time spent out of the office, suggesting that occupants that had spent a larger proportion of their working day away from the office also had a greater need for workspace (Spearman's rho, $p < 0.05$). This is counter-intuitive, in that occupants working out of the office for a greater proportion of their time would be expected to have less need for workspace. However, this statistic may reflect the fact those occupants working out of the office for a higher proportion of time are those at higher grades who may expect to have more workspace due to cultural factors. Significant differences also existed in workspace requirements across the three local authorities (Kruskal-Wallis, $p < 0.05$). The values of the mean rankings indicated that occupants at local authority B had significantly greater workspace requirements than those at local authorities A and C.

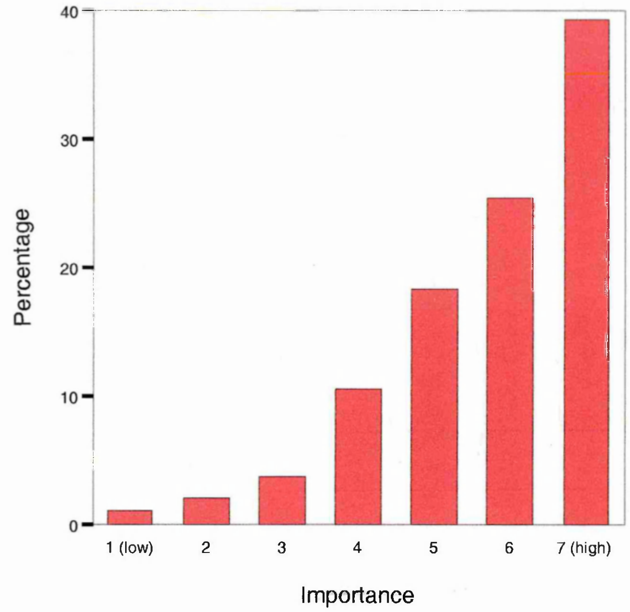


Statistics	
Mean	5
Median	5
Std. Deviation	2
Minimum	1
Maximum	7
Lower quartile	4
Upper quartile	6

Figure 4.22: Perceived workspace requirements

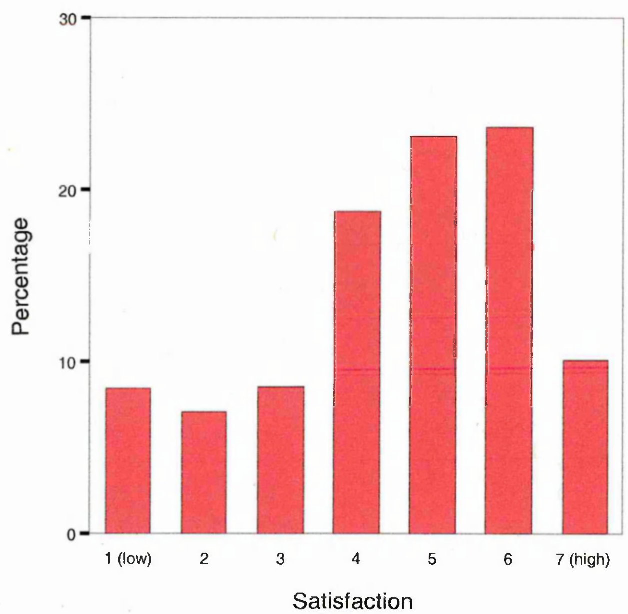
Nearly two-thirds (64%) of occupants placed a high level of importance on being able to interact with colleagues (Figure 4.23). Only 3% of occupants viewed interaction with colleagues as unimportant. This is not surprising, given that a number of studies have highlighted the importance that occupants place on interaction in the workplace (Oldham and Brass, 1979; Hatch, 1987; Olson, 2002; Nathan, 2002; Stokols *et al.*, 2002). A weak positive correlation suggests that females placed more importance on interacting with colleagues than males (Spearman's rho, $p < 0.01$). The importance of interacting with colleagues was also higher for those occupants that had spent a greater proportion of their time working at a computer, using a telephone or working in groups (Spearman's rho, $p < 0.01$).

Figure 4.24 shows the distribution of scores for occupants' job satisfaction. The term 'job satisfaction' is used in this study to refer to the 'degree to which employees are contented with their jobs' (Colman, 1997). Job satisfaction tends to be low when experience in a job fails to live up to expectations (Colman, 1997).



Statistics	
Mean	6
Median	6
Std. Deviation	1
Minimum	1
Maximum	7
Lower quartile	5
Upper quartile	7

Figure 4.23: Importance of interacting with colleagues



Statistics	
Mean	5
Median	5
Std. Deviation	2
Minimum	1
Maximum	7
Lower quartile	4
Upper quartile	6

Figure 4.24: Job satisfaction

Research has shown that low job satisfaction is related to higher rates of absenteeism and staff turnover (Glisson and Durick, 1988; Brooke and Price, 1989; Hackett, 1989; Sagie, 1998). A mean score of five suggests that, on average, occupants were reasonably satisfied with their job. More than a third (34%) of occupants had a high level of job satisfaction. A weak positive correlation between job satisfaction and grade suggests that occupants at higher grades were more satisfied with their job (Spearman's rho, $p < 0.01$). Again, this reflects the finding of previous studies (Ronen, 1978; Near *et al.*, 1978; Miles *et al.*, 1996; Oshagbemi, 1997), all of which show a positive relationship between grade and job satisfaction. The positive relationship between job satisfaction and grade may also explain the weak positive correlations between job satisfaction and time spent out of the office and time spent working in groups (Spearman's rho, $p < 0.01$) since occupants at higher grades spent more of their time doing each of these activities.

There was, however, a weak negative correlation between job satisfaction and the number of people that occupants shared their workspace with, suggesting that the more people that occupants shared their workspace with, the lower their job satisfaction (Spearman's rho, $p < 0.05$). This supports the findings of previous studies by Oldham and Brass (1979), Oldham and Rotchford (1983), Carlopio and Gardner (1992), and Olson (2002). There were also weak negative correlations between job satisfaction and the amount of time that occupants spent working at their desk or doing repetitive and routine tasks (Spearman's rho, $p < 0.05$), indicating that the more time that occupants had spent doing either of these activities, the lower their job satisfaction. This finding was not surprising, since low task variety has long been shown to be associated with low job satisfaction (Stimson and Johnson, 1977; Zeffane, 1994; Wright and Davis, 2003).

4.4.4 Occupant perceptions and expectations of the workplace

Sections A and C of the questionnaire were designed to measure occupants' perceptions and expectations of their workplace, respectively. In Section A of the questionnaire occupants were asked to indicate the extent to which they felt their workplace had each of the 22 attributes identified in Chapter 3. In Section C occupants were asked to indicate the extent to which their workplace should have each of the 22 attributes. Their responses are used to determine the utility of the 39 office buildings covered by the occupant survey.

Occupants' perception and expectation scores are summarised in Table 4.8. The table contains index figures and rank values for each of the 22 attributes. These figures show the magnitude of scoring in the sample and highlight any differences between occupants' perceptions and expectations of the 22 attributes. Attributes are grouped according to the four factors described in Chapter 3 and ranked according to the index figures (1 = highest rank, 22 = lowest rank). The index figures were calculated by dividing the scores for each attribute by the total possible score in the sample.

The general pattern is one of occupants' expectations exceeding their perceptions of the workplace. Differences between perceptions and expectations were highest for environment attributes and lowest for appearance attributes. The difference between perceptions and expectations was also high for conversational privacy and visual privacy (ranks 3 and 8, respectively). Table 4.8 suggests that occupants' expectations were highest for environment attributes, all of which are ranked among the top ten attributes. The results may be symptomatic of the fact that occupants tend to have particularly high expectations when it comes to the internal environment of office buildings (Wyon, 2000; Leaman and Bordass, 2000), a view confirmed in this study.

Table 4.8: Occupant perceptions and expectations of the workplace

Factor/attribute	Perc. index	Perc. rank	Expec. index	Expec. rank	Differ. index	Differ. rank
Configuration	**2.24**	**2**	**3.91**	**3**	**-1.67**	**3**
Amount of space for team projects	0.39	14	0.84	6	-0.46	9
Access to informal meeting space	0.47	5	0.81	11	-0.34	13
Common areas allow chance interaction	0.49	4	0.77	16	-0.28	16
Amount of informal meeting space	0.38	16	0.76	17	-0.38	11
Layout enables circulation and movement	0.51	2	0.73	18	-0.22	18
Environment	**2.16**	**1**	**5.30**	**1**	**-3.14**	**1**
Comfortable temperature	0.39	15	0.92	1	-0.53	=3
Well ventilated	0.38	17	0.91	2	-0.53	=3
Comfortable humidity	0.41	12	0.90	=3	-0.49	6
Responsive to changes in temperature	0.35	18	0.90	=3	-0.55	=1
Control over temperature	0.28	22	0.83	7	-0.55	=1
Control over ventilation	0.35	19	0.83	8	-0.48	7
Appearance	**2.28**	**3**	**3.33**	**4**	**-1.05**	**4**
Visually appealing	0.43	11	0.77	=14	-0.34	14
Modern appearance	0.46	=6	0.68	19	-0.21	19
Visually appealing from the outside	0.46	=6	0.67	20	-0.21	20
Tidy appearance	0.46	9	0.66	21	-0.20	21
Modern from the outside	0.46	8	0.55	22	-0.09	22
Functionality	**2.45**	**4**	**4.83**	**2**	**-2.39**	**2**
Amount of workspace	0.52	1	0.85	5	-0.33	15
Work free from distraction	0.39	13	0.83	9	-0.44	10
Conversational privacy	0.29	21	0.82	10	-0.53	=3
Amount of storage space	0.45	10	0.79	12	-0.35	12
Accessible storage space	0.50	3	0.78	13	-0.29	17
Visual privacy	0.31	20	0.77	=14	-0.47	8

Occupants also had high expectations of functionality attributes, two of which were ranked among the top ten attributes. In contrast, the lowest expectations were for the appearance attributes, which comprised the bottom four ranks. Occupants also had lower expectations of configuration attributes, all but one of which were ranked outside of the top ten attributes. This was surprising, since previous research has shown that occupant expectations of configuration attributes, such as space for interaction and informal meeting, are usually high (Nathan, 2002; Olson, 2002).

The pattern of perception scores was more varied. Although the highest ranking attributes were from the functionality and configuration factors, both factors also had low ranking attributes. For instance, occupants' perceptions of visual privacy and conversational privacy in their workplace were very low (ranked 20 and 21, respectively). This is important, since quiet work is an activity that many office workers are engaged in for a high proportion of their time (Olson, 2002). Occupants also had very low perceptions of environment attributes, all of which were ranked among the bottom ten attributes, particularly those relating to control of ventilation and temperature (ranked 19 and 22, respectively). This is also significant, because occupants' perception of environmental control has been shown to be an important factor affecting health, energy efficiency and productivity in office buildings (Wyon, 2000; Leaman and Bordass, 2000).

Occupants were also asked to nominate the most important and least important workplace attributes. Table 4.9 shows the five most important attributes. The two most important attributes were responsiveness to changes in temperature and a layout that enables circulation and movement. The high level of importance placed on the former of these two attributes is unsurprising, given that previous studies have shown that occupants get frustrated if they are unable to achieve a quick response from their own actions, control systems or other people (Leaman, 1995; Leaman and Bordass, 1999).

Table 4.9: Most important workplace attributes

Attribute	Percentage	Rank	Factor
Responsive to changes in temperature	14	=1	Environment
Layout enables circulation and movement	14	=1	Configuration
Work free from distraction	13	3	Functionality
Comfortable temperature	10	4	Environment
Amount of workspace	7	5	Functionality

Occupants also placed a high level of importance on being able to work free from distraction, thereby confirming the results of research by Olson (2002) and Haynes and

Price (2002), which suggested that the ability to do distraction-free solo work was one the two attributes, the other being interaction, with the strongest effects on individual performance, team performance and job satisfaction.

The least important workplace attributes are in shown in Table 4.10. Occupants placed little importance on whether their workplace looked modern or visually appealing from the outside. Visual privacy and access to informal meeting space were also considered to be less important. The latter was somewhat surprising, given the high level of importance that occupants placed on interacting with colleagues (Figure 4.23).

Table 4.10: Least important workplace attributes

Attribute	Percentage	Rank	Factor
Modern from the outside	19	1	Appearance
Modern appearance	18	2	Appearance
Visual privacy	12	3	Functionality
Visually appealing from outside	8	4	Appearance
Access to informal meeting space	7	5	Configuration

4.4.5 Workplace utility

The utility of each workplace attribute was determined by dividing perceptions scores by expectations scores. Difference scores (perceptions – expectations) were unsuitable because the resultant values were positive and negative. This created inaccuracies when summing factor scores and calculating statistics. The validity of the chosen approach was established in previous research (Bottom *et al.*, 1999). The resultant values range between 0 and 7, where scores of 1 or above indicate that perceptions matched or exceeded expectations, and scores below 1 indicate that expectations exceeded perceptions.

Figure 4.25 shows the utility scores for each individual factor and the average scores across all four factors. The boxplots show the distribution of scores (cross-hairs), interquartile range (box), median values (middle line) and outliers. The charts suggest that for the majority of occupants, their workplace exhibited scores below 1 for each factor, the median score across all four factors being 0.6. There was, however, variation within and between factors. The appearance factor had the largest proportion of utility scores above 1 (21%) and the environment factor had the smallest proportion (16%). The median scores for these two factors were 0.8 and 0.4, respectively. This was unsurprising given that the differences between perceptions and expectations were greatest for environment and smallest for appearance (Table 4.8).

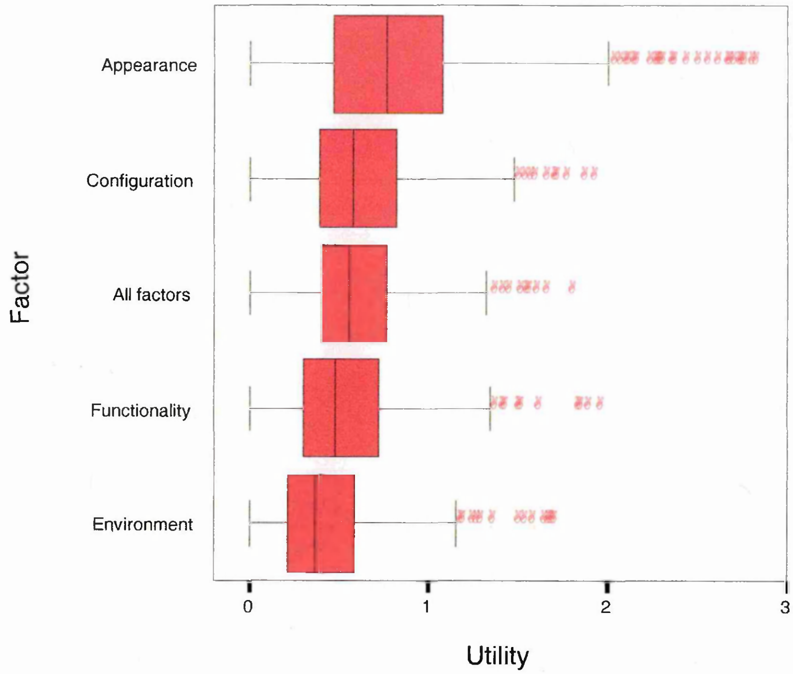


Figure 4.25: Utility scores, by factor

Differences between individual factors can be explored further by breaking each factor down into its constituent attributes. The utility scores for the five workplace configuration attributes are shown in Figure 4.26. The charts indicate that for more than a third (36%) of occupants the configuration of their workplace matched or exceeded expectations in terms of facilitating circulation and movement. A similar proportion (30%) occupied workplaces that exceeded expectations with regard to facilitating chance interaction with colleagues, although this is still a seemingly low figure given the importance that occupants place on such interactions (Figure 4.23). The lowest levels of utility on the configuration factor were for the provision of team project space and informal meeting space, which only exceeded expectations in 17% and 19% of cases, respectively.

The utility scores for the six environment attributes are shown in Figure 4.27. Average utility scores for these attributes were lower than for the configuration attributes, with median scores ranging between 0.2 and 0.4, and the distribution of scores positively skewed. A very high proportion of scores were below 1. For example, in 90% of cases occupants' control over the temperature of their workplace was less than was expected. Only in 9% of cases did the workplace function at a temperature that matched or exceeded expectations. These figures were unsurprising, because occupants' expectations for these attributes were very high and perceptions were very low (Table 4.8).

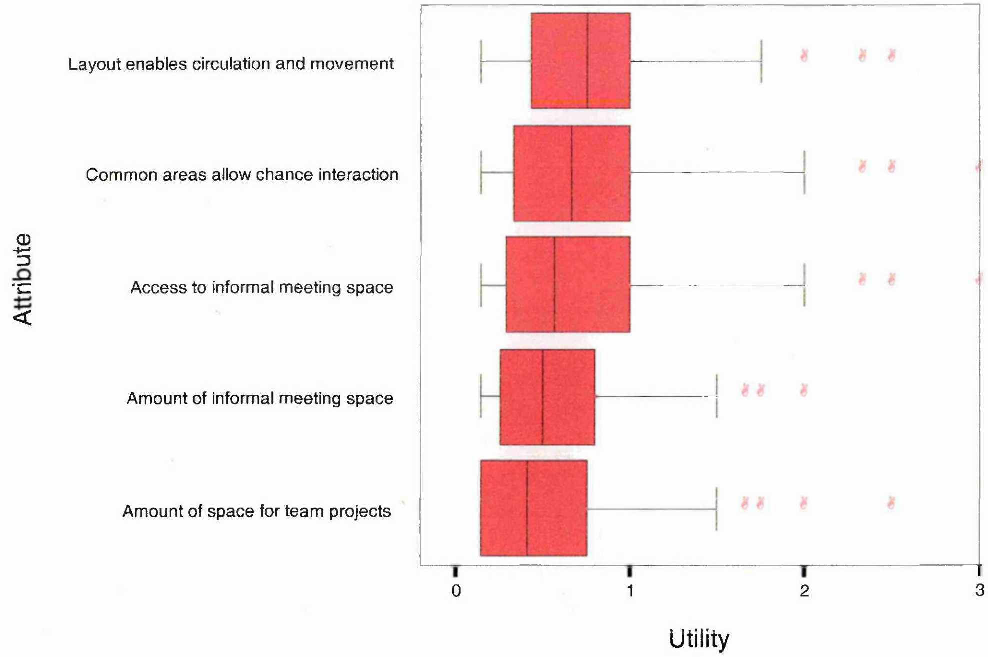


Figure 4.26: Utility of configuration attributes

Figure 4.28 shows the distribution of utility scores for appearance attributes. The scores were, on average, higher than for the configuration and environment attributes, with median values ranging between 0.6 and 1.0. For example, the external appearance of the workplace matched or exceeded expectations in the majority (52%) of cases. Again, the higher level of scoring for the appearance attributes was not surprising, because the differences between occupants' perceptions and expectations were smaller than for configuration, environment and functionality attributes (Table 4.8).

The utility scores for the functionality attributes are shown in Figure 4.29. There are differences between the distribution of scores for the six attributes, with conversational and visual privacy having the highest proportion of scores below 1, 86% and 84%, respectively. It was unsurprising, therefore, that only in a small proportion (19%) of cases did workplaces match or exceed occupants expectations for distraction free work. In contrast, more than a quarter of occupants occupied workplaces that provided the expected amount of workspace and storage space, and storage space that was easily accessible. The median score for these three attributes was 0.7.

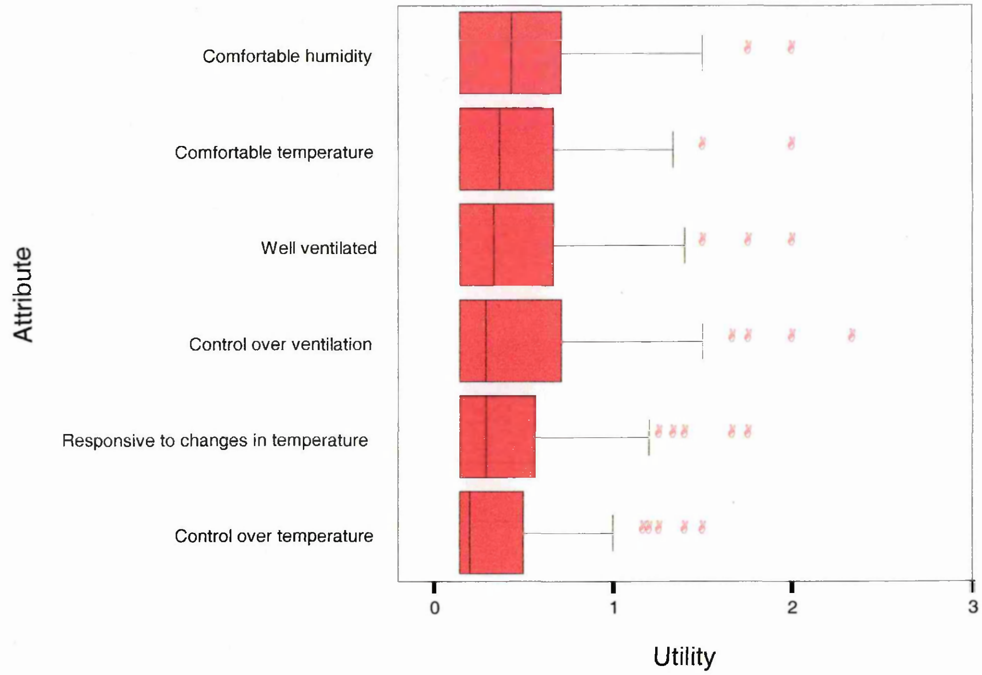


Figure 4.27: Utility of environment attributes

Notwithstanding the above results, the conclusions that can be drawn about the utility of the sample buildings is still limited. That is because a raw score on a measuring scale is not particularly informative about the position of a given object, in this case office buildings, on the attribute being measured, since the units in which the scale is expressed are unfamiliar (Churchill, 1979). To assess the position of an object on an attribute it is necessary to compare the object's score with the score achieved by other objects (Churchill, 1979). This involved comparing the average utility scores across the sample of buildings.

Figure 4.30 shows the distribution of average utility scores for the sample buildings, arranged by factor. The charts suggest that whilst there is considerable variation in the average utility scores across the sample, the majority of building have scores below 1. There was, however, variation between factors. For instance, only one building in the sample had a score above 1 on the environment factor, whereas nine buildings had a score above 1 on the appearance factor. The difference is reflected in the median utility scores for these factors, 0.48 and 0.80, respectively.

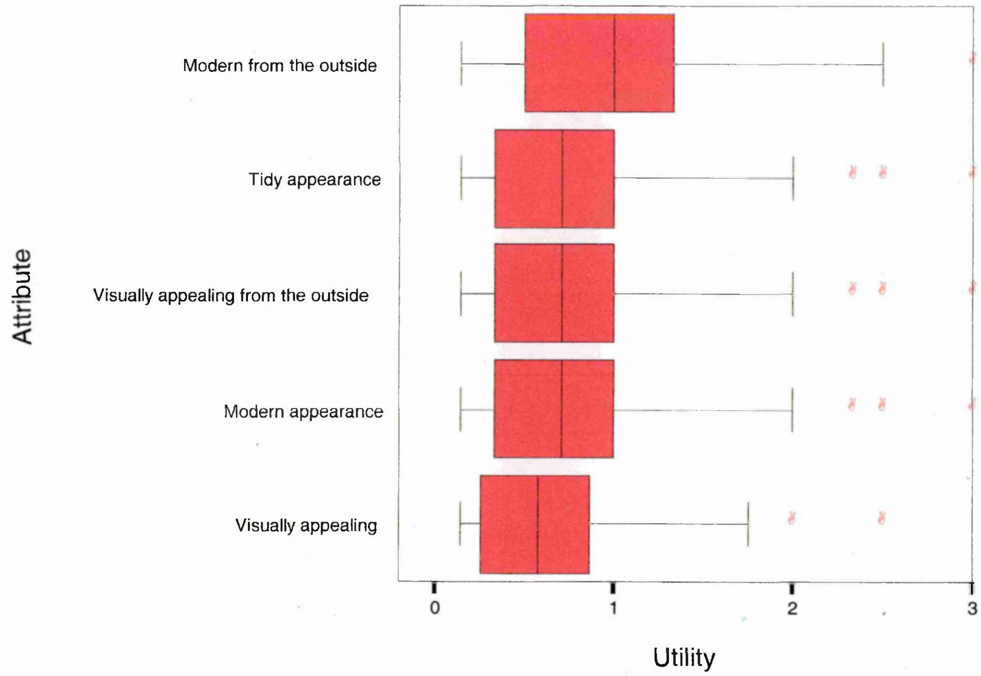


Figure 4.28: Utility of appearance attributes

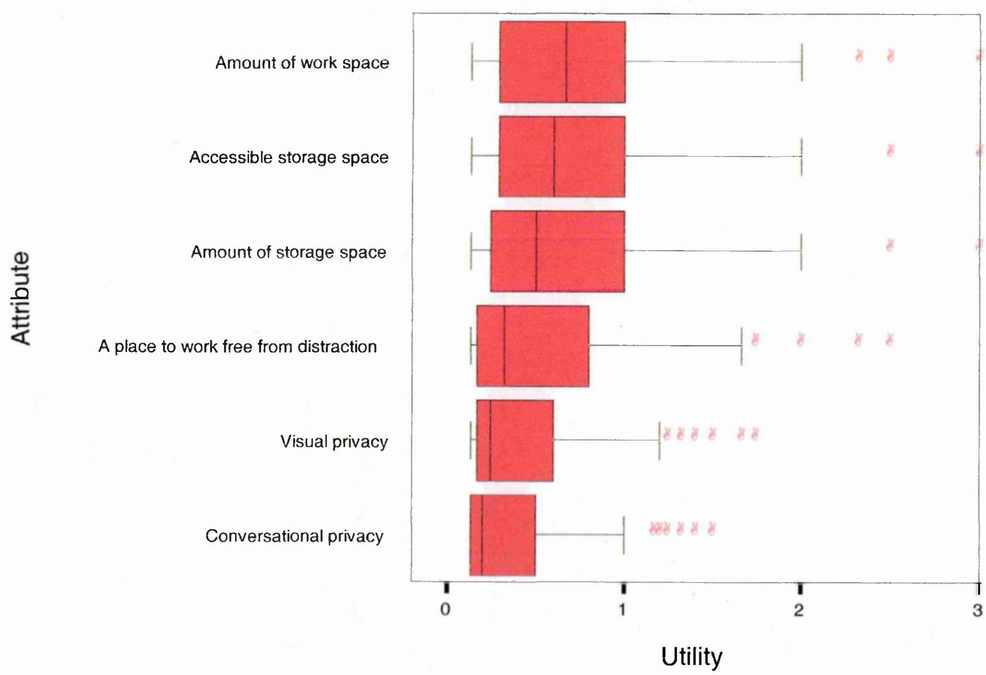


Figure 4.29: Utility of functionality attributes

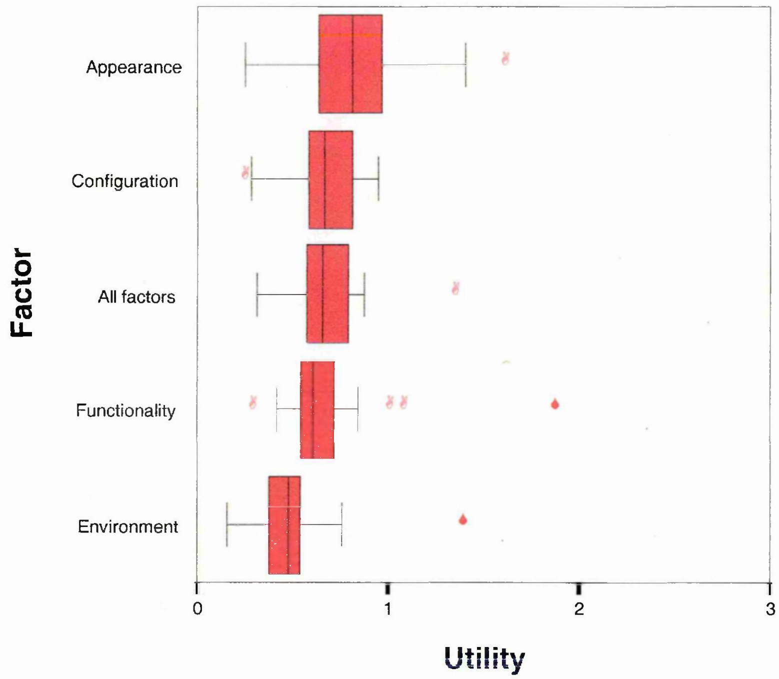


Figure 4.30: Utility scores of the sample buildings for all factors

Again, differences between individual factors can be explored by breaking each one down into its constituent attributes. The utility scores of the sample buildings for the configuration, environment, appearance and functionality attributes are shown in Figure 4.26 - Figure 4.34. The charts highlight the variations in utility of the sample buildings across the 22 workplace attributes. Taking Figure 4.26 as an example, it can be seen that, on average, the sample buildings perform better in relation to facilitating chance interaction than in respect of space for team projects. The next two chapters focus on explaining the variation in utility across the sample buildings by using physical characteristics and occupant characteristics as explanatory variables.

4.4.6 Summary

This section has examined data from a questionnaire survey of over 5000 building occupants from three local authorities. The occupant survey yielded 905 usable responses, relating to 38 office buildings from the sample of 64 buildings described in Section 4.2. Data from the survey were used to develop a profile of the buildings' occupants and determine the utility of the sample buildings. The next section in this chapter draws conclusions from the survey results presented in this and earlier sections.

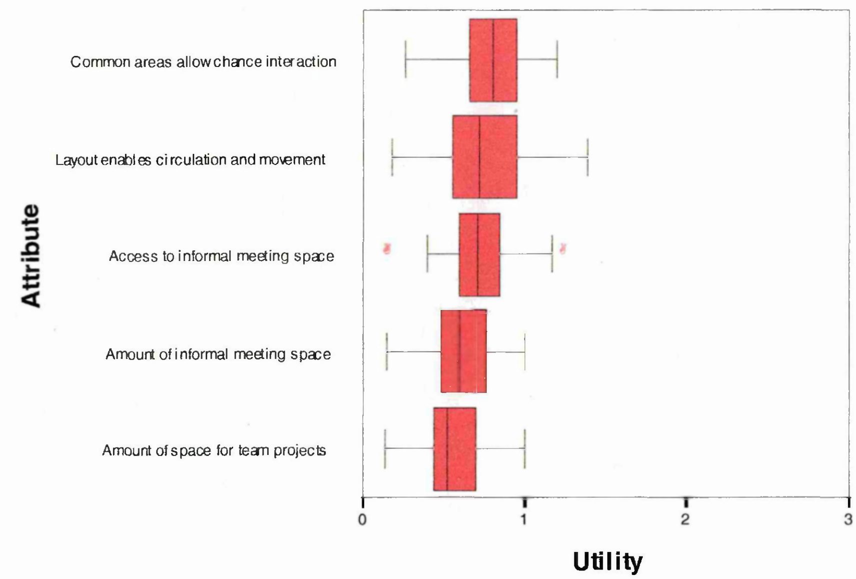


Figure 4.31: Utility scores of the sample buildings for configuration attributes

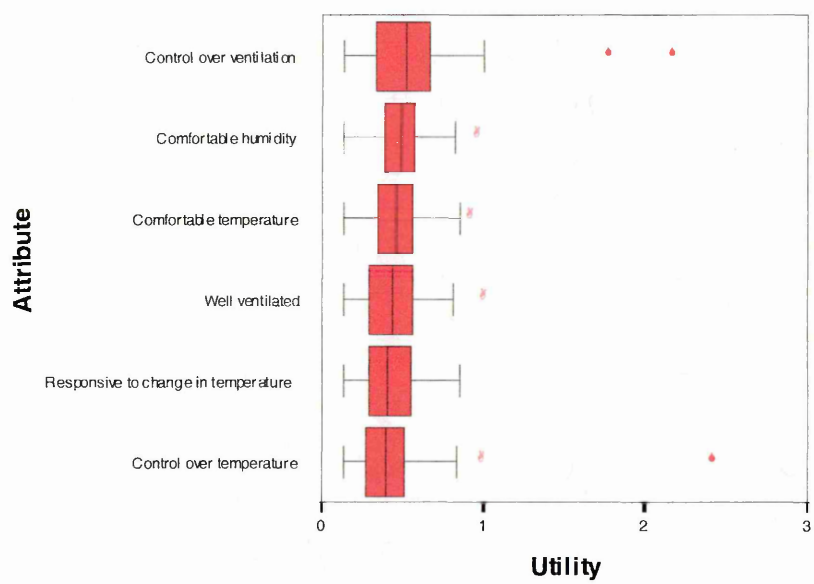


Figure 4.32: Utility scores of the sample buildings for environment attributes

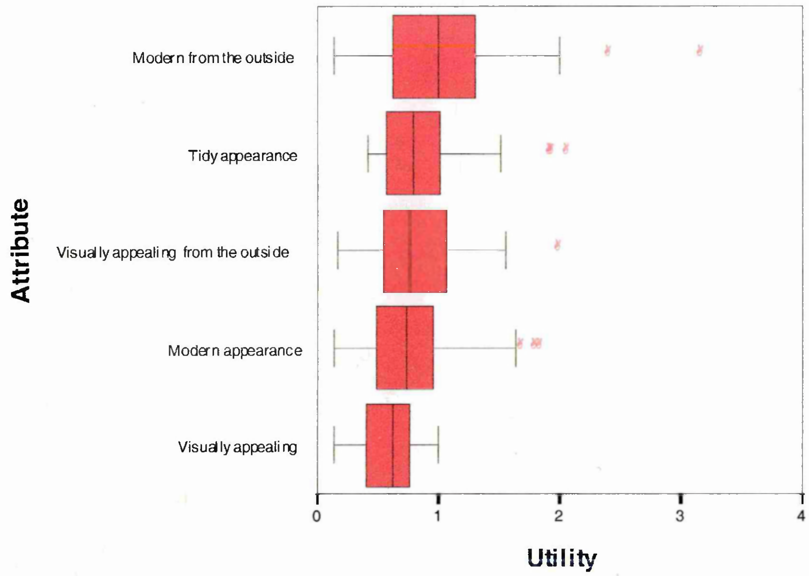


Figure 4.33: Utility scores of the sample buildings for appearance attributes

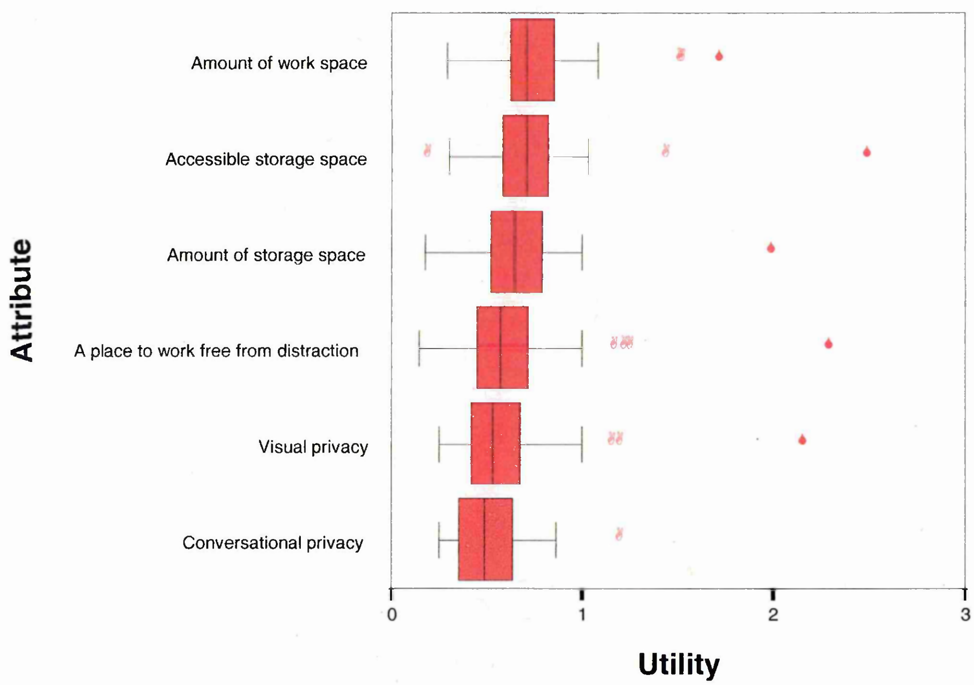


Figure 4.34: Utility scores of the sample buildings for functionality attributes

4.5 Conclusion

The purpose of this chapter was to present the results of each of the data collection surveys described in Chapter 3. Presentation of the survey results was undertaken as a prerequisite to further bivariate and multivariate analysis described in Chapters 5 and 6. The results presented in this chapter concerned:

- the physical and locational characteristics of the sample buildings;
- the occupancy costs of the sample buildings;
- the characteristics of the occupier organisations;
- the characteristics of the building's occupants, including their perceptions and expectations of their workplace; and
- the utility of the sample buildings.

The principal conclusions arising from each of these areas are discussed below.

Analysis of data from the buildings surveys revealed that there was considerable variability in the physical and locational characteristics of the sample buildings (Section 4.2). This was to be expected given that, even within local authorities of the same type, no two property portfolios are exactly alike. Moreover, the range of office buildings occupied by local authorities varies considerably in size and style, from large Victorian town halls through to parts of leased office blocks (Audit Commission, 2000). Such variation can be attributed to a multitude of factors, including the changing demands on local authorities over time, the diversity in scale and nature of different local authorities, the influence of periodic local government reorganisations and the broad range of public services that local authorities are required to provide. It can be concluded that these and other factors have, over time, had a differential impact on the activities of different local authorities and, in turn, their property requirements.

Although the sample of buildings was relatively old, it was found to be comparable with the age profile of the UK's office stock as a whole. The age profile of the sample buildings can be attributed to the long-term lack of investment in local government capital stock (Clark *et al.*, 2002), but also to the presence of Victorian town halls and other historical buildings in local authority property portfolios (Audit Commission, 2000). Moreover, because physical characteristics, such as layout and construction, tend to follow distinct trends over time in line with changes in materials and technology (Dunse and Jones, 2002), the age profile was reflected in the physical characteristics of the sample buildings, the majority being of traditional construction with wet heating systems and natural ventilation via openable windows. The relationships between the physical characteristics of the sample buildings and their utility and operation costs are examined in Chapters 5 and 6.

Most of the buildings in the sample were occupied on a freehold basis, reflecting the findings of the Audit Commission's (2000) own research into local government property holdings. However, the proportion of freehold property in the sample is much higher than in the private sector or central government, where, on average, 64% of property is owner-occupied (Bootle and Kalyan, 2002). This is significant, because leasehold occupation tends to be associated with lower property costs, a relationship that is supported in this study. The lower occupancy costs associated with leasehold properties can be explained by the fact that owner-occupied space tends to be less densely occupied (Gerald Eve, 2000). More than half of the office buildings in this study had occupant densities in excess of the UK practice of 12-17m^2 per person. This may reflect the inclusion of town halls in the sample, many of which were built as symbols of civic grandeur and are difficult to use efficiently, but it may also be symptomatic of the generous space standards still employed by some local authorities (Audit Commission, 2000). Bootle and Kalyan (2002) attribute owner-occupiers' less efficient use of their office space to the fact that there is no rent to remind them that their property is not 'free' or the expectation that capital appreciation will compensate for inefficient utilisation. Local authorities have, in the past, been criticised for viewing their property in this way (Audit Commission, 1988a; 1988b; 2000). The relationship between occupancy characteristics and the operation costs of the sample buildings are examined in Chapters 5 and 6.

Although property costs are the second biggest business cost after salaries, access to accurate and comprehensive occupancy cost data remains poor (Haynes *et al.*, 2000; Audit Commission, 2000; Bootle and Kalyan, 2002) a fact reflected in this chapter. Of the 86 variables included in the occupancy cost survey, 53 were excluded from the analysis due to missing data. These variables primarily related to property operation costs, business support and management costs. However, participating local authorities were also unable to provide data relating to the utilisation of their office buildings, for instance the proportion of staff involved in formal hot desking practices. The lack of cost and utilisation data was not altogether surprising, given that the Audit Commission's (2000) own research had suggested that fewer than 20 percent of local authorities routinely recorded costs of repairs and maintenance for their properties. Nevertheless, the lack of such data clearly represents a major barrier to the efficient use of office buildings (Audit Commission, 2000; Bootle and Kalyan, 2002). It also means that property operation costs will be employed as the sole measure of financial performance in this study. The next chapter looks to explain variation in the operation costs of the sample buildings by employing physical characteristics and occupancy characteristics as explanatory variables.

The way in which the sample buildings were utilised by the occupier organisations was, nevertheless, reflected in data from the occupant survey (Section 4.4). The results of the occupant survey suggested that occupants were in the main office- and desk-based, with only a small proportion working from home on a regular basis. This supports the view that, despite the existence of technology to permit employees to work from home or other locations, many local authorities have yet to embrace flexible working as way of improving utilisation of their office buildings, even though experience from local authorities that have introduced flexible working indicates that office space can be reduced by up to one-quarter (Audit Commission, 2000; Price, 2001). Data from the occupant survey also provided an insight into some of the underlying cultural influences and unwritten rules operating in the occupier organisations. For example, the fact that occupants at higher grades were more likely to work separately from and in larger workspaces than their colleagues at lower grades suggests that office space is allocated on the basis of status, rather than need, thereby reflecting the findings of previous studies (Haynes *et al.*, 2001; Nathan, 2002).

Another significant finding arising from the occupant survey was that while occupants generally placed a high level of importance on interacting with their colleagues, the more people that occupants shared their workspace with, the lower their job satisfaction. What is more, occupants also had high expectations regarding conversational privacy and being able to work free from distraction. This apparent contradiction may be explained by other studies (Olson, 2002; Haynes and Price, 2002; Stokols *et al.*, 2002), each of which point to a potential conflict between interaction and distraction in the workplace. Olson (2002) suggested that quiet, individual work and informal interactions are the two workplace activities with the greatest impact on job satisfaction and performance, and that workplace design should focus on ensuring that both activities can coexist within the same workspace. The next chapter explores this issue further by examining the relationship between these and other workplace attributes, and the physical characteristics of the sample buildings.

Data from the occupant survey suggested that occupants' expectations tended to exceed their perceptions of their workplace, giving rise to a large number of utility scores below 1 for each factor. There was, however, considerable variation in utility scores across each of the four factors and the 22 attributes. For instance, utility scores tended to be higher for appearance attributes than environment attributes. Similar variation was found in the average utility scores for the sample buildings, suggesting that different buildings in the sample had different levels of utility or functional performance. This supports the assumption put forward in Chapter 3, namely that buildings of the same type vary in the way they perform basic functions (Gray and Tippett, 1993). The next chapter focuses on explaining this variation by analysing the relationships between utility and physical characteristics on one hand, and utility and occupant characteristics on the other. Analysis of these relationships is precursor to the statistical modelling described in Chapter 6.

References

Aronoff, S. and Kaplan, A. (1995) *Total workplace performance*, WDL Publications, Ottawa, Canada.

Audit Commission (2000) *Hot property: getting the best from local authority assets*, Audit Commission, London.

Audit Commission (1988a) *Local Authority Property: A Management Overview*, HMSO, London.

Audit Commission (1988b) *Local Authority Property: A Management Handbook*, HMSO, London.

BCO (2000) *Best practice in the specification for offices*, Third Edition, British Council for Offices, Reading.

Bon, R., Gibson, V. and Luck, R. (2003) Annual CREMRU-JCI survey of corporate real estate practices in Europe and North America: 1993-2002, *Facilities*, **21** (7/8), 151-167.

Bootle, R. and Kalyan, S. (2002) *Property in business - a waste of space?*, The Royal Institution of Chartered Surveyors, London.

Brand, S. (1994) *How buildings learn*, Phoenix Illustrated, London.

Brooke, P.P. and Price, J.L. (1989) The determinants of employee absenteeism: An empirical test of a causal model, *Journal of Occupational Psychology*, **62**, 1-19.

Brill, M., Weidemann and the BOSTI Associates (2001) *Disproving widespread myths about workplace design*, Kimball International, Jasper.

Carlopio, J.R. and Gardner, D. (1992) Direct and interactive effects of the physical work environment on attitudes, *Environment and Behavior*, **24** (5), 579-601.

Churchill, G.A. (1979) A paradigm for developing better marketing constructs, *Journal of Marketing Research*, 16, February, 64-73.

Clark, T., Elsby, M. and Love, S. (2002) Trends in British Public Investment, *Fiscal Studies*, **23** (3), 305-342.

Colman, A.M. (ed) (1997) *A Dictionary of Psychology*, Oxford University Press, University Press, Oxford Press. Accessed 2 December 2003, http://www.oxfordreference.com/

de Vaus, D.A. (1996) *Surveys in social research*, Fourth Edition, UCL Press, London.

Dench, S., Aston, J., Evans, C., Meager, N., Williams, M. and Willison, R. (2002) *Key indicators of women's position in Britain*, The Department of Trade and Industry, London.

Dunse, N. and Jones, C. (2002) Rental depreciation, obsolescence and location: the case of industrial properties, *In proceedings of European Real Estate Society Conference*, Glasgow.

Gerald Eve (2000) *Overcrowded, under-utilised or just right? A study of office occupational densities in the UK*, Gerald Eve Research.

Glisson, C. and Durick, M. (1988) Predictors of job satisfaction and organizational commitment in human service organizations, *Administrative Quarterly*, **33**, 61-81.

Gray, J. and Tippett, H. (1993) *Building quality assessment: a prerequisite to economic analysis*, Center for Building Performance Research, Victoria University of Wellington, New Zealand.

Hackett, R.D. (1989) Work attitudes and employee absenteeism: A synthesis of the literature, *Journal of Occupational Psychology*, **62**, 235-248.

Hatch, M.J. (1987) Physical barriers, task characteristics and interaction activity in research and development firms, *Administrative Science Quarterly*, **32**, 387-399.

Haynes, B. and Price, I. (2002) Quantifying the complex adaptive workplace, *Proceedings of the CIB W70 2002 Global Symposium*, Glasgow.

Haynes, B., Matzdorf, F., Nunnington, N., Ogunmakin, C., Pinder, J. and Price, I. (2000) *Does property benefit occupiers? An evaluation of the literature*, Report No. 1, http://www.occupier.org.

Kumar, R. (1999) *Research methodology: A step-by-step guide for beginners*, Sage Publications, London.

Leaman, A. (1995) Dissatisfaction and office productivity, *Facilities*, **13** (2), 13-19.

Leaman, A. and Bordass, B. (1999) Productivity in buildings: the 'killer' variables, *Building Research & Information*, **27** (1), 4-19.

Leaman, A. and Bordass, W. (2000) Productivity in buildings: the 'killer' variables, *In Clements-Croome, D. (ed), Creating the productive workplace*, E & FN Spon, London.

Miles, E.W., Patrick, S.L. and King, W.C. (1996) Job level as a systemic variable in predicting the relationship between supervisory communication and job satisfaction, *Journal of Occupational and Organizational Psychology,* **69**, 277-292.

Nathan, M. (2002) *The state of the office*, The Industrial Society, London.

Near, J.P., Rice, R.W. and Hunt, R.G. (1978) Work and extra work correlates of life and job satisfaction, *Academy of Management Journal,* **21**, 248-264.

ODPM (2002) *Age of commercial and industrial building stock 2000*, The Office of the Deputy Prime Minister, London.

Oldham, G.R. and Brass, D.J. (1979) Employee reactions to an open-plan office: a naturally occurring quasi-experiment, *Administrative Science Quarterly*, **24**, 267-284.

Oldham, G.R. and Rotchford, N.L. (1983) Relationships between office characteristics and employee reactions: A study of the physical environment, *Administrative Science Quarterly*, **28**, 542-556.

Olson, J. (2002) Research about office workplace activities important to US business -And how to support them, *Journal of Facilities Management*, **1** (1), 31-47.

Oshagbemi, T. (1997) The influence of rank on job satisfaction of organizational members, *Journal of Managerial Psychology*, **12** (8), 511-519.

Price, I. (2001) *Flexible working policies and environments in UK local authorities: Current practice*, COPROP and ACES.

Rostron, J. and Fordham, M. (1996) *Adapting housing for people with disabilities*, Arena, Aldershot.

Ronen, S. (1978) Job satisfaction and the neglected variable of job seniority, *Human Relations,* **31**, 297-308.

Sagie, A. (1998) Employee absenteeism, organizational commitment and job satisfaction: Another look, *Journal of Vocational Behavior*, **52**, 156-171.

Savery, L.K. (1990) Men and women in the workplace: Evidence of occupational differences, *Leadership & Organization Development Journal*, **11** (2), 13-16.

Stimson, J. and Johnson, T. (1977) Tasks, individual differences and job satisfaction, *Industrial Relations*, **3**, 315-322.

Stokols, D., Clitheroe, C. and Zmuidzinaz, M. (2002) Qualities of work environments that promote perceived support for creativity, *Creativity Research Journal*, **14** (2), 137-147.

Wright, B.E. and Davis, B.S. (2003) Job satisfaction in the public sector: The role of the work environment, *American Review of Public Administration*, **33** (1), 70-90.

Wyon, D.P. (2000) Individual control at each workplace: the means and the potential benefits, *In Clements-Croome, D. (ed), Creating the productive workplace*, E & FN Spon, London.

Zeffane, R. (1994) Computer usage and job satisfaction: An empirical exploration, *Information Management & Computer Security*, **2** (2), 10-22.

Chapter 5
Preliminary analysis

Chapter 5 Preliminary analysis

5.1 Introduction

Chapter 4 presented data relating to the utility and operation costs of a sample of local authority office buildings. As was expected, the data highlighted variability in the functional performance (utility) and financial performance (operation costs) across the sample, indicating differences in the level of obsolescence between buildings. The purpose of this chapter is to explain the differential impact of obsolescence in the sample, that is to say why some buildings exhibit higher or lower levels of performance than others, by analysing the bivariate relationships depicted in Figure 5.1[38]. The analysis presented in this chapter provides the foundation for further, multivariate analysis in Chapter 6.

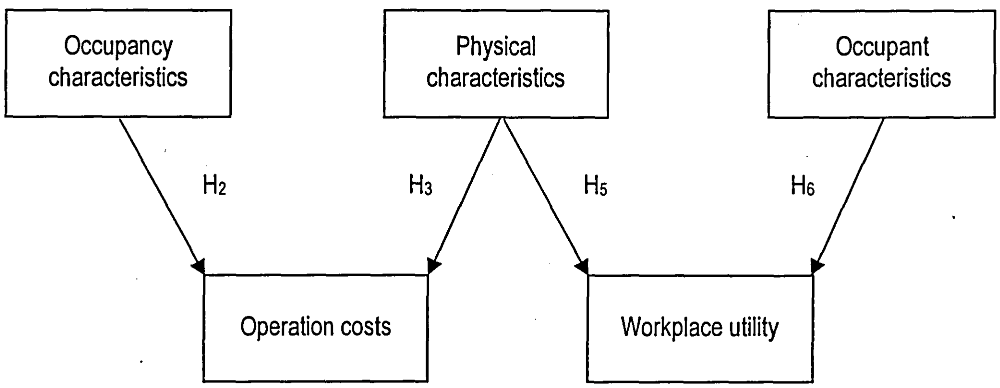


Figure 5.1: Summary of hypothesised bivariate relationships

The next section in this chapter (Figure 5.2) examines the relationships between the utility and physical characteristics of the sample buildings to establish whether variations in utility correspond with differences in workplace characteristics (H_5). Section 5.3 focuses on the relationships between the utility of the sample buildings and the characteristics of the buildings' occupants (H_6). This is followed by an analysis of the relationships between the operation costs and physical characteristics of the sample buildings to determine whether variations in operation costs of the buildings can be explained by differences in their physical characteristics (H_4). Section 5.5 examines the relationships between the operation costs of the sample buildings and the characteristics of their occupier organisations (H_3). A summary of the statistical tests used in this chapter are in Appendix J.

[38] It is important to note that this chapter focuses solely on describing the statistical relationships between the explanatory and outcome variables, and should not be taken to imply causality (Vogt, 1999). This issue is discussed further in Chapter 7.

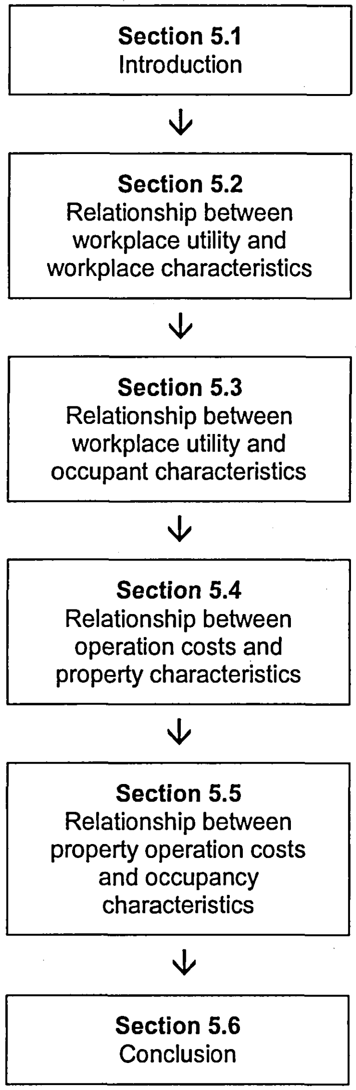


Figure 5.2: Structure of Chapter 5

5.2 Relationship between workplace utility and workplace characteristics

Analysis of the workplace utility data in Chapter 4 revealed considerable variability in average utility scores of the sample buildings, which suggests that different office buildings perform differently with regard to the 22 workplace attributes identified in Chapter 3. The purpose of this section is to examine the extent to which this variability can be explained by differences in the physical characteristics of the sample buildings (H_5). The statistics presented in this section relate to the aggregate utility scores (all factors) and the scores across each of the four individual factors. However, the analysis also examined the scores of the 22 individual attributes, the statistics for which are discussed below and included in Appendix K.

5.2.1 Construction characteristics

The first part of the analysis examined whether there was a significant relationship between the utility and age of the sample buildings. The age of a building can be used as a proxy for its construction characteristics, because the latter tend to follow distinct trends through time (Dunse and Jones, 2002), a fact reflected in this study (Chapter 4). Analysis of building age and utility using Spearman's correlation coefficient revealed statistically significant correlations with two factors and a number of workplace attributes (Table 5.1). A weak positive correlation between age and appearance suggests that the most recently constructed buildings in the sample performed best on this factor. This was not surprising given that architectural styles invariably fall out of favour in the medium term (Salway, 1986). More recently constructed buildings also performed better on a number of individual appearance attributes (visually appealing and tidiness) (Spearman's rho, $p < 0.05$).

Table 5.1: Correlation between utility and age of building

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Period of construction			.115(*)		-.124(*)

* Correlation is significant at the 0.01 level (2-tailed).

There was, however, a negative relationship between building age and functionality, which suggests that older buildings in the sample performed better on this factor than buildings that had been constructed more recently (Table 5.1). The relationship was particularly strong for the visual and conversational privacy attributes (Spearman's rho, $p < 0.01$). There were also significant negative correlations between building age and two of the environment attributes, with older buildings performing better than newer buildings in terms of occupants' control over temperature and ventilation (Spearman's rho, $p < 0.01$). This could be attributed to the fact that older buildings in the sample were more likely to have openable windows and more localised heating controls (Chapter 4).

Although building age therefore goes some way to explaining differences in workplace utility, its use as an explanatory variable does not take account of the fact that buildings tend to undergo periodic refurbishment, which can serve to enhance a building's utility, irrespective of its age (Bryson, 1997). Furthermore, research into property depreciation has shown that physical characteristics other than age provide a superior explanation of a building's relative performance (Baum, 1991; Khalid, 1994; Bottom *et al.*, 1999).

Table 5.2 shows the association between the utility and structural characteristics of the sample buildings. Comparison of the mean rankings suggests that buildings with timber frame and loadbearing wall structures performed significantly better than those with steel or concrete frames, the greatest difference being on the environment factor. Analysis of individual environment attributes indicated that buildings with steel or concrete frames had significantly lower scores on all six attributes (Kruskal-Wallis, $p < 0.01$). Buildings with loadbearing walls performed better in terms of responsiveness to changes in temperature. Scores for control over temperature and ventilation were comparable for buildings constructed with timber frames or loadbearing walls. However, timber framed buildings performed better in terms of ventilation and comfort. These differences may reflect the fact that the structural characteristics of a building have an effect on its other physical characteristics, such as the type of workspace, which are in turn correlated with the same workplace attributes (see Section 5.2.3 below). Intercorrelation between the physical characteristics of buildings means that similar relationships are apparent throughout this section of the analysis.

Table 5.2: Association between utility and structural characteristics

Characteristic	Mean rank				
	All factors*	Environment*	Appearance*	Configuration*	Functionality*
Type of structure					
Timber frame	485	625			503
Steel/concrete frame	436	421			434
Loadbearing walls	492	521			496
Arrangement of structure					
Shallow depth	479	494	474	461	449
Medium depth	420	395	431	454	422
Deep plan	756	781	483	757	827
Courtyard	436	451	435	401	488
Atrium	605	634	569	631	525
Internal sub-division					
Lightweight demountable	402	378	422	415	424
Stone/masonry/concrete	515	529	510	488	482
Stud and sheet system	402	432	355	452	448

*Kruskal-Wallis, $p < 0.01$

There was also a significant association between the utility and structural arrangement of the sample buildings (Table 5.2). Examination of the mean rankings indicate that buildings with deep plan floor plates or atria performed significantly better than buildings with shallow and medium depth buildings, or buildings with courtyards. Buildings with medium depth floor plates had the lowest aggregate utility scores, a pattern that was found across all four factors and a number of attributes. For instance, buildings with atria had the highest scores for ventilation and hygroscopic comfort, whereas buildings with deep plan floor plates had the highest scores for thermal comfort, and control over temperature and ventilation (Kruskal-Wallis, $p < 0.01$). This was surprising, because environmental comfort in buildings is usually associated with the distance of workspaces to the building perimeter, so whilst buildings with atria would be expected to perform well, buildings with deep plan floor plates would not (Shpuza, 2003). It does, however, substantiate findings reported by Bordass *et al.* (2001). Buildings with deep plan floor plates also scored well in term of configuration, having the highest scores for circulation and movement, whereas buildings with atria had the highest scores for chance interaction between colleagues (Kruskal-Wallis, $p < 0.01$).

Table 5.2 also shows the association between the utility and internal sub-division of the sample buildings. Examination of the mean rankings indicates that buildings with stone, masonry or concrete sub-dividing walls performed significantly better than those with lightweight demountable or stud partitions. The greatest disparity between utility scores was on the environment factor. Significant differences in scores were also found on individual workplace attributes. For instance, buildings with stone, masonry or concrete walls had higher scores for hygroscopic and thermal comfort than buildings with lightweight demountable or stud partitions (Kruskal-Wallis, $p < 0.01$). However, buildings with lightweight demountable partitions performed better in terms of conversational privacy than buildings with stone, masonry or concrete walls (Kruskal-Wallis, $p < 0.01$). This may be explained by the fact that hard wall surfaces, such as stone, masonry or concrete, provide lower sound absorption than partitions and other soft wall surfaces (Fuchs *et al.*, 2001).

The association between utility scores and different types of exterior elements are shown in Table 5.3. Comparison of the mean rankings suggests that buildings with stone, masonry or curtain walls had the highest levels of utility, whilst those with timber clad exterior walls had the lowest utility. These differences were reflected in the scores on the environment and appearance factors and attributes. There were, however, a number of departures from this pattern. For instance, timber clad buildings performed better than buildings with curtain walls in terms of ventilation and responsiveness to changes in temperature (Kruskal-Wallis, $p < 0.01$). Table 5.3 also indicates that buildings with timber or cast iron window frames had significantly higher utility scores than buildings with PVCu or aluminium window frames. Although this was also the case on the environment factor, the scores on the appearance factor were significantly higher for buildings with timber and aluminium window frames. The mean rankings also suggest that buildings with single glazed window units had significantly higher scores than those with double glazed units, including on the environment factor. This was not surprising, given that previous research has shown that the indoor environment does not change significantly regardless of whether windows are single or double glazed (Al-Hamdani and Ahmad, 1987).

Table 5.3: Association between utility and exterior elements

Element	Mean ranking				
	All factors	Environment	Appearance	Configuration	Functionality
Walls**					
Timber cladding	399	533*	322		
Stone and masonry	560	724*	455		
Stone	530	549*	502		
Masonry	442	433*	450		
Curtain wall	511	417*	583		
Cladding	437	456*	416		
Window frames*					
Timber	514	521	487		
PVCu	343	451	298		
Cast iron	537	512	380		
Aluminium	437	429	451		
Glazing***					
Single	487	508			
Double	435	424			
Doors**					
Timber		488	421		
Aluminium		439	466		

* Kruskal-Wallis, $p < 0.01$
** Kruskal-Wallis, $p < 0.05$
*** Mann-Whitney, $p < 0.01$

The analysis revealed significant relationships between the utility and exterior condition of the sample buildings (Table 5.4). As was expected, there were weak negative correlations with scores on the appearance factor, suggesting that buildings that were in better condition externally had higher scores on this factor than buildings that were in poor condition externally. Analysis of individual appearance attributes revealed significant negative correlations between the condition of exterior elements and attributes that relate to the building exterior (modern appearance and visually appealing). This indicates that buildings that were in better condition externally had higher scores for these attributes (Spearman's rho, $p < 0.01$).

Table 5.4: Correlation between utility and condition of building exterior

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Site			-.142(*)		
Walls			-.150(*)		
Windows			-.134(*)		
Doors	-.149(*)		-.225(*)		

* Correlation is significant at the 0.01 level (2-tailed).

The relationships between the utility and circulation characteristics of the sample buildings are shown in Table 5.5. The general pattern was one of declining utility as circulation capacity increased, perhaps reflecting the fact larger buildings performed worse than smaller buildings (see below). Only one circulation characteristic, corridor width, was positively correlated with utility, suggesting that buildings with wider corridors had higher utility scores than buildings with narrow corridors. Analysis of individual attributes revealed that circulation characteristics were correlated with a number of configuration attributes. For instance, buildings with wider staircases had, somewhat intuitively, higher scores for circulation and movement than those with narrower staircases (Spearman's rho, $p < 0.01$).

Table 5.5: Correlation between utility and circulation characteristics

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
No. of lifts	-.139(*)			-.110(*)	
Lift capacity	-.137(*)			-.090(*)	
No. of staircases	-.093(*)			-.097(*)	
Corridor width	.112(*)				

* Correlation is significant at the 0.01 level (2-tailed).

Table 5.6 shows the relationships between the utility and spatial characteristics of the sample buildings. A weak negative correlation between utility and floor area (GIA and NIA) suggests that smaller buildings performed better than larger buildings, a relationship that was strongest for the environment factor. Analysis of individual environmental attributes indicated that buildings with larger floor areas had the lowest scores for comfort, responsiveness to changes in temperature, and control over ventilation and temperature (Spearman's rho, $p < 0.01$).

There was, however, a weak positive correlation between utility and floor-to-ceiling height, indicating that buildings with larger floor-to-ceiling heights had higher utility scores than those with more restricted floor-to-ceiling heights (Table 5.6). There was also a weak positive correlation between occupant density and scores on the configuration and functionality factors, suggesting that the scores on both of these factors were higher for buildings with lower occupant densities. Analysis of individual functionality attributes suggested that buildings with higher occupant densities received lower scores for visual privacy, conversational privacy and the potential to work free from distraction (Spearman's rho, $p < 0.01$). This was expected because higher occupant densities imply closer proximity of co-workers, particularly in open plan workspaces (Sundstrom *et al.*, 1994).

Table 5.6: Correlation between utility and spatial characteristics

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Number of floors	-.150(**)	-.228(**)	-.120(**)	-.071(*)	-.074(*)
Floor-to-ceiling height	.131(**)	.156(**)	.090(**)	.126(**)	.100(**)
Building depth			.140(**)		
Gross internal area	-.173(**)	-.228(**)	-.170(**)		
Net internal area	-.143(**)	-.174(**)	-.161(**)		
Floor plate efficiency	.166(**)	.170(**)	.127(**)		.185(**)
Occupant density			-.076(**)	.113(**)	.133(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5.2.2 Building services and common amenities

Table 5.7 shows the correlation between the utility and building services provisions of the sample buildings. The statistics indicate that buildings with natural ventilation and wet heating systems had higher aggregate utility scores than buildings without these features. Moreover, a positive correlation between utility and the percentage of openable windows suggests that buildings with a higher proportion of openable windows had the highest aggregate utility scores and highest scores on the environment factor. Similarly, there was a positive correlation between the level of heating control and utility, indicating that buildings with more localised heating controls had higher scores, particularly on the environment factor.

Analysis of individual environment attributes revealed that that buildings with natural ventilation and wet heating systems had significantly higher scores for responsiveness to changes in temperature and comfort than buildings without these features. Scores for control over temperature and ventilation were also significantly higher for buildings with natural ventilation and wet heating systems, but lower for fully air-conditioned buildings in which controls are more centralised (Spearman's rho, $p < 0.01$). A weak positive correlation between the level of heating control and scores for control of temperature indicates that buildings with more centralised heating controls had lower scores for control over the temperature than buildings with localised controls (Spearman's rho, $p < 0.01$). These findings were not surprising, because previous research has shown that openable windows give a faster response and intuitively obvious control, even if they do not always deliver optimal or even reasonable conditions (Bordass and Leaman, 1997). Moreover, it has been found that when occupants have greater control over their indoor environment they tolerate of wider range of temperature (Humphreys, 1976; Leaman and Bordass, 1999).

Table 5.7: Correlation between utility and building services provisions

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Wet heating	-.133(*)	-.195(*)			
Natural ventilation	-.149(*)	-.196(*)			
Air-conditioning (split units)	-.095(*)	-.136(*)			
Heating control	.167(*)	.215(*)			
% openable windows	.149(*)	.163(*)			

* Correlation is significant at the 0.01 level (2-tailed).

As might have been expected, there were significant differences in scores on the appearance attributes and the type of finishes in common areas and amenities. Comparison of mean rankings indicate that buildings with plastered walls had higher scores than buildings with decorative papers or exposed masonry walls (Kruskal-Wallis, $p < 0.01$). In terms of floor and ceiling finishes, buildings with carpeted or parquet floors and plastered ceilings had the highest scores on these attributes (Kruskal-Wallis, $p < 0.01$), reflecting the fact that these finishes were generally in better condition (Chapter 4). The analysis also indicated significant relationships between utility and the condition of finishes in common areas (Table 5.8). Weak negative correlation with the appearance factor suggest that buildings that were in better physical condition had higher scores than buildings that were in poorer condition. As was envisaged, there were weak negative correlations between the physical condition of common areas and amenities and the appearance attributes of the sample buildings (Spearman's rho, $p < 0.05$). The statistics indicate that buildings that were in better physical condition had the highest scores for the appearance attributes.

Table 5.8: Correlation between utility and condition of common areas

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Walls	-.124(**)		-.081(*)		
Ceilings	-.204(**)		-.170(**)		
Floors	-.087(**)		-.138(**)		
Fixtures and fittings	-.179(**)		-.222(**)		

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5.2.3 Workspace characteristics

Table 5.9 shows the correlation between utility and the type of workspace provision in the sample buildings. There was a positive correlation between the proportion of open plan workspace and scores for both the appearance and configuration factors. Conversely, there was a negative correlation between the proportion of cellular workspace and the scores for both of these factors. This suggests that the scores on these factors were highest for buildings with larger proportions of open plan workspace and smaller proportions of cellular workspace. However, a negative correlation between the proportion of open plan space and scores on the functionality factor indicate that buildings with the largest proportions of open plan space had the lowest scores on this factor.

Table 5.9: Correlation between utility and type of workspace

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Open plan space			.126(**)	.102(**)	-.095(**)
Group space		.071(*)	-.096(**)		.125(**)
Cellular space	-.096(**)		-.117(**)	-.162(**)	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Analysis of individual attributes revealed significant relationships between the type of workspace and attributes from all four factors. A negative correlation between open plan workspace and control over ventilation and temperature suggests that scores on these attributes were lowest for buildings with larger proportions of open plan workspace (Spearman's rho, $p < 0.05$). This was to be expected, given that cellular workspaces had more localised controls (Chapter 4). There was, however, a weak negative correlation between the proportion of cellular workspace and scores for ventilation and thermal comfort (Spearman's rho, $p < 0.05$), indicating that buildings with higher proportions of cellular workspace had lower scores for both of these attributes. This was counter-intuitive because it was expected that the higher level of control found in cellular workspaces would result in better ventilation and greater thermal comfort.

A weak negative correlation between the proportion of open plan space and visual and conversational privacy suggests that scores for these attributes were lower in buildings with higher proportions of open plan space (Spearman's rho, $p < 0.01$). Conversely, a weak positive correlation between the proportion of cellular workspace and visual and conversational privacy suggests that scores for these attributes were higher in buildings with higher proportions of cellular workspace (Spearman's rho, $p < 0.01$). These results are in accordance with much of the established literature, which suggests that open plan workspaces are less supportive of conversational and visual privacy, due to, *inter alia*, higher occupant densities, fewer physical barriers and closer proximity of workstations (Oldham and Brass, 1979; Sundstrom *et al.*, 1980; Sundstrom *et al.*, 1982; Hedge, 1982; Oldham, 1988; Carlopio and Gardner, 1992; Sundstrom *et al.*, 1994; Olson, 2002). However, analysis of configuration attributes indicated that buildings with higher proportions of open plan space had higher scores for chance interaction and circulation and movement, whereas the proportion of cellular space was negatively correlated with both of these attributes (Spearman's rho, $p < 0.01$). Again, this supports the findings of previous which suggests that open plan workspaces are more conducive of interaction between colleagues (Nemecek and Gradnjean, 1973; Zahn, 1991; Olson, 2002), but highlights the trade-off between privacy on one hand and interaction on the other.

Table 5.10 shows the significant relationships between utility and the condition of elements in workspace areas. As was expected, the statistics indicate a weak negative correlation between the condition of workspace areas and aggregate utility scores of the sample buildings. There were also negative correlations with scores on the appearance factor, suggesting that buildings that were in the worst physical condition had the lowest scores on that factor.

Table 5.10: Correlation between utility and condition of workspace areas

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Walls	-.133(**)		-.178(**)		
Ceilings	-.110(**)		-.114(**)		
Floors	-.084(*)		-.119(**)		
Fixtures and fittings			-.105(**)		

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5.2.4 Summary

This section has examined the significant relationships between the utility and physical characteristics of the sample buildings. The analysis revealed that utility varied in accordance with differences in a number of construction, buildings services and workspace characteristics. These findings form the basis of further, multivariate analysis in Chapter 6. The next section in this chapter examines the relationships between the utility of the sample buildings and the characteristics of the buildings' occupants.

5.3 Relationship between workplace utility and occupant characteristics

The results presented in the previous section appear to support the hypothesis that variability in the utility of the sample of buildings can be explained by differences in the buildings' physical characteristics. However, an underlying premise of this study is that variability in the utility of the sample buildings can also be explained by differences in the characteristics of the buildings' occupants (H_6). The purpose of this section is to examine whether this is indeed the case. The statistics presented in this section relate to the aggregate utility scores (all factors) and the utility scores across each of the four individual factors. However, the analysis also examined the utility scores of the 22 individual attributes, the statistics for which are discussed below and included in Appendix L.

5.3.1 Occupant demographics

Analysis of utility and occupant demographics using Spearman's correlation coefficient revealed a number of statistically significant relationships (Table 5.11). A weak negative correlation between workplace utility and gender suggests that aggregate utility scores were lower for females than males. This was the case across each of the four factors, although the relationship was strongest for the environment factor. The relationship between utility and gender might be seen to be a function of the positive correlation between utility and grade, in that males are more likely than females to occupy higher grades (Chapter 4). Occupants at lower grades tended to spend more time doing repetitive routine tasks, using a telephone and working at a computer, activities that were all found to be negatively correlated with utility (see Section 5.3.1 below). Moreover, occupants at lower grades tended to share their workspace with more people in comparison with those at lower grades (Chapter 4). A weak negative correlation between utility and the number of people that occupants shared their workspace with suggests that the lowest aggregate utility scores were from occupants that shared their workspace with the most number of people.

Examination of individual attributes revealed weak negative correlations between the number of people that occupants shared their workspace with and scores on the environment attributes (Spearman's rho, $p < 0.01$). Occupants that shared their workspace with fewer people returned the highest scores for comfort and control over temperature and ventilation. This is understandable, given that control over heating and ventilation was found to be more centralised in open plan workspaces, which tended to accommodate larger numbers of occupants, and more localised in cellular workspaces, which contained fewer occupants. However, it does appear to contradict the result reported in Section 5.3.2, which suggested that scores for thermal comfort were lower in cellular workspaces.

Table 5.11: Correlation between utility and occupant demographics

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Gender	-.119(**)	-.150(**)	-.083(*)	-.076(*)	-.100(**)
Grade	.120(**)	.113(**)	.134(**)		.117(**)
Years in building		-.083(*)			
No. people shared workspace with	-.144(**)	-.167(**)	-.078(*)		-.198(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Occupants that shared their workspace with larger numbers of people also had lower scores for working free from distraction, conversational privacy and visual privacy than those occupants that had shared their workspace with a smaller number of people (Spearman's rho, $p < 0.01$). This was to be expected given that they were more likely to be working in open plan or group spaces, in which there tended to be fewer physical barriers, higher occupant densities and closer proximity of workstations (Sundstrom *et al.*, 1994). Occupants that shared their workspace with fewer people also returned higher scores for the amount of work, storage and team project space than occupants that shared their space with larger numbers of people (Spearman's rho, $p < 0.01$). Again, this was unsurprising, given that occupants that shared their workspace with fewer people tended to be at higher grades and would therefore have been provided with more work and storage space by virtue of their higher status within their organisation (Nathan, 2001).

5.3.2 Occupant working practices

The significant relationships between utility and occupants' working practices are shown in Table 5.12. Aggregate utility scores were negatively correlated with the proportion of time that occupants spent working at a computer, using a telephone or doing repetitive and routine tasks, indicating that the lowest aggregate utility scores were from occupants that had spent a higher proportion of their working day carrying out these activities. There was also a weak negative correlation between hours at desk and utility scores on the environment factor, suggesting that the lowest utility scores on this factor were from occupants that had spent the most number of hours working at their desk. However, a weak positive correlation between the time that occupants had spent working in groups and utility scores on the environment and appearance factors indicates that occupants that had spent a greater proportion of their time working in groups reported the highest levels of utility on both factors.

Table 5.12: Correlation between utility and occupant working practices

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
No. hours at desk		-.098(**)			
Repetitive and routine tasks	-.124(**)	-.149(**)	-.104(**)		-.136(**)
Using a computer	-.124(**)	-.178(**)	-.072(*)		-.081(*)
Using a telephone	-.148(**)	-.082(*)	-.078(*)	-.141(**)	-.205(**)
Working in groups		.087(**)	.073(*)		

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Analysis of individual attributes revealed weak negative correlations between hours at desk and the scores of all but one of the environment attributes, suggesting that the highest scores for these attributes were from occupants that had spent the least number of hours sat working at their desk (Spearman's rho, $p < 0.05$). There were also a number of negative correlations between functionality attributes and occupant working practices. For instance, occupants that spent a high proportion of their time doing repetitive and routine tasks, working at a computer or using a telephone had the lowest scores for working free from distraction (Spearman's rho, $p < 0.05$). They also had lower scores for conversational and visual privacy. This may reflect the fact that occupants that spent a higher proportion of their time doing these activities tended to work in open plan space, where distractions from colleagues are more likely and privacy is less so (Hedge, 1982; Brennan *et al.*, 2002). However, it may also be that occupants carrying out these activities require higher levels of concentration and are therefore more susceptible to distractions than other occupants (Sundstrom *et al.*, 1982).

A negative correlation between the time spent working out of the office and amount of storage space indicates that the lowest scores for this attribute were from occupants that spent a higher proportion of their time working out of the office (Spearman's rho, $p < 0.05$). Occupants that spent a higher proportion of their time working away from the office also had lower scores for access to and amount of informal meeting space (Spearman's rho, $p < 0.05$). This can be attributed to the fact that occupants that spent a high proportion of their time working out of the office had particularly high perceived workspace requirements (Chapter 4).

5.3.3 Attitudes to workplace issues

Table 5.13 shows the significant relationships between the utility scores of the sample buildings and occupants' attitudes to workplace issues. There was a weak negative correlation between occupants' perceived workspace requirements and the aggregate utility scores of the sample buildings, suggesting that the lowest utility scores were from those occupants with the highest perceived workspace requirements. The relationship between utility and perceived workspace requirements was strongest for the functionality factor, for which there was a weak moderate correlation. As might be expected, analysis of individual functionality attributes revealed moderate negative correlations between occupants' perceived workspace requirements and amount of work and storage space, indicating that the highest scores for these attributes were from occupants with the lowest perceived workspace requirements (Spearman's rho, $p < 0.01$).

Table 5.13: Correlation between utility and attitudes to workplace issues

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Workspace requirements	-.191(**)	-.107(**)	-.099(**)	-.171(**)	-.303(**)
Interaction with colleagues	-.103(**)	-.165(**)		-.080(*)	-.099(**)
Job satisfaction	.123(**)	.122(**)	.078(*)	.089(**)	.130(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

A weak negative correlation between aggregate utility scores and the importance that occupants placed on interacting with colleagues suggests that the lowest utility scores were from those occupants that placed the highest level of importance on interacting with their colleagues (Table 5.13). There were also weak negative correlations between the importance of interacting with colleagues and the scores on configuration attributes. For instance, occupants that placed a high level of importance on interacting with colleagues had the lowest scores for amount of informal meeting space (Spearman's rho, $p < 0.01$). This reflects the findings of previous research (Nathan, 2001) and might be attributed to the fact that occupants that placed a high level of importance on interacting with colleagues were generally at lower grades and were therefore less likely to be provided with informal meeting space.

The analysis revealed a weak positive correlation between aggregate utility scores and occupants' job satisfaction, indicating that the highest utility scores were from occupants that were most satisfied with their jobs. This was case for each of the four factors (Table 5.13). Analysis of individual attributes revealed that job satisfaction was positively correlated with the scores on five of the six environment attributes, indicating that the lowest scores on these attributes were from occupants that were less satisfied with their jobs. There was also a positive correlation between job satisfaction and functionality attributes, suggesting that occupants with high job satisfaction returned higher scores for working free from distraction, amount of work and storage space, and conversational and visual privacy (Spearman's rho, $p < 0.01$). These results are understandable in the light of previous studies, which have consistently shown a positive relationship between occupants' perceptions of their working environment and job satisfaction (Oldham and Brass, 1979; Oldham and Rotchford, 1983; Sundstrom *et al.*, 1980; Hedge, 1982; Oldham, 1988; Carlopio and Gardner, 1992; Sundstrom *et al.*, 1994; Leather *et al.*, 1998; Olson, 2002).

5.3.4 Summary

This section has explored the significant relationships between workplace utility and occupant characteristics. The analysis revealed that utility varied according to differences in occupants' demographic characteristics, working practices and attitudes to workplace issues. These findings form the basis of further, multivariate analysis in Chapter 6. The next section in this chapter examines the relationships between the operation costs and physical characteristics of the sample buildings.

5.4 Relationship between operation costs and property characteristics

Analysis of property operation costs in Chapter 4 revealed considerable variability in the costs and cost efficiency of the sample buildings. The purpose of this section is to examine the extent to which this variability can be explained by differences in the physical characteristics of the sample buildings (H_3). The statistics presented in this section relate to the total operation costs, total operation costs per floor area and total operation costs per person of the sample buildings. However, the analysis also examined variations in individual property operation cost items, the statistics for which are discussed below and included in Appendix M.

5.4.1 Construction characteristics

The variations in total operation costs for buildings with different structural characteristics are shown in Table 5.14. The values of the mean rankings suggest that buildings with loadbearing wall structures had significantly higher total operation costs per person than buildings with steel or concrete frames. In terms of internal sub-division, buildings with loadbearing walls or stud partitions had significantly lower total operation costs than those with lightweight demountable partitions. There were also moderate positive correlations between the age of buildings and a number of operation cost items. Insurance, cleaning, security, and water and sewerage costs were all higher in buildings that had been constructed more recently (Spearman's rho, $p < 0.05$).

Table 5.14: Association between building operation costs and structural characteristics

Mean rank	Total operation costs**	Total operation costs per floor area	Total operation costs per person*
Type of structure			
Steel/concrete frame			17
Loadbearing walls			29
Internal sub-division			
Lightweight demountable	37		
Stone/masonry/concrete	22		
Stud and sheet system	19		

* Kruskal-Wallis, $p < 0.01$
** Kruskal-Wallis, $p < 0.05$

Analysis of the total operation costs and spatial characteristics of the sample buildings using Spearman's correlation coefficient revealed a number of significant relationships (Table 5.15). The general pattern was one of increasing operation costs as the spatial dimensions of the sample buildings increased. Inevitably, there was a very strong positive correlation between the total operation costs and floor area (GIA and NIA) of the sample buildings. Analysis of individual cost items revealed moderate-strong positive correlations between floor area and each of the ten individual cost items (Spearman's rho, $p < 0.05$). There was also a moderate positive correlation between floor area and security costs per person and security costs per floor area (Spearman's rho, $p < 0.05$). However, a negative correlation between net internal area and cleaning costs per floor area suggests that the costs of cleaning decreased as the net internal area of the sample buildings increased, presumably due to economies of scale (Spearman's rho, $p < 0.05$).

As might have been expected, there was a moderate to strong positive correlation between the number of floors and total operation costs of the sample buildings (Table 5.15). Analysis of individual cost items revealed that the costs of insurance, minor improvements, cleaning, security and utilities all increased as the number of floors in buildings increased (Spearman's rho, $p < 0.01$). There was also a moderate positive correlation between total operation costs per person and the floor-to-ceiling height of the sample buildings. A moderate positive correlation between floor-to-ceiling height and cleaning costs per person suggests that the costs of cleaning increased as the floor-to-ceiling height of the buildings increased, possibly reflecting the additional time and effort required to clean high ceilings or higher specification finishes in buildings such as town halls (Spearman's rho, $p < 0.05$).

Table 5.15: Correlation between building operation costs and spatial characteristics

Spearman's rho	Total operation costs	Total operation costs per floor area	Total operation costs per person
Gross internal area	.931(**)		
Net internal area	.865(**)		
Floor plate efficiency	.367(*)		
Number of floors	.648(**)		
Floor-to-ceiling height		.306(*)	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 5.16 shows the relationship between the total operation costs and circulation characteristics of the sample buildings. The statistics reveal that total operation increased as the number of lifts and staircases, and travel distances increased. This was expected because buildings with larger floor areas tend to have more lifts and staircases, and longer travel distances. There were also a number of moderate to strong positive relationships between circulation characteristics and individual operation cost items. For instance, the costs of utilities (water and sewerage, electricity and gas) all increased as circulation characteristics increased (Spearman's rho, $p < 0.01$).

Table 5.16: Correlation between building operation costs and circulation characteristics

Spearman's rho	Total operation costs	Total operation costs per floor area	Total operation costs per person
No. of lifts	.584(*)		
No. staircases	.491(**)		
Travelling distance	.354(*)		

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Analysis of the operation costs and window characteristics of the sample buildings revealed that total operation costs increased as the number of exterior windows in buildings increased (Table 5.17). Again, this was expected because buildings with larger floor areas tended to have more extensive perimeter walls and, consequently, more windows. Heating and cooling loads also tend to increase as the number of windows in a building increase, resulting in higher utilities costs. Total operation costs per person were higher for buildings with larger windows and window units that were in poorer physical condition. Predictably, total operation costs per person were lower for buildings with double glazing.

Table 5.17: Correlation between building operation costs and window characteristics

Spearman's rho	Total operation costs	Total operation costs per floor area	Total operation costs per person
Window width			.330(*)
Window height			.430(*)
No. windows per floor	.806(*)		
Condition of exterior windows			.410(*)
Glazing type			-.373(*)
Natural ventilation	.334(*)		

* Correlation is significant at the 0.05 level (2-tailed).

Buildings that were ventilated naturally via openable window units also had significantly lower total operation costs (Table 5.17). This is consistent with the established body of evidence concerning the cost advantages of naturally ventilated buildings (BCO, 2000; Bordass, 2000). Analysis of individual cost attributes revealed that buildings with wet heating systems and natural ventilation had significantly lower electricity costs per person and floor area than buildings with alternative systems, such as full air-conditioning (Spearman's rho, $p < 0.05$).

5.4.2 Building amenities

Table 5.18 shows the significant relationships between the operation costs and security provisions in the sample buildings. The statistics indicate that total operation costs were higher for buildings with active security provisions, such as security guards or closed-circuit television systems, reflecting the additional staff costs that such systems entail. Analysis of individual cost items suggests, unsurprisingly, that security costs were higher for buildings with security guards or reception desks (Spearman's rho, $p < 0.05$). Security costs per person were also higher for buildings without swipe card access provisions (Spearman's rho, $p < 0.05$).

The relationships between total operation costs and car parking provisions are shown in Table 5.19. There is a weak positive correlation between the number of car parking spaces and the total operation costs of the sample buildings. This may be explained by the fact that larger buildings tended to have a larger number of car parking spaces. Total operational costs were also higher for buildings with indoor car parking facilities or attended control stations, as were security costs (Spearman's rho, $p < 0.05$).

Table 5.18: Correlation between building operation costs and security provisions

Spearman's rho	Total operation costs	Total operation costs per person	Total operation costs per person
No security provision	.385(*)		
Door control (intercom)			-.300(*)
Security guard	-.388(*)		
CCTV	-.323(*)		
Swipe card			.349(*)

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.19: Correlation between building operation costs and car parking provisions

Spearman's rho	Total operation costs	Total operation costs per person	Total operation costs per floor area
No. car parking spaces	.293(*)		
Indoor parking	-.468(**)		
Attended control station	-.411(**)		

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 5.20 shows the significant relationships between common amenities and building operation costs. The table reveals a positive correlation between the number of w.c. units and total operation costs. This was expected because larger buildings tended to have more w.c. units. Consequently, a number of individual cost items, such as cleaning or water and sewerage, were also positive correlated with this characteristic (Spearman's rho, $p < 0.01$).

Table 5.20: Correlation between building operation costs and common amenities

Spearman's rho	Total operation costs	Total operation costs per person	Total operation costs per floor area
No. of W.C units	.666(*)		
Kitchenette(s)	.444(**)		
Multiple kitchens/lunch rooms	-.478(**)		
Cafeteria/restaurant	-.350(*)		
No provision of informal seating			-.322(*)
Condition of floor finishes in common areas	.327(*)	.337(*)	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Buildings with kitchenette facilities had lower total operation costs than those with lunchrooms or restaurants. Again, this could be attributed to differences in the floor area of the sample buildings. Total operation costs per floor area were lower for buildings without informal seating provisions, perhaps reflecting the cost advantages of higher occupant densities (see Section 5.4.3 below). Finally, total operation costs per person tended to be highest for buildings with floor surfaces that were in the poorest condition. This might be due to the additional effort required to clean such surfaces; cleaning costs were significantly higher for buildings with floor surfaces that were in poor condition (Spearman's rho, $p < 0.01$).

5.4.3 Summary

This section has examined the significant relationships between the operation costs and physical characteristics of the sample buildings. The analysis revealed that variability in property operation costs can be explained by differences in a number of construction characteristics and building amenities. These findings form the basis of further, multivariate analysis in Chapter 6. The next section in this chapter examines the relationships between the operation costs and occupancy characteristics of the sample buildings.

5.5 Relationship between operation costs and occupancy characteristics

The statistics presented in the previous section add support to the hypothesis that variability in the operation costs of the sample of buildings can be explained by differences in the buildings' physical characteristics. However, an underlying premise of this study is that variability in the property operation costs of the sample buildings can also be explained by differences in occupancy characteristics (H_4). The purpose of this section is to examine whether this is indeed the case. The statistics described in this section relate to the total operation costs, operation costs per floor area and operation costs per person for the sample buildings. However, the analysis also examined individual property operation cost items, the statistics for which are discussed below and included in Appendix N.

5.5.1 Occupancy characteristics

Table 5.21 shows the significant relationships between the operation costs and occupancy characteristics of the sample buildings. The statistics indicate that total operation costs were positively correlated with the number of floors occupied and the number of full time equivalent staff. This was to be expected given that buildings with larger floor areas, and hence higher overall operation costs, tended to have more floors and accommodate more people. There was, nevertheless, a moderate negative correlation between the number of full time equivalent staff and total operation costs per person, suggesting buildings accommodating more people had lower operation costs per person than those accommodating fewer people. Total operation costs per person were also lower for those buildings occupied on a leasehold basis or with higher occupant densities, reflecting the findings of previous research (Bootle and Kaylan, 2002). However, total operation costs per floor area decreased as occupant densities decreased and building operating hours increased.

Table 5.21: Correlation building operation costs and occupancy characteristics

Spearman's rho	Total operation costs	Total operation costs per person	Total operation costs per floor area
Floors occupied	.656(**)		
Listed		-.351(*)	-.345(*)
Years occupied	.386(*)		-.548(**)
Occupation type		-.469(**)	
FTE staff	.890(**)	-.358(*)	
Operating hours			-.524(**)
Occupant density		.457(**)	-.621(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Analysis of individual operation cost items revealed that most increased as the number of floors occupied and number of full time equivalent staff increased (Spearman's rho, $p < 0.01$), a relationship that was particularly strong for the costs of cleaning and utilities. Operation costs per floors area were negatively correlated with building operating hours and occupant density. For instance, cleaning and utilities costs per floor area decreased as building operating hours increased and occupant density decreased (Spearman's rho, $p < 0.01$). Finally, buildings that were occupied on a leasehold basis generally had lower cleaning, waste disposal, grounds maintenance and utilities costs than those occupied on a freehold basis (Spearman's rho, $p < 0.01$).

5.5.2 Summary

This section has examined the significant relationships between the operation costs and occupancy characteristics of the sample buildings. The analysis revealed that variability in property operation costs can be explained by differences in a number of occupancy characteristics. These findings form the basis of further, multivariate analysis in Chapter 6. The next section in this chapter draws conclusions from the statistical analysis presented in this and earlier sections.

5.6 Conclusion

The purpose of this chapter was to analyse the hypothesised bivariate relationships underpinning the theoretical framework in Chapter 3. These relationships provide the foundation for explaining the differential impact of obsolescence, that is to say why some buildings exhibit higher or lower levels of performance than others. The bivariate analysis was conducted using data from a sample of local authority office buildings described in Chapter 4 and focused on the relationships between:

- the utility and physical characteristics of the buildings (H_5);
- the utility and characteristics of the buildings' occupants (H_6);
- the operation costs and physical characteristics of the buildings (H_3); and
- the operation costs and occupancy characteristics of the buildings (H_2).

The analysis revealed a considerable number of statistically significant relationships, summarised in Table 5.22. The principal conclusions arising from the analysis are discussed below.

Analysis of the relationships between the utility and physical characteristics of the sample buildings supports the hypothesis that the physical characteristics of a building can be used to explain its utility relative to a group of similar buildings (H_5). Workplace utility was found to be correlated with a range of construction, building services and workspace characteristics, the details of which vary from building to building. However, interpretation of the statistics was complicated by the fact that many building characteristics are intercorrelated. Physical characteristics such as depth of space from perimeter, type of workspace and method of ventilation all depend on each other to a greater or lesser extent, resulting in groups of statistical interdependencies that can be difficult to disentangle (Leaman and Bordass, 1999). Take, for instance, what was considered by occupants to be the most important workplace attribute. Variability in the scores for responsiveness to changes in temperature can explained by a number of different physical characteristics, including the type of heating and ventilation system, floor-to-ceiling height, type of exterior walls, arrangement of structure and method of internal sub-division. So whilst logic suggests that responsiveness to changes in temperature is most likely to be affected by the type of heating and ventilation system, this in itself will be affected by the other physical characteristics listed previously.

Notwithstanding these complications, the analysis still provided an insight into which physical characteristics were associated with higher or lower levels of workplace utility. The results indicate that variability in the scores for different workplace attributes can be explained by different combinations of physical characteristics (Table 5.22). For the most part, the age and physical condition of the sample buildings were only found to correlate with scores on the appearance factors and attributes, but not with scores on the other three factors. Instead, variability in scores on the environment, configuration and functionality attributes were explained by other building characteristics such as internal layout, type of engineering services and specification of interior and exterior finishes.

Table 5.22: Summary of significant relationships from Chapter 5

Characteristic	All factors	Environment	Appearance	Configuration	Functionality	Total operation costs	Total operation costs per floor area	Total operation costs per person
Physical characteristic	(+)							
Period of construction	(-)		(+)		(-)			
Condition of site			(-)					
Type of structure								
Arrangement of structure								
Internal sub-division								
Exterior walls								
Condition of exterior walls			(-)					
Exterior windows								
Condition of exterior windows			(-)					(+)
Exterior doors								
Condition of exterior doors	(-)		(-)					
Glazing type								(-)
Number of lifts	(-)			(-)		(+)		
Lift capacity	(-)			(-)				
Number of staircases	(-)			(-)		(+)		
Travelling distance						(+)		
Corridor width	(+)							
Number of floors	(-)	(-)	(-)	(-)	(-)	(+)		
Floor-to-ceiling height	(+)	(+)	(+)	(+)	(+)		(+)	
Building depth			(+)					

Table 5.22 (continued)

	All factors	Environment	Appearance	Configuration	Functionality	Total operation costs	Total operation costs per floor area	Total operation costs per person
Gross internal area	(-)	(-)	(-)			(+)		
Net internal area	(-)	(-)	(-)			(+)		
Floor plate efficiency	(+)	(+)	(+)		(+)	(+)		
Occupant density			(-)	(+)	(+)			
Wet heating	(-)	(-)						
Natural ventilation	(-)	(-)				(+)		
Air-conditioning (split-units)	(-)	(-)						
Heating control	(+)	(+)						
Window width								(+)
Window height								(+)
Number of windows per floor						(+)		
Percentage openable windows	(+)	(+)						
Condition of walls in common areas	(-)		(-)					
Condition of ceilings in common areas	(-)		(-)					
Condition of floors in common areas	(-)		(-)			(+)	(+)	
Condition of fixtures/fittings in common areas	(-)		(-)					
No security provision						(+)		
Door control (intercom)								(-)
Security guard						(-)		
CCTV						(-)		
Swipe card								(+)

Table 5.22 (continued)

	All factors	Environment	Appearance	Configuration	Functionality	Total operation costs	Total operation costs per person	Total operation costs per person
Number of car parking spaces						(+)		
Indoor car parking						(-)		
Attended control station						(-)		
No. of W.C units						(+)		
Kitchenette(s)						(+)		
Multiple kitchens/lunch rooms						(-)		
Cafeteria/restaurant						(-)		
No provision of informal seating								(-)
Open plan space			(+)	(+)	(-)			
Group space		(+)	(-)		(+)			
Cellular space	(-)		(-)	(-)				
Condition of walls in workspace areas	(-)		(-)					
Condition of ceilings in workspace areas	(-)		(-)					
Condition of floors in workspace areas	(-)		(-)					
Condition of fixtures/fittings in workspace areas			(-)					
Occupancy characteristic								
Floors occupied						(+)		
Listed							(-)	(-)
Years occupied						(+)		(-)
Occupancy type							(-)	
Full time equivalent staff						(+)	(-)	

Table 5.22 (continued)

	All factors	Environment	Appearance	Configuration	Functionality	Total operation costs	Total operation costs per floor area	Total operation costs per person
Operating hours								(-)
Occupant density							(+)	(-)
Occupant characteristic								
Gender	(-)	(-)	(-)	(-)	(-)			
Grade	(+)	(+)	(+)		(+)			
Years in buildings		(-)						
Number of people shared workspace with	(-)	(-)	(-)		(-)			
Number of hours at desk		(-)						
Repetitive and routine tasks	(-)	(-)	(-)		(-)			
Using a computer	(-)	(-)	(-)		(-)			
Using a telephone	(-)	(-)	(-)	(-)	(-)			
Working in groups		(+)	(+)					
Perceived space requirements	(-)	(-)	(-)	(-)	(-)			
Interaction with colleagues	(-)	(-)		(-)	(-)			
Job satisfaction	(+)	(+)	(+)	(+)	(+)			

Note: Shading indicates relationships where $p < 0.05$
(+) indicates a positive correlation
(-) indicates a negative correlation

This might explain why previous studies into property depreciation have shown that the age and condition of buildings provide only a limited explanation of obsolescence, and that other physical characteristics provide a much better explanation of a buildings relative utility (Baum, 1991; Khalid, 1994; Bottom *et al.*, 1999).

Chapter 4 drew attention to the potential conflict between interaction and distraction in the workplace, whereby occupants generally placed a high level of importance on interacting with their colleagues, but also on being able to work free from distraction. Olson (2002), who also identified the potential conflict between interaction and distraction, concluded that the use of open plan workspace was the problem and cellular workspace the most practical solution, enabling occupants to interact without disturbing others. However, the results presented in this chapter do not support this conclusion. As might be expected, chance interaction is negatively correlated with cellular workspace, but positively correlated with open plan workspace, suggesting that open plan workspaces are more conducive to chance interaction. Similarly, both conversational and visual privacy are positively and negatively correlated with cellular and open plan workspace, respectively, indicating that cellular workspaces provided higher levels of privacy. However, there is no correlation between distraction and cellular or open plan workspace. Indeed, group workspace (4-12 workstations) is positively correlated with scores on the distraction attribute.

The utility of the sample buildings was also found to vary in accordance with different occupant characteristics (H_6). Variability in the scores for different workplace attributes can be explained by different combinations of occupant characteristics (Table 5.22). Nevertheless, intercorrelation between different occupant characteristics again made interpretation of the statistics difficult. For instance, the negative correlation between gender and scores on the conversational and visual privacy attributes must be interpreted in the light of the fact that gender was intercorrelated with other occupant characteristics, such as time spent doing repetitive and routine tasks, number of people that occupants shared their workspace with and the time that occupants spent working at their desks. So the negative relationship between gender and scores for conversational and visual privacy might be explained by the fact that females are more likely to be working in open plan or group spaces, in which there tended to be fewer physical barriers, higher occupant densities and closer proximity of workstations, whilst carrying out tasks that require higher levels of privacy. This implies an interaction between occupant characteristics, physical characteristics and utility, a hypothesis that is explored further in Chapter 6.

Analysis of property occupation costs indicated that variability in the total costs and cost efficiency of the sample buildings could be explained by particular occupancy characteristics and physical characteristics (*H_2 and H_3*, respectively). As was expected, total operation costs and individual cost items were positively correlated with the spatial characteristics of the sample buildings, such as floor area and the number of floors. The cost efficiency of the sample buildings tended to be correlated with a different group of physical characteristics, such as window characteristics, building services provisions and common amenities. The results of the analysis are therefore an improvement over those from previous research by Purkis *et al.* (1977), who analysed data for 28 government office buildings and concluded that 'there was little correlation between costs and the physical characteristics of the buildings'. This improvement may be due to the wider range of physical characteristics analysed in this study.

The cost efficiency of the sample buildings was also found to be correlated with a number of occupancy characteristics, such as occupant density and occupation type. Indeed, the results of this study tend to support the established view that leasehold occupation is associated with higher cost efficiency than freehold occupation (Bootle and Kaylan, 2002). Occupant density was also positively correlated with cost efficiency, a potential conflict given that occupant density was negatively correlated with utility. This suggests that increasing occupant density to improve cost efficiency is likely to be false economy if it leads to reduced functional performance, particular in view of the fact that property occupancy costs are relatively insignificant in comparison with staff and other business costs (Williams, 2003). The implementation of new working practices, such as hot desking and home working, might provide a possible solution to this conflict.

In summary, therefore, the bivariate analysis presented in this chapter has shown that variability in the utility of the sample buildings can be explained by differences in the buildings' physical characteristics and the characteristics of the buildings' occupants. It has also demonstrated that variability in the operation costs of the sample buildings can be explained by differences in the buildings' physical characteristics and occupancy characteristics. The next chapter examines whether a better explanation of these relationships can be attained through the use of multivariate statistical analysis, in which the explanatory variables are analysed concurrently.

References

Al-Hamdani, N.I. and Ahmad, A.I. (1987) Effect of window parameters on indoor thermal environment of buildings, *Solar & Wind Technology*, **4** (1), 71-75.

Baum, A. (1991) *Property investment depreciation and obsolescence*, Routledge, London.

BCO (2000) *Best practice in the specification for offices*, Third Edition, British Council for Offices, Reading.

Bootle, R. and Kalyan, S. (2002) *Property in business - a waste of space?*, The Royal Institution of Chartered Surveyors, London.

Bordass, B. (2000) Cost and value: Fact and fiction, *Building Research & Information*, **28** (5/6), 338-352.

Bordass, B. and Leaman, A. (1997) Design for manageability, *Building Research & Information*, **25** (3), 148-157.

Bordass, B., Leaman, A. and Ruyssevelt, P. (2001) Assessing building performance in use 5: conclusions and implications, *Building Research & Information*, **29** (2), 144-157.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999) Appraising the functional performance characteristics of office buildings, *Journal of Property Research*, **16** (4), 339-358.

Brennan, A., Chugh, J. and Kline, T. (2002) Traditional versus open office design: A longitudinal field study, *Environment and Behavior*, **34** (3), 279-299.

Bryson, J.R. (1997) Obsolescence and the process of creative reconstruction, *Urban Studies*, **34** (9), 1439-1458.

Carlopio, J.R. and Gardner, D. (1992) Direct and interactive effects of the physical work environment on attitudes, *Environment and Behavior*, **24** (5), 579-601.

Dunse, N. and Jones, C. (2002) Rental depreciation, obsolescence and location: the case of industrial properties, *In proceedings of European Real Estate Society Conference*, Glasgow.

Fuchs, H.V., Zha, X., Zhou, X. and Drotleff, H. (2001) Creating low-noise environments in communication rooms, *Applied Acoustics*, **62**, 1375-1396.

Hatch, M.J. (1987) Physical barriers, task characteristics and interaction activity in research and development firms, Administrative Science Quarterly, **32**, 387-399.

Hedge, A. (1982) The open-plan office: A systematic investigation of employee reactions to their work environment, *Environment and Behavior*, **14** (5), 519-542.

Humphreys, M (1976) Fields studies of thermal comfort compared and applied, *Building Services Engineer*, **44**, 5-27.

Khalid, G. (1994) Obsolescence in hedonic price estimation of the financial impact of commercial office buildings: The case of Kuala Lumpa, *Construction Management and Economics*, **12**, 37-44.

Leaman, A. and Bordass, B. (1999) Productivity in buildings: the 'killer' variables, *Building Research & Information*, **27** (1), 4-19.

Leather, P., Pyrgas, M., Beale, D. and Lawrence, C. (1998) Windows in the workplace: Sunlight, view and occupational stress, *Environment and Behavior*, **30** (6), 739-762.

Nathan, M. (2002) *The state of the office*, The Industrial Society, London.

Nemecek, J. and Grandjean, E. (1973) Results of an ergonomic investigation of large-space offices, *Human Factors*, **15** (2), 111-124.

Oldham, G.R. (1988) Effects of changes in workspace partitions and spatial density on employee reactions: A quasi-experiment, *Journal of Applied Psychology*, **73**, 253-258.

Oldham, G.R. and Brass, D.J. (1979) Employee reactions to an open-plan office: a naturally occurring quasi-experiment, *Administrative Science Quarterly*, **24**, 267-284.

Oldham, G.R. and Rotchford, N.L. (1983) Relationships between office characteristics and employee reactions: A study of the physical environment, *Administrative Science Quarterly*, **28**, 542-556.

Olson, J. (2002) Research about office workplace activities important to US business -And how to support them, Journal of Facilities Management, **1** (1), 31-47.

Purkis, H.J., How, R.F.C., Hooper, N.J. and Poole, M.T. (1977) *Occupancy costs of offices*, Current Paper CP 44/77, Building Research Establishment, Watford.

Salway, F. (1986) *Depreciation of commercial property*, The College of Estate Management, Reading.

Shpuza, E. (2003) Lights, views and money: Average perimeter distance and its relation to floor plate geometry, *Fourth International Space Syntax Symposium*, University College London, London.

Sundstrom, E., Burt, R.E. and Kamp, D. (1980) Privacy at work: architectural correlates of job satisfaction and job performance, *Academy of Management Journal*, **23** (1), 101-117.

Sundstrom, E., Town, J.P., Brown, D.W., Forman, A. and McGee, C. (1982) Physical enclosure, type of job, and privacy in the office, *Environment and Behavior*, **14** (5), 543-559.

Sundstrom, E., Town, J.P., Rice, R.W., Osborn, D.P. and Brill, M. (1994) Office noise, satisfaction and performance, *Environment and Behavior*, **26** (2), 195-222.

Vogt, W.P. (1999) *Dictionary of statistics & methodology*, Sage Publications, London.

Williams, B. (2003) *Facilities economics in the UK*, Building Economics Bureau Ltd, Bromley.

Zahn, L.G. (1991) Face to face communication in an office setting: The effects of position, proximity and exposure, *Communications Research*, **18**, 737-754.

Chapter 6
Statistical modelling

Chapter 6 Statistical modelling

6.1 Introduction

Chapter 5 presented the results of the bivariate analysis of data from a sample of local authority buildings. The analysis supported the bivariate hypothesised relationships put forward in Chapter 3, which suggested that that variability in the functional performance (utility) and financial performance (operation costs) of a group of buildings could be explained by differences in the buildings' physical characteristics and the characteristics of the occupants and organisations using the buildings. These relationships form the basis for explaining the differential impact of obsolescence, that is to say why some buildings exhibit higher levels of performance than others. The purpose of this chapter is to determine whether a better explanation of these relationships can be attained through the use of multivariate statistical techniques, in which explanatory variables are analysed concurrently.

Multivariate statistical techniques enable the analysis of two more explanatory variables at the same time. They can be used to examine the relationship between two variables, while controlling for how each of the variables might be influenced by other variables (Vogt, 1999). The potential for applying multivariate techniques in this study is apparent in the light of the results of the bivariate analysis presented in Chapter 5. For example, whilst variability in the utility of the sample buildings was explained by using variables representing the buildings' physical characteristics and the characteristics of the buildings' occupants, the analysis stopped short of examining whether any interaction between these variables could provide a better explanation of a building's utility. Multivariate analysis can be used to examine whether this is the case or not.

Deciding which multivariate technique to use depends on the nature of the research problem and the types of variables to be included in the analysis (Hair *et al.*, 1995). Multiple regression analysis was employed in this study because it can be used to explain the variation of a continuous outcome variable using two or more continuous explanatory variables[39] (Hair *et al.*, 1995; Fielding and Gilbert, 2000; Miles and Shevlin, 2001). The technique has also been applied successfully in previous studies of property depreciation and obsolescence (Chapter 2). Multiple regression analysis is employed in this study to model the hypothesised multivariate relationships (H_1 *and* H_4) that were described in Chapter 3 and summarised in Figure 6.1.

[39] The statistical principles underpinning multiple regression analysis are explained in Appendix J.

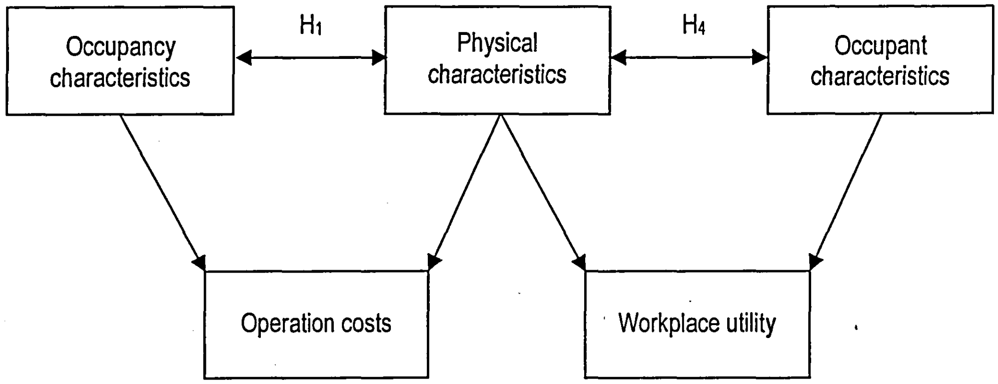


Figure 6.1: Summary of hypothesised multivariate relationships

Figure 6.2 provides a summary of the multiple regression analysis, the stages of which form the basis of this chapter. This chapter begins by explaining the selection and treatment of variables that were included in the multiple regression analysis (Section 6.2.1). It also describes the method that was used to enter variables into the models (Section 6.2.2). This is followed by refinement of the models by identifying outliers and eliminating influential cases (Section 6.2.3). The models are then interpreted, and examined using graphical and statistical techniques to determine whether they satisfy the assumptions of multiple regression analysis (Section 6.2.4 and 6.2.5). Before concluding, this chapter discusses the validity of the models (Section 6.2.6).

6.2 Multiple regression analysis

6.2.1 Selection of variables

Multiple regression analysis is a technique that is used to explain the variation of a outcome variable using two or more explanatory variables. Each explanatory variable is weighted, the weights being representative of the variables relative contribution to the model. Eight outcome variables were selected in this study, five relating to workplace utility (all factors, environment, appearance, configuration, functionality) and three to property operation costs (total operation costs, total operation costs per person and total operation costs per floor area). These aggregate measures were selected in preference to individual workplace utility attributes or cost items so as to make the analysis more manageable. A total of 87 explanatory variables were included in the analysis. These were selected on the basis that they might explain variations in the utility or total operation costs of the sample buildings.

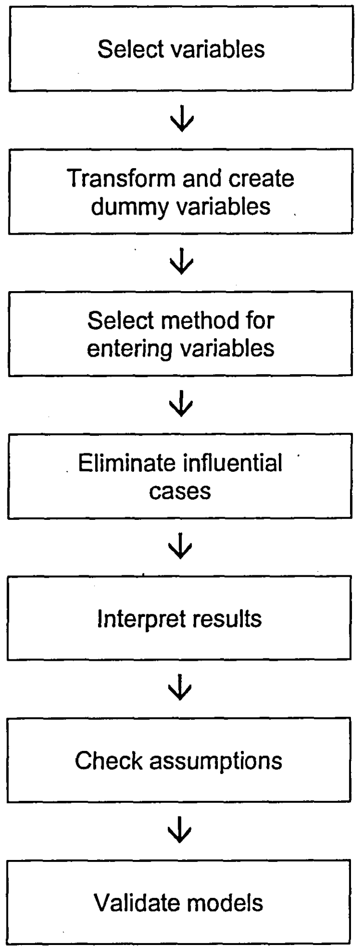


Figure 6.2: Stages in the multiple regression analysis

One of the principal assumptions underpinning the use of multiple regression analysis concerns the level of measurement of variables included in the analysis, namely that the outcome and explanatory variables should be measured on a continuous (ratio or interval) scale (Hair *et al.*, 1995; Miles and Shevlin, 2001). The outcome variables and a large proportion of explanatory variables were continuous. However, a number of categorical variables were also present. The conventional approach to overcoming this problem is to create dummy variables (Fielding and Gilbert, 2000). These are dichotomous variables, coded 1 to indicate the presence of an attribute and 0 to indicate its absence (Vogt, 1999). A number of dummy variables were therefore created to represent the categorical variables in the analysis.

A further prerequisite to multiple regression analysis is that the outcome variables are normally distributed. Visual examination of the five workplace utility variables revealed that each one departed from a normal distribution, with a very high proportion of scores below 1 (Figure 6.3). It was therefore necessary to transform the variables by modifying the scores mathematically. Although there is controversy surrounding this approach, it was felt to be justifiable given the impact that the distributions would have on the results of the multiple regression analysis[40] (Pallant, 2001). A logarithmic transformation of each variable resulted in five new variables with distributions closer to the normal distribution (Figure 6.4). These new variables formed the basis of the five workplace utility models described below.

Examination of the three property operation cost variables revealed that two (total operation costs and total operation costs per person) departed from a normal distribution (Figure 6.5). A logarithmic transformation of the total operation cost variable and square root transformation of the total operation cost per person variable resulted in two new variables with distributions closer to normal (Figure 6.6). These two variables, together with the un-transformed total operation costs per floor area variable, formed the basis of the three property operation cost models described below. Any explanatory variables that departed from a normal distributed were also transformed. A schedule of outcome and explanatory variables included in the analysis is in Appendix O.

6.2.2 Specification of models

The method of specification employed in the multiple regression analysis determines the way in which explanatory variables are entered into the model. Field (2000) identified three principal methods of variable entry. These were:

- hierarchical (blockwise entry), where the explanatory variables are entered into the model in a sequence specified by the researcher, based on their (theoretical) order of importance;
- forced entry, where the explanatory variables are entered into the model simultaneously; and
- stepwise, where the variables are entered into the model automatically based on a set of statistical criteria[41].

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[40] If the variables were not normally distributed this could impact on the accuracy of standard errors and significance tests (Miles and Shevlin, 2001).

[41] Stepwise regression combines the methods of backwards elimination, where the explanatory variables are all entered at once and then removed one by one, and forward selection, where the variables are added one at a time (Vogt, 1999).

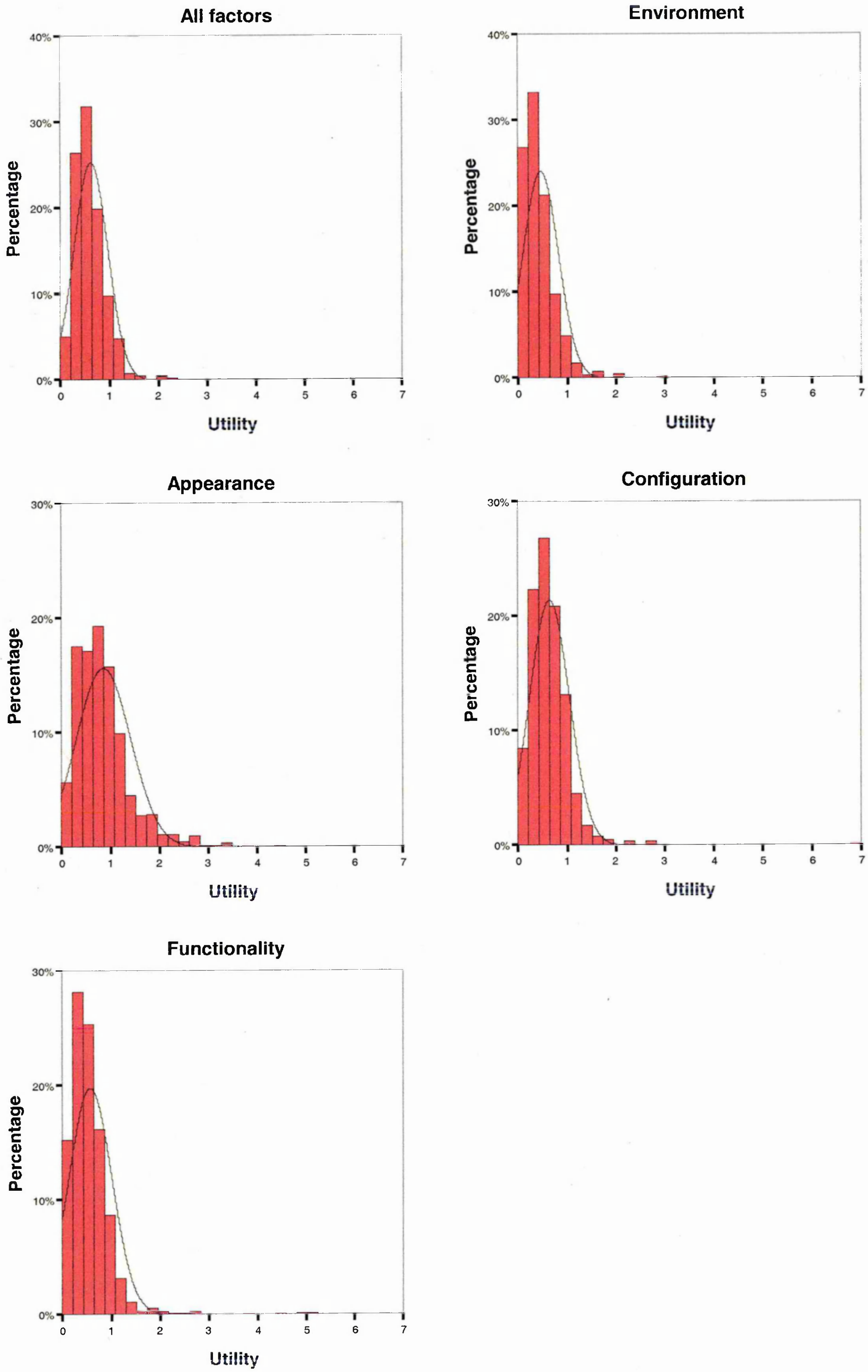

Figure 6.3: Distribution of workplace utility variables prior to transformation

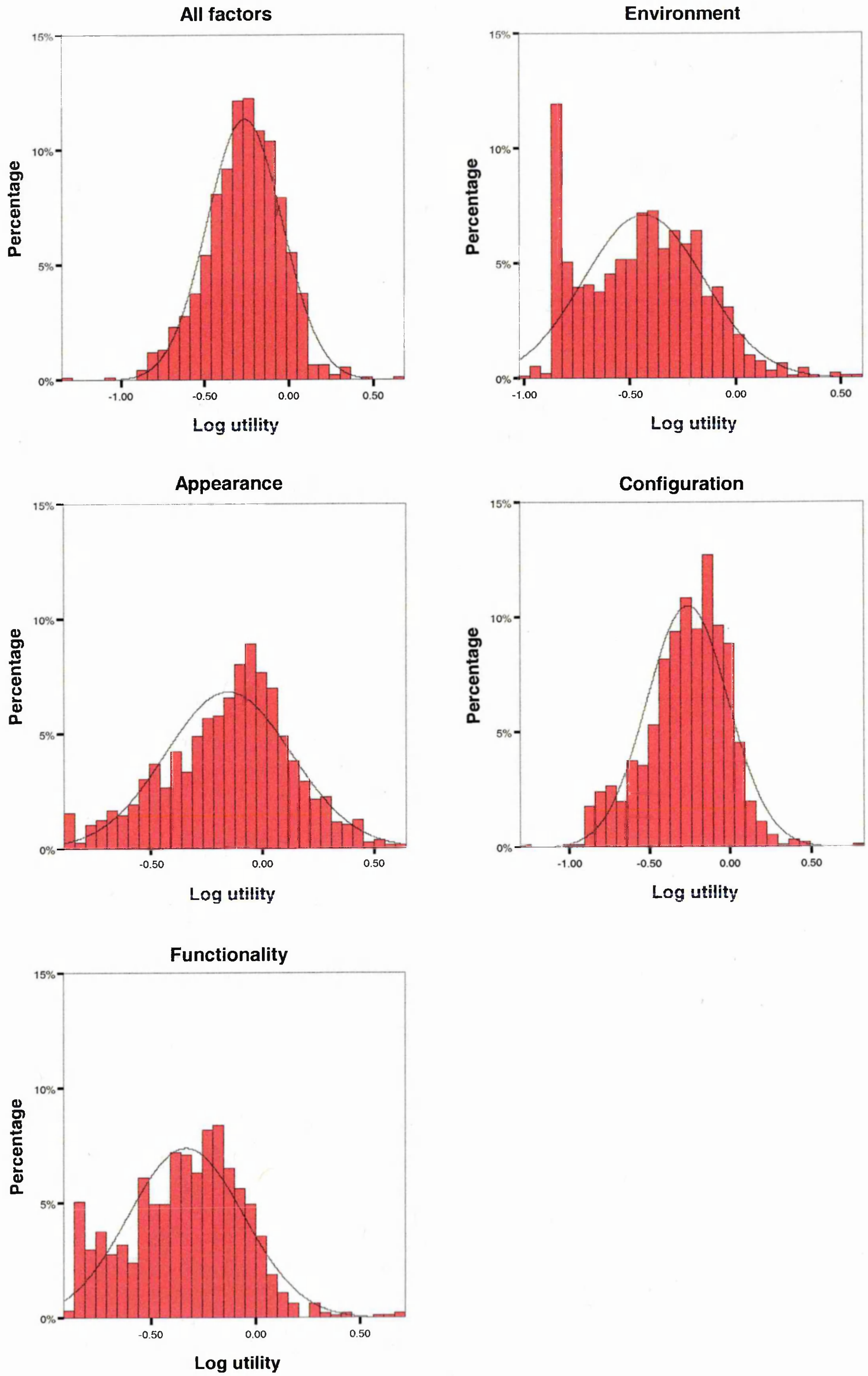

Figure 6.4: Distribution of workplace utility variables post transformation

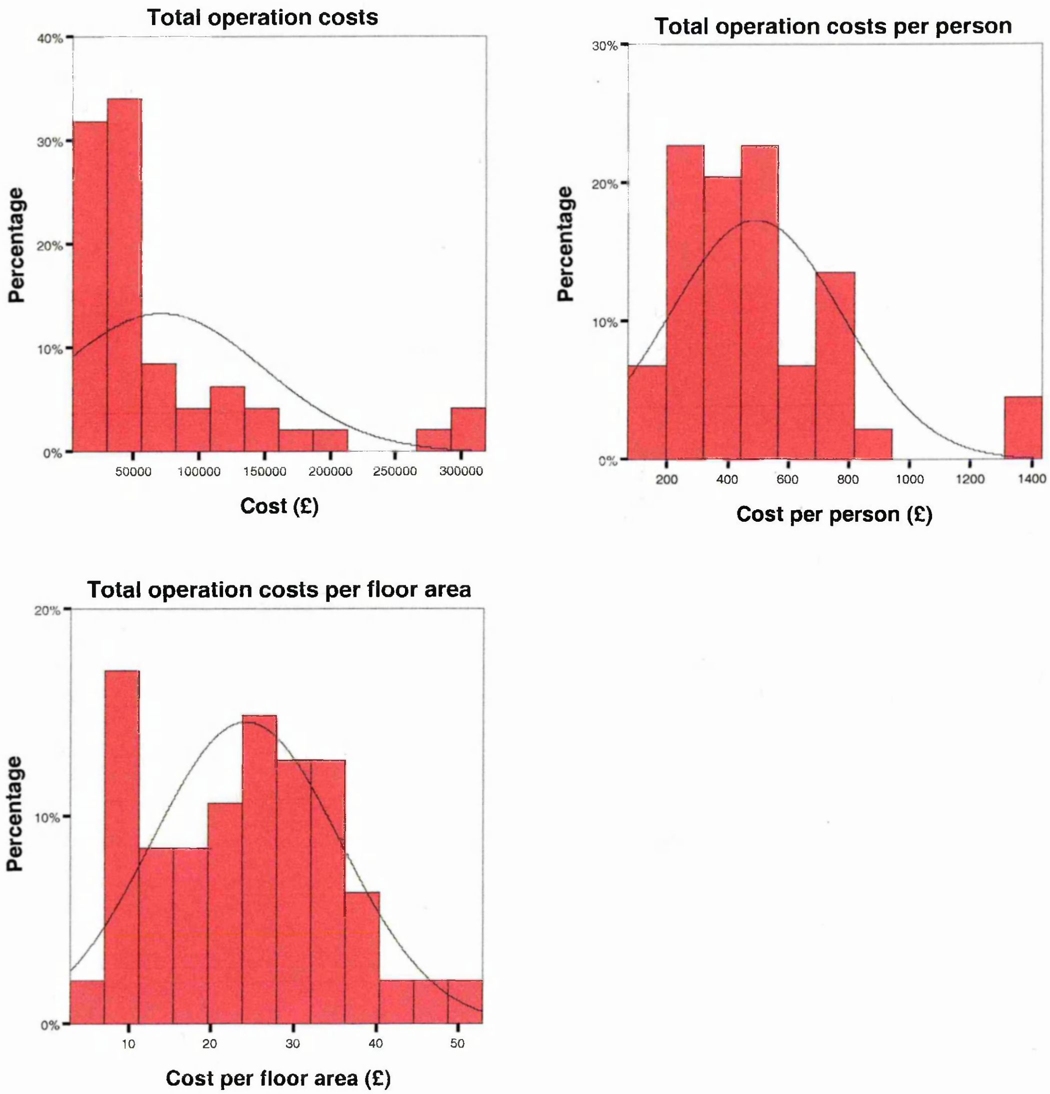

Figure 6.5: Distribution of total operation cost variables prior to transformation

Stepwise methods are most suited to exploratory model building and were therefore deemed suitable for use in this study (Field, 2000). However, stepwise methods have been criticised because they take many decisions out of the hands of the researcher (Hair *et al.*, 1995). Moreover, the models derived from stepwise regression often take advantage of random sampling variations, so that the outcomes might not always be theoretically meaningful (Field, 2000). Hierarchical regression and forced entry methods are often employed instead to ensure that only variables with a strong theoretical grounding were included in the analysis (Field, 2000). A compromise approach was adopted in this study, whereby only theoretically meaningful variables were subjected to stepwise analysis. This was an iterative process, resulting in the development of numerous models for each outcome variable. The best model for each outcome variable, defined as the model providing the highest level of explanation with the least number of significant explanatory variables, was further refined by identifying outliers and eliminating influential cases.

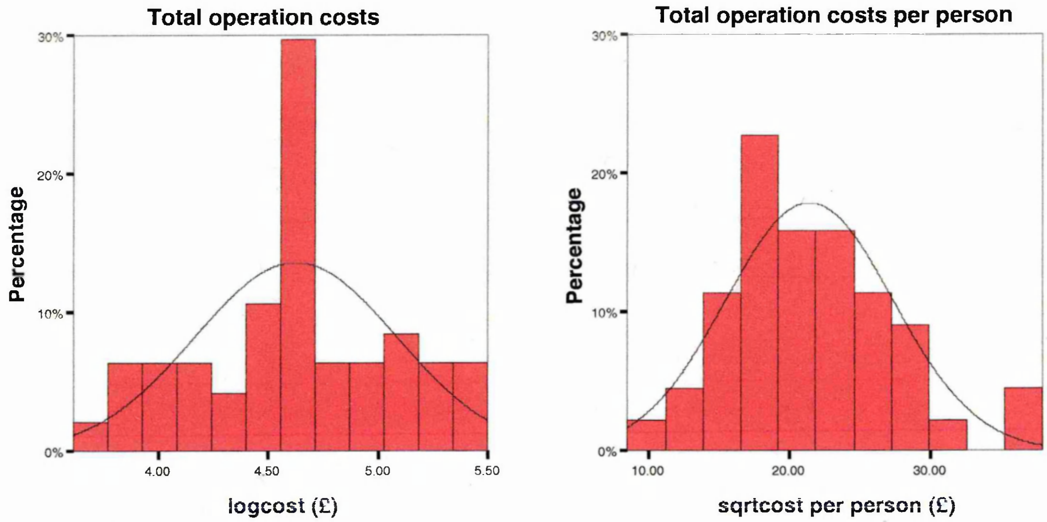

Figure 6.6: Distribution of total operation cost variables post transformation

6.2.3 Elimination of influential cases

Outliers are cases that differ from the general trend of the data (Field, 2000). The existence of outliers is problematic because they can introduce bias into a model (Hair *et al.*, 1995). Omitting outliers can have a substantial influence on the composition of a model (Fielding and Gilbert, 2000). Influential cases can be identified by plotting values of Cook's distance against values of the outcome variable. Cook's distance is a measure of the overall influence that a case has on a model (Field, 2000). Examination of the plots for the workplace utility and property operation cost models revealed a number of influential cases, which were omitted from the models in order to determine their effect. This was an iterative process in which:

- the potentially most influential case was omitted from the analysis;
- the multiple regression analysis was re-run;

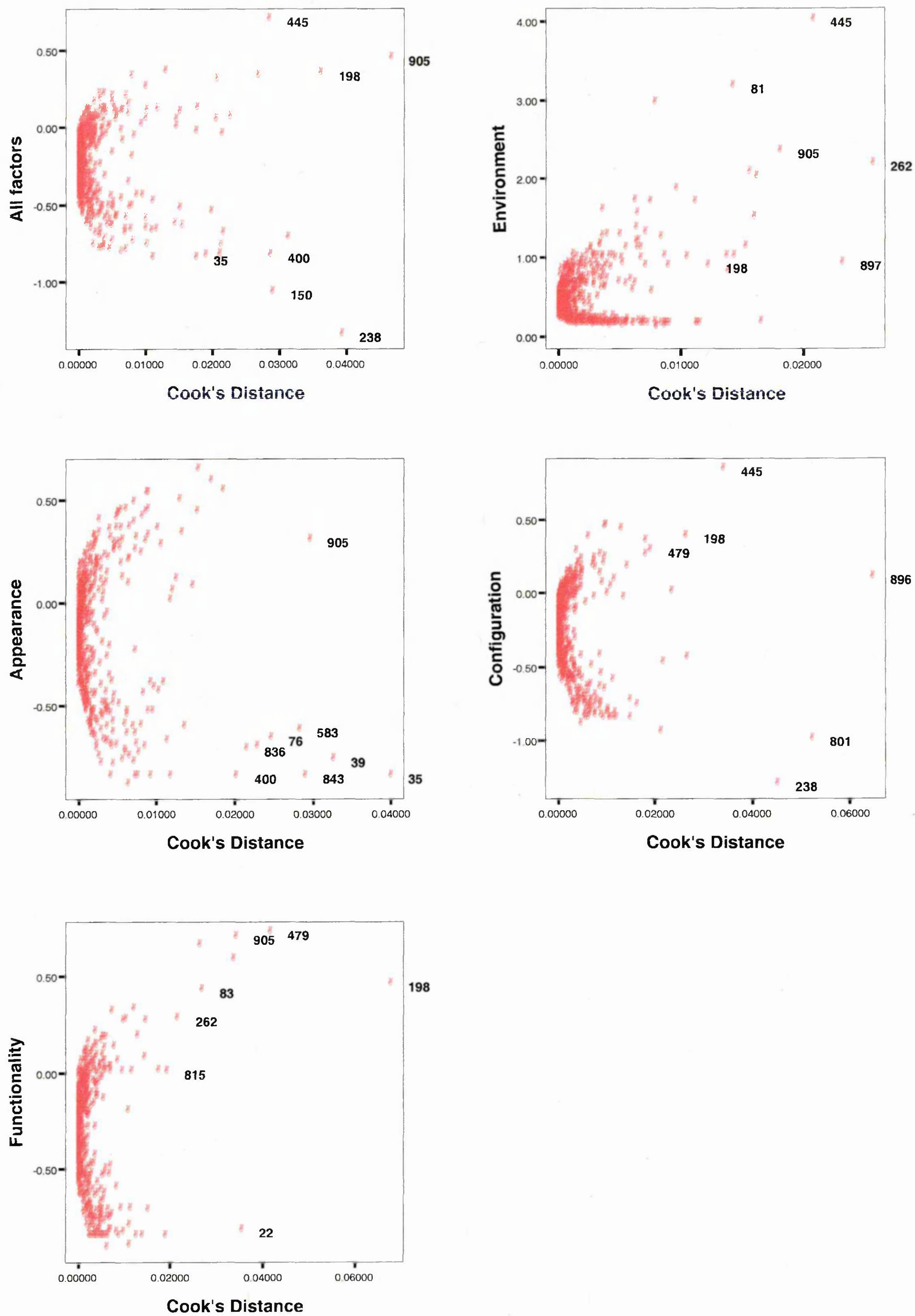

Figure 6.7: Plots of Cook's distances against actual values for utility models

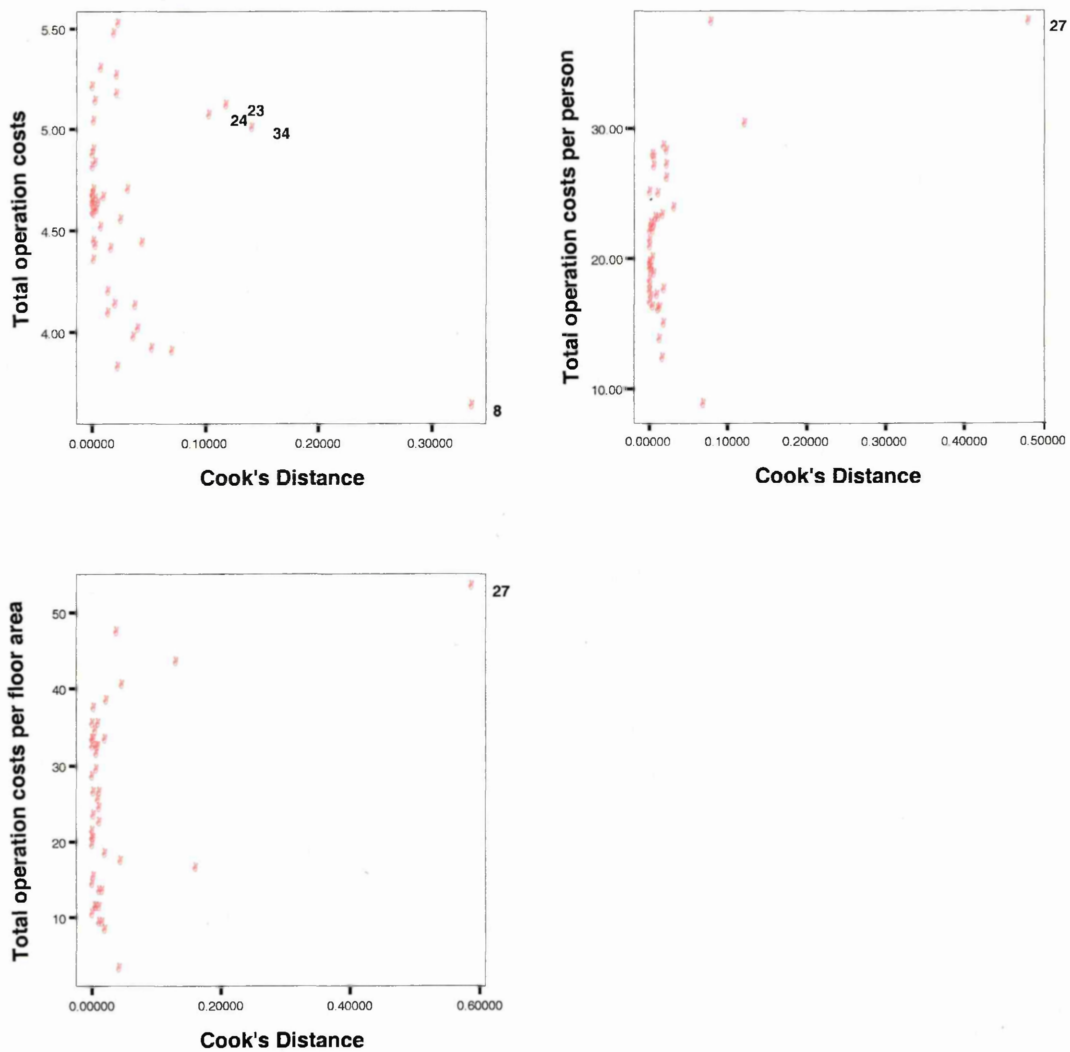

Figure 6.8: Plots of Cook's distances against actual values for operation cost models

- the new model was assessed to see whether omitting the case had made any impact on the composition of the model or the amount of variance explained by the explanatory variables; and
- the values of Cook's distance for the new model were plotted against the values of the outcome variable to identify further influential cases.

This process was repeated until no further influential cases could be identified or their omission had no effect on the model. The plots of Cook's distances against actual values for the workplace utility models (Figure 6.7) and property operation cost models (Figure 6.8) show which cases were eliminated. The final models are discussed below.

6.2.4 Workplace utility models

Table 6.1 contains the summary statistics for the workplace utility models. The statistics reveal the degree to which the models were able to estimate the *log* utility scores for the sample buildings. Specifically, the R^2 (coefficient of determination) values indicate the total amount of variance in the outcome variables accounted for by the explanatory variables (Miles and Shevlin, 2001). For instance, 22% (0.221 x 100) of the variance in the *log* utility scores on the functionality variable was explained by the model. This suggests that 78% of the variance was explained by other variables that were not included in the model or outside the scope of this study. The F statistic show that all five workplace utility models were statistically significant ($p < 0.005$). Table 6.1 also contains adjusted R^2 values for each of the models, which give a truer, usually smaller, estimate of the total amount of variance explained by the model by taking into account the number of explanatory variables (Vogt, 1999). The adjusted R^2 values are therefore useful for comparing models with different numbers of explanatory variables (Hair *et al.*, 1995). It can therefore be seen that the functionality model gives the highest level of explanation (21%) and the configuration model the lowest (12%).

Table 6.1: Summary of workplace utility models

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	F	Sig.
All factors	.432	.186	.173	.19374	14.447	.000
Environment	.395	.156	.142	.25787	11.567	.000
Appearance	.421	.177	.164	.25398	13.376	.000
Configuration	.360	.130	.116	.23318	9.420	.000
Functionality	.470	.221	.213	.23305	28.406	.000

The coefficients for the five workplace utility models are in Table 6.2. These show the contribution of each explanatory variable to the model (Pallant, 2001). The constant in each model represents the expected value of the outcome variable when the values of the explanatory variables equal zero (Miles and Shevlin, 2001). The B values are regression coefficients and indicate the strength and direction of the relationship between the explanatory and outcome variables, when the other explanatory variables are held constant (Field, 2000). They can be interpreted as the change in the outcome variable resulting from a unit change in the explanatory variable (Field, 2000). For example, in the functionality model a B value of -0.048 for perceived space requirements indicates that as perceived space requirements increased by 1 point, *log* functionality scores declined by 0.05 points. However, because the outcome variable is logged, it is necessary to convert back to the original functionality scale by calculating antilogs (Fielding and Gilbert, 2001).

Table 6.2: Coefficients for the workplace utility models

Model	Variable	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
All factors	(Constant)	.046	.067		.689	.491		
	Perceived space requirements	-.023	.005	.65	-4.472	.000	.950	1.052
	Condition of exterior doors	-.050	.011	.66	-4.428	.000	.943	1.060
	Number of people shared workspace with	-.007	.002	.70	-3.661	.000	.927	1.078
	Mechanical ventilation control	.132	.034	1.46	3.817	.000	.868	1.153
	Job satisfaction	.014	.005	1.30	2.809	.005	.980	1.021
	Number of car parking spaces	-.001	.000	.50	-6.329	.000	.707	1.414
	Condition of site and environs	-.065	.019	.70	-3.461	.001	.779	1.284
	Proportion of time using a telephone	-.013	.005	.79	-2.414	.016	.936	1.068
Environment	(Constant)	-.281	.078		-3.615	.000		
	Stone, masonry or concrete sub-dividing walls	.065	.028	1.30	2.340	.020	.684	1.462
	Number of people shared workspace with	-.011	.003	.67	-3.941	.000	.871	1.148
	Proportion of cellular workspace	-.001	.001	.78	-2.410	.016	.851	1.174
	Centralised heating control	-.089	.030	.71	-2.935	.003	.665	1.503
	Average window width	.000	.000	.76	-2.755	.006	.926	1.080
	Job satisfaction	.019	.007	1.30	2.759	.006	.985	1.015
	Gender	.069	.024	1.32	2.844	.005	.948	1.055
	Air-conditioning (split units)	.162	.068	1.26	2.386	.017	.965	1.036
Appearance	(Constant)	.351	.105		3.341	.001		
	Constructed 1970s	.142	.053	1.42	2.672	.008	.516	1.938
	Constructed 1900-39	.163	.052	1.45	3.155	.002	.644	1.553

Table 6.2 (continued)

Model	Variable	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
	Condition of site and environs	-.150	.028	.54	-5.263	.000	.639	1.564
	Exposed walls in common areas	.615	.180	1.41	3.415	.001	.880	1.137
	Condition of ceiling finishes in common areas	-.037	.015	.76	-2.368	.018	.629	1.589
	Condition of floor finishes in common areas	-.078	.025	.67	-3.144	.002	.527	1.896
	Timber window frames	.089	.037	.137	2.428	.016	.513	1.949
	Repetitive/routine tasks	-.013	.006	.81	-2.171	.030	.993	1.008
Configuration	(Constant)	.145	.105		1.384	.167		
	Perceived space requirements	-.025	.006	.68	-3.906	.000	.954	1.048
	Proportion of cellular workspace	-.002	.001	.68	-3.884	.000	.938	1.066
	Occupant density	.004	.001	1.32	2.739	.006	.879	1.137
	Job satisfaction	.019	.006	1.36	3.110	.002	.955	1.047
	Importance of interacting with colleagues	-.020	.008	.78	-2.460	.014	.925	1.081
	Stone, masonry or concrete sub-dividing walls	.050	.022	1.26	2.270	.024	.873	1.145
	Average width of corridors	.000	.000	.69	-3.055	.002	.603	1.658
	Kitchenette(s)	-.063	.025	.75	-2.512	.012	.686	1.458
Functionality	(Constant)	.008	.053		.153	.878		
	Perceived space requirements	-.048	.006	.50	-7.497	.000	.954	1.048
	Number of people shared workspace with	-.012	.002	.62	-5.141	.000	.978	1.022
	Proportion of time using a telephone	-.025	.007	.69	-3.883	.000	.925	1.081
	Job satisfaction	.022	.006	1.38	3.502	.001	.984	1.016
	Medium depth floor construction	-.047	.021	.81	-2.216	.027	.959	1.043

Since 0.90 is the antilog of –0.048, a 1 point increase in perceived space requirements corresponded to a 0.90 decrease in scores on the functionality factor, when the other explanatory variables are held constant. Perceived space requirements therefore makes only a small contribution to the model. Even so, the *t* statistic suggests that the variable contributes significantly to the ability of the model to estimate values of the outcome variable ($p = 0.005$). The difficulty with interpreting regression coefficients is that they are expressed in terms of the units of the associated variable, which makes comparisons of different explanatory variables inappropriate (Hair *et al.*, 1995). This problem can be eliminated by using beta coefficients. These are standardised regression coefficients that can be compared with one another in order to assess their relative explanatory power of the outcome variable. In other words, beta coefficients can be used to determine the relative importance of the explanatory variables in a model (Hair *et al.*, 1995). The beta coefficients in Table 6.2 are antilogs.

Interpretation of the all factors model (Table 6.2) suggests that eight variables explained 17% of the variability in aggregate utility scores for the sample buildings. The explanatory variables are a combination of building characteristics, such as the number of car parking spaces, condition of site and environs, and level of control over mechanical ventilation, and occupant characteristics, such as perceived space requirements and number of people that occupants shared their workspace with. This supports the hypothesis (H_4) that some of the variability in the functional performance across a group of buildings can be explained through differences in the interaction between the buildings' physical characteristics and the characteristics of the buildings' occupants.

As might be expected, physical deterioration of the sample buildings was negatively correlated with the outcome variable. There were also negative relationships between aggregate utility scores and a number of occupant characteristics, including perceived space requirements and the proportion of time that occupants spent using a telephone. These relationships are consistent with the findings of the bivariate analysis reported in Chapter 5. The beta coefficients suggest that the most important explanatory variables were job satisfaction and mechanical ventilation control, with the least important variable being the number of car parking spaces. The broad range of explanatory variables included in the all factors model is understandable in view of the fact that the outcome variable is an aggregate score, providing an indication as to the overall utility of the buildings across the four factors. However, this also means that the model is more difficult to interpret than the models for the individual factors.

The environment model comprised eight explanatory variables, five physical characteristics and three occupant characteristics. Physical characteristics were concerned with the spatial layout and building services provisions of the sample buildings (Table 6.2). For example, a negative correlation with centralised heating control suggests that buildings with more localised heating controls had higher scores on the environment factor. This was unsurprising in the light of previous research into occupants' perceptions of control over their working environment (Leaman, 1995; Leaman and Bordass, 1999). Scores on the environment factor were also negatively correlated with the proportion of cellular workspace in the sample buildings. In terms of occupant characteristics, scores were higher for males and occupants with higher levels of job satisfaction, although there was a negative correlation with the number of people that occupants shared their workspace with. The most important explanatory variable was gender, with a beta coefficient of 1.32. Other important explanatory variables were air-conditioning and stone, masonry or concrete sub-dividing walls. Job satisfaction was again an important explanatory variable, the inclusion of which is discussed further in Section 6.3.

Variability in scores in the appearance model was principally explained by variables relating to the age, condition and fabric of the sample buildings (Table 6.2). As might have been expected, the condition variables were negatively correlated with the outcome variable, suggesting that buildings that were in poor physical condition had the lowest scores. The most important explanatory variables were age (constructed 1900-39 and 1970s), exposed walls in common areas and timber window frames. The least important explanatory variables were condition of site and environs, and floor and ceiling finishes in common areas. Only one occupant characteristic, the proportion time spent doing repetitive and routine tasks, was included in the appearance model. This suggests, somewhat intuitively, that the physical characteristics of buildings are much more important than occupant characteristics in explaining variability in the appearance of different buildings.

The variability in scores on the configuration factor was predominantly explained by variables concerning the spatial characteristics of the sample buildings, such as the proportion of cellular workspace and average width of corridors, as well as a number of occupant characteristics, such as perceived space requirements and importance of interacting with colleagues (Table 6.2). Again, this was expected given that the configuration factor is comprised of attributes relating to the quantity and accessibility of space. The most important explanatory variables were occupant density, job satisfaction and stone, masonry or concrete sub-dividing walls, the least important being perceived space requirements, the proportion of cellular workspace and corridor width. A positive correlation between occupant density and the outcome variable suggests that buildings with the lowest occupant densities had the highest scores. However, buildings with a higher proportion of cellular space had lower utility scores. This was somewhat contradictory, in view of the fact that buildings with higher proportions of cellular workspace tended to have lower occupant densities (Chapter 4).

The functionality model comprised the least number of explanatory variables, but provided the highest level of explanation (Table 6.1, Table 6.2). In contrast to the appearance model, the functionality model was primarily based on occupant characteristics, rather than physical characteristics, the most important being job satisfaction. Only one physical characteristic was included in the model (medium depth floor plate), indicating that occupant characteristics are much better at explaining variability in functionality than the buildings' physical characteristics. Possible reasons for this are discussed in Section 6.3. As in the configuration model, perceived space requirements was negatively with the outcome variable. There was also a negative correlation between the number of people that occupants shared their workspace with and the functionality variable, suggesting that occupants that had shared their workspace with a larger number of people reported the lowest utility scores, thereby confirming the results of the bivariate analysis presented in Chapter 5.

Table 6.2 also contains measures of whether there is multicollinearity in the workplace utility models. Multicollinearity is when two or more explanatory variables are highly correlated (Vogt, 1999) and might be expected to arise given the intercorrelation between physical characteristics and occupant characteristics highlighted in Chapters 4 and 5. According to Field (2000) multicollinearity causes a number of problems, including:

- an increase in the probability that significant explanatory variables will be deemed non-significant and excluded from the model;
- limiting the amount of variance that can be explained by the explanatory variables;
- difficulties in determining the individual contribution to the model of the correlated explanatory variables; and
- specification of models that are unstable from sample to sample.

The variance inflation factor (VIF) in Table 6.2 provides an indication of whether an explanatory variable is correlated with other explanatory variables in the model (Field, 2000). Since all VIF values are below 10 and the average value is lower than 1, multicollinearity was not deemed to be a problem. This was confirmed by reference to the tolerance values in Table 6.2, all of which are above 0.2 (Field, 2000).

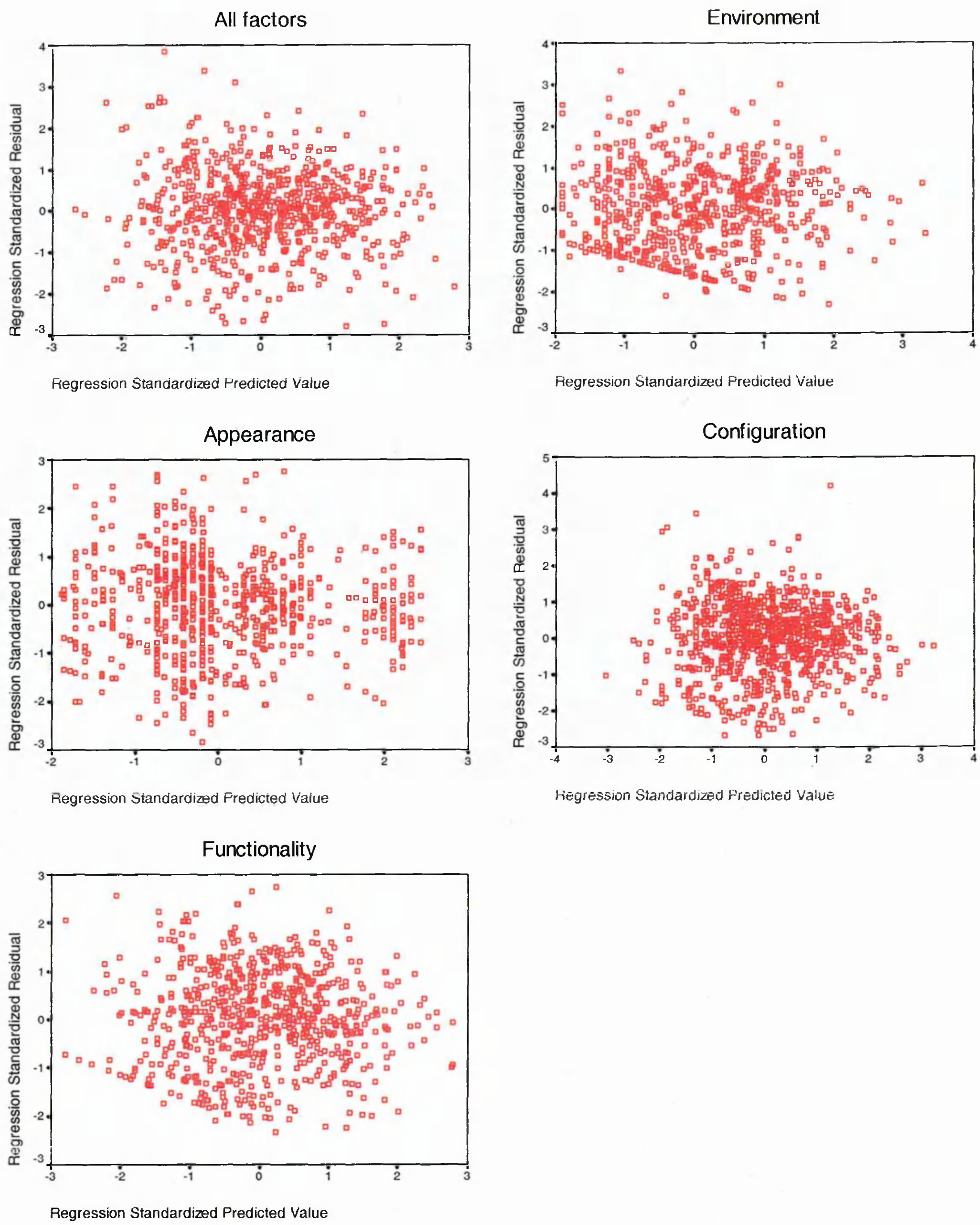

Figure 6.9: Plots of standardised residuals against standardised predicted values for workplace utility models

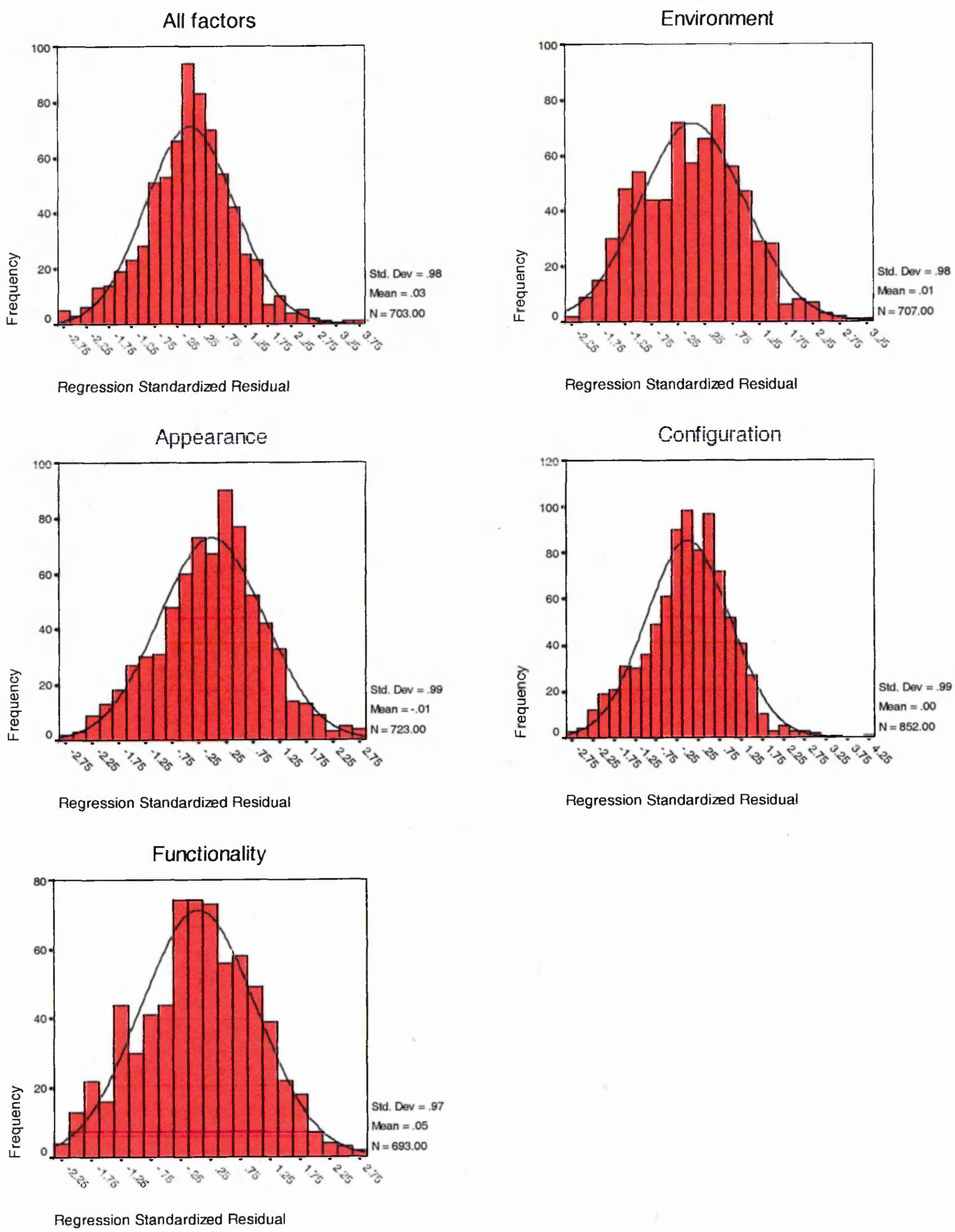

Figure 6.10: Distribution of standardised residuals for workplace utility models

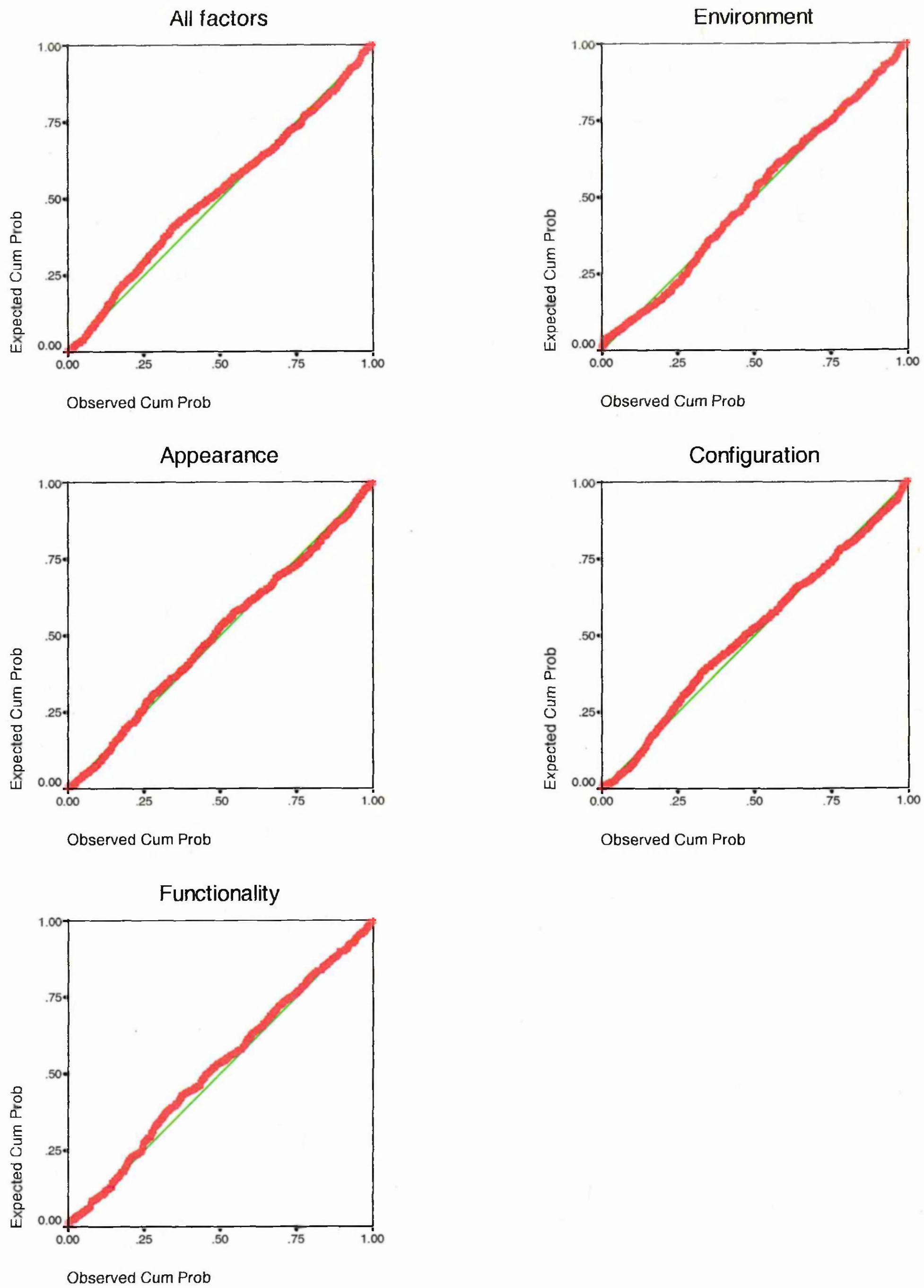

Figure 6.11: Normal probability plots for workplace utility models

Multiple regression analysis is also sensitive to a number of other assumptions, namely: homoscedasticity; linearity; and normality (Miles and Shevlin, 2001). Homoscedasticity is when there is equal variance in the outcome variable for the same values of the explanatory variable (Vogt, 1999). The presence of unequal variance is described as heteroscedasticity and can result in the model being mis-specified (Field, 2000; Miles and Shevlin, 2001).

Linearity is when the relationships being modelled are linear ones, that is to say that the mean values of the outcome value for each increment of the explanatory variables lie along a straight line (Field, 2000). Failure to satisfy this assumption can limit the generalisability of the model. Both assumptions can be tested by inspecting the plots of standardised residuals against standardised predicted values for the utility models (Figure 6.9). Standardised residuals represent the error present in a model (Miles and Shevlin, 2001). Figure 6.9 reveals that the points are randomly and fairly evenly distributed throughout the plots for the utility models, indicating that the assumptions of homoscedasticity and linearity have both been satisfied (Field, 2000).

The assumption of normality suggests that errors should be normally distributed, so that differences between the model and the observed data are zero or very close to zero (Field, 2000). This assumption can be tested by examining the distribution of standardised residuals in Figure 6.10 and the normally probability plots in Figure 6.11. The normal probability plots show the cumulative distribution of standardised residuals against the expected normal distribution (Fielding and Gilbert, 2000). The standardised residuals are fairly close to a normal distribution for each of the utility models and the normal probability plots show that the observed residuals are distributed along a straight line, indicating a normal distribution (Fielding and Gilbert, 2000).

6.2.5 Property operation cost models

Table 6.3 shows the summary statistics for the property operation cost models. The R^2 values for the models are higher than for the workplace utility models, ranging between 0.42 and 0.85. Table 6.3 reveals that 85% (0.850 x 100) of the variance in *log* of total operation costs was explained by the model ($p < 0.005$). The proportion of variance explained in the total operation costs per person and total operation costs per floor area models was 56% and 42%, respectively ($p < 0.005$). The adjusted R^2 values for the operation cost models are also high, ranging between 0.39 and 0.85. Reference to the F statistic indicates that all three property operation cost models were statistically significant ($p < 0.005$).

The property operation cost models were more parsimonious than the workplace utility models (Table 6.4). The total operation costs model has only one explanatory variable, net internal area, indicating that 85% of the variability in total operation costs across the sample is best explained through differences in the size of buildings. This was to be expected and is in accordance with the existing literature (Tomlinson *et al.*, 1996; BMI, 1998). The total operation costs per person model comprised three explanatory variables, one physical characteristic and two occupancy characteristics, the most important variable being occupant density, followed by floor-to-ceiling height and occupancy type (freehold or leasehold). Interpretation of the *B* values for this model suggests that, on average, the operation costs of buildings occupied on a freehold basis were £11.6/m^2 higher than for those occupied on a leasehold basis[42], confirming the findings of previous research by Bootle and Kaylan (2002). Floor-to-ceiling height and occupant density were also included in the total operation costs per floor area model, with the latter again being the most important explanatory variable of the two.

Table 6.3: Summary of property operation cost models

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	F	Sig.
Total operation costs	.922	.850	.846	.172	215.317	.000
Total operation costs per person	.746	.557	.523	4.107	16.731	.000
Total operation costs per floor area	.645	.416	.387	8.359	14.270	.000

Table 6.4 indicates that the property operation cost models satisfy the assumptions of multiple regression analysis. The VIF values in are below 10 and the average values are no more than 1, indicating that multicollinearity was not a problem. This was confirmed by the tolerance values, all of which are above 0.2. The plots of standardised residuals against standardised predicted values for the operation cost models were randomly and evenly distributed, suggesting that the assumptions of homoscedasticity and linearity had been satisfied (Figure 6.13). The standardised residuals for the models were fairly close to a normal distribution, although total operation costs and operation costs per floor area deviated slightly (Figure 6.14). This was also evident in the normal probability plots, with the majority of points in the total operation cost model falling below the straight line (Figure 6.12).

6.2.6 Validation

Validation of the models involved splitting the sample into a 65% sub-sample and a 35% holdout sample. The multiple regression analysis was then repeated to test for comparability and generalisability (Hair *et al.*, 1995). Validation was restricted to the utility models because the small number of cases in the operation cost dataset precluded the use of a sub-sample and holdout sample. The validation revealed that the sub-sample and holdout sample solutions were by and large comparable across the five workplace utility models, boosting confidence in their validity.

[42] Since the *B* is for the square root of operation costs per floor area, it was necessary to square the value to obtain the costs per m^2 ($3.41^2 = 11.6$).

Table 6.4: Coefficients for property operation cost models

Model	Variable	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
Total operation costs	(Constant)	1.349	.226		5.964	.000		
	Log of net internal area	1.032	.070	.922	14.674	.000	1.000	1.000
Total operation costs per person	(Constant)	1.373	3.954		.347	.730		
	Occupant density	.147	.031	.504	4.681	.000	.957	1.045
	Floor-to-ceiling height	.005	.001	.378	3.509	.001	.957	1.045
	Occupancy type	3.408	1.484	.252	2.296	.027	.917	1.091
Total operation costs per floor area	(Constant)	-2.839	8.988		-.316	.754		
	Inverse of occupant density	225.394	43.276	.632	5.208	.000	.992	1.008
	Floor-to-ceiling height	.005	.003	.201	1.657	.105	.992	1.008

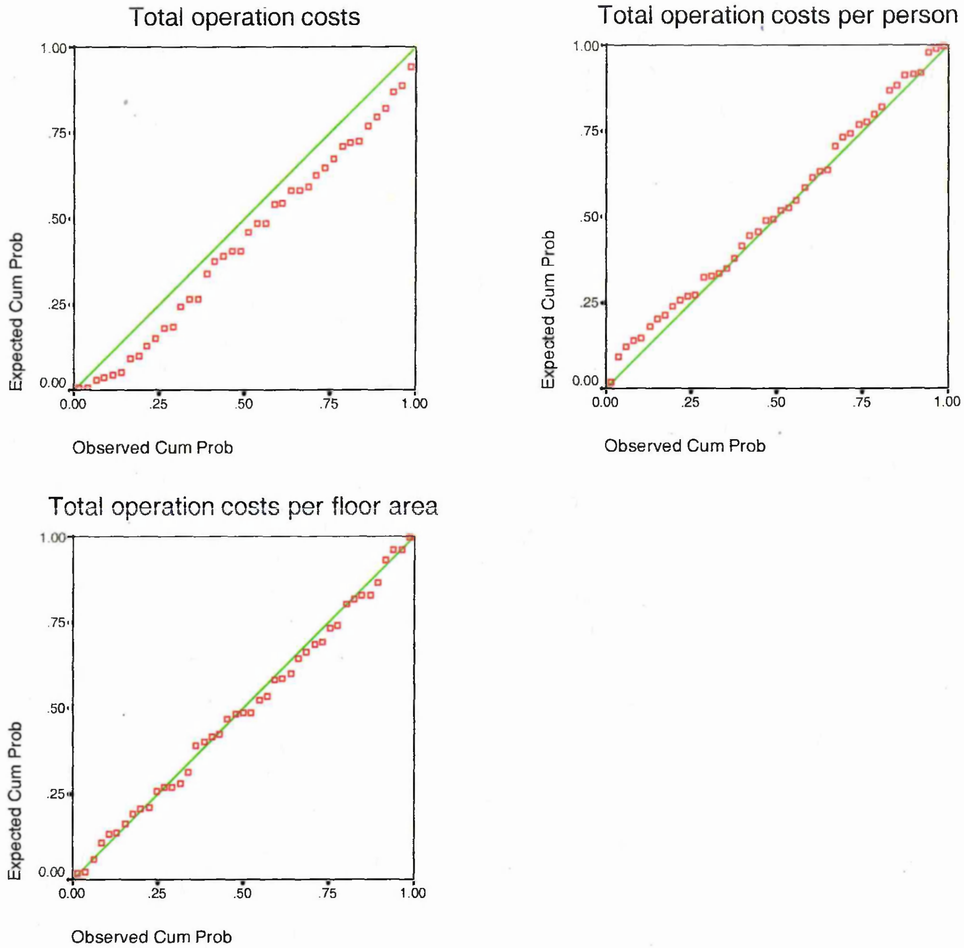

Figure 6.12: Normal probability plots for operation cost models

For example, Table 6.5 shows the results of the validation of the appearance model. The R^2 values indicate that both solutions explained a similar amount of variance in the outcome variables, with sub-sample explaining 17% of variance and the holdout sample explaining 16%. Furthermore, the results are comparable with the appearance model in Table 6.1, which explained 18% of variance in the outcome variable.

Table 6.5: Validation results for appearance model

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	F	Sig.
Sub-sample	.409	.167	.157	.24707	16.721	.000
Holdout sample	.396	.157	.136	.27299	7.580	.000

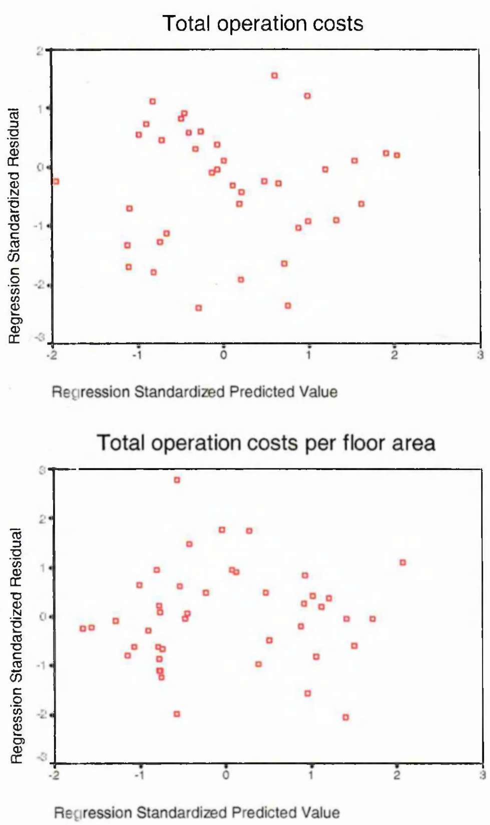

Figure 6.13: Plots of standardised residuals against standardised predicted values for operation cost models

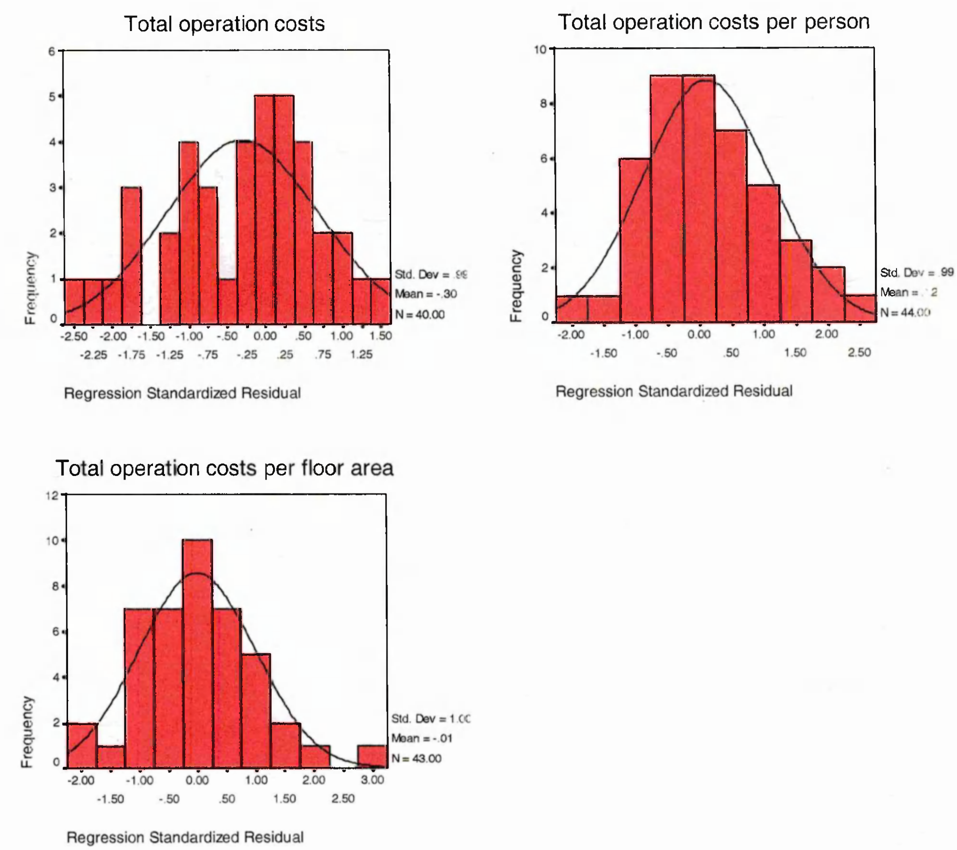

Figure 6.14: Distribution of standardised residuals for operation cost models

6.3 Conclusion

The purpose of this chapter was to build upon the bivariate analysis presented in Chapter 5 and examine the hypothesised relationships underpinning the theoretical framework in Chapter 3 through the application of multivariate statistical techniques. These hypothesised relationships were put forward as way of explaining the differential impact of obsolescence in buildings, that is to say why some buildings exhibit higher or lower levels of functional and financial performance than others. Multiple regression analysis was used to see whether a better explanation of these relationships could be attained by examining the explanatory variables concurrently. It was also used to determine the relative contribution or importance of each explanatory variable. Using data from a sample of local authority office buildings described in Chapter 4, the analysis focused on the relationships between:

- occupancy characteristics, physical characteristics and operation costs (H_1); and
- occupant characteristics, physical characteristics and utility (H_4).

Eight multiple regression models were developed, five relating to the utility of the buildings and three to the operation costs of the buildings. Each model comprised a different combination of explanatory variables (Table 6.6). The principal conclusions arising from the analysis are discussed below.

Interpretation of the workplace utility models suggested that variability in scores on each of the four factors can be explained by different combinations of physical characteristics and occupant characteristics, thereby providing support for hypothesis H_4 (Table 6.6). This was to be expected, because each factor represents a distinct part of the workplace utility construct (Chapter 3). Generally speaking, the composition of the models substantiated the results of the bivariate statistical analysis presented in Chapter 5, in that many of the same explanatory variables were found to correlate with the outcome variables. However, the regression models provided a much more parsimonious means of explaining variability in scores on the outcome variables, confirming the benefits of using multivariate techniques. For example, 31 statistically significant explanatory variables correlated with scores on the environment factor in the bivariate analysis (Table 5.22), compared with just eight in the multivariate analysis (Table 6.6). This difference can be explained by the fact that multiple regression takes account of the correlation between the outcome variable and each explanatory variable, whilst controlling for the influence of other explanatory variables (Hair *et al.*, 1995). The multiple regression analysis also enabled the relative importance of the eight explanatory variables to be determined.

Job satisfaction was consistently found to be an important variable in explaining variability in the scores in the workplace utility models. Indeed, the only model in which job satisfaction did not feature was appearance. The importance of job satisfaction as an explanatory variable was not surprising, given that previous studies have consistently shown a positive relationship between occupants' perceptions of their working environment and job satisfaction (Oldham and Brass, 1979; Oldham and Rotchford, 1983; Sundstrom *et al.*, 1980; Hedge, 1982; Oldham, 1988; Carlopio and Gardner, 1992; Sundstrom *et al.*, 1994; Leather *et al.*, 1998; Olson, 2002). However, because of the cross-sectional nature of this study it is not possible to determine whether increased utility promotes a higher level of job satisfaction or vice versa, although the former explanation would seem more plausible. Further research is therefore required to determine whether workplace utility is a mediating variable between physical characteristics and occupant characteristics, and job satisfaction.

A further benefit of using multiple regression analysis is that it can indicate how much of the variability of the outcome variable is explained by the explanatory variables. The workplace utility models derived from the multiple regression analysis explained some of the variability in the scores of the sample buildings, although there were differences in the level of explanation provided by each model. For example, the functionality model provided the highest level of explanation (21%) and the configuration model the lowest (12%). However, the results suggest that a large proportion of the variability in scores remained unexplained. The unexplained variance may be attributable to a number of factors, such as errors in measuring the outcome or explanatory variables, or the use of aggregate scores rather than scores for individual workplace attributes. The impact of using aggregate scores could be tested by employing individual workplace attributes as outcome variables to see whether the level of explanation increases. Another, more plausible reason for the low level of explanation is that there are other explanatory variables that are outside the scope of this study, particularly those relating to organisational or workplace culture (Mallak *et al.*, 2003). The presence of non-linear relationships between the outcome and explanatory variables may also have reduced the explanatory power of the models (Hair *et al.*, 1995). The implications of each of these factors further research are discussed in Chapter 7.

Despite, the relatively low level of explanation provided by the models, the multiple regression analysis still served to provide an insight into which combinations of explanatory variables are associated with higher or lower scores on each of the factors. As might have been expected, the environment and configuration models were both comprised of a combination of physical characteristics and occupant characteristics.

Table 6.6: Summary of significant relationships from Chapter 6

Explanatory variables	All factors	Environment	Appearance	Configuration	Functionality	Total operation costs	Total operation costs per floor area	Total operation costs per person
Physical characteristic								
Constructed 1970s			(+)					
Constructed 1900-39			(+)					
Condition of site and environs	(-)		(-)					
Number of car parking spaces	(-)							
Timber windows frames			(+)					
Condition of exterior doors	(-)							
Net internal area						(+)		
Floor-to-ceiling height							(+)	(+)
Medium depth floor plate					(-)			
Stone, masonry or concrete sub-dividing walls		(-)		(+)				
Average width of corridors				(+)				
Exposed walls in common areas			(+)					
Condition of ceiling finishes in common areas			(-)					
Condition of floor finishes in common areas			(-)					
Kitchenette(s)				(-)				
Average window width		(+)						
Air-conditioning (split-units)		(+)						
Centralised heating control		(-)						
Centralised mechanical ventilation control	(+)							
Proportion of cellular workspace		(-)		(-)				

Table 6.6 (continued)

	All factors	Environment	Appearance	Configuration	Functionality	Total operation costs	Total operation costs per floor area	Total operation costs per person
Occupancy characteristic								
Occupancy type							(+)	
Occupant density							(+)	(+)
Occupant characteristic								
Gender		(+)						
Number of people shared workspace with	(-)	(-)			(+)			
Proportion of time spent doing repetitive tasks			(-)					
Proportion of time using a telephone	(-)				(-)			
Importance of interacting with colleagues				(-)				
Perceived space requirements	(-)			(-)	(-)			
Job satisfaction	(+)	(+)		(+)	(+)			

Note: Shading indicates variable is significant at $p < 0.05$
(+) indicates a positive correlation
(-) indicates a negative correlation

However, variability in scores on the appearance factor was largely explained by physical characteristics, suggesting that they were much more important than occupant characteristics in explaining variability in appearance. In contrast, explanatory variables in the functionality model were predominantly occupant characteristics, indicating that variability in scores for attributes on this factor, such as conversational or visual privacy, were primarily explained by occupant characteristics. The workplace utility models also supported the findings of previous studies into property depreciation, which found that physical deterioration, as measured through building condition, provided only limited explanation of obsolescence relative to other building characteristics (Baum, 1991).

Interpretation of the property operation cost models revealed that a high proportion of the variability in operation costs was explained by the multiple regression analysis. The total operation costs model provided the highest level of explanation (85%) and the total operation costs per floor area model the lowest (39%). The unexplained variance in the models might be attributed to measurement error, arising from different cost management systems (Purkis *et al.*, 1977), or missing data, which resulted in a number of explanatory variables being excluded from the analysis, for example those that relate to organisational working practices (Chapter 4). Nevertheless, the explanation provided by the models compared favourably with models developed in previous research by Purkis *et al.* (1977), which only utilised a limited range of physical characteristics.

As well as explaining a higher proportion of variance, the property operation cost models were also more parsimonious than the workplace utility models, indicating that variability in property operation costs can be explained by a relatively small number of explanatory variables (Table 6.6). Unsurprisingly, the net internal area of buildings provided a very good estimate of total operation costs, with larger buildings having, on average, higher operation costs. The inclusion of occupant density and occupancy type (freehold or leasehold) as statistically significant explanatory variables in the cost per area and cost per person models was also to be expected, in the light of previous empirical studies (Gerald Eve, 2000; Bootle and Kaylan, 2002) and the results of the bivariate analysis presented in Chapter 5.

In summary, therefore, the results presented in this chapter have demonstrated that variability in the utility and operation costs of the sample buildings can be better explained through multivariate analysis of the explanatory variables. The models developed in this chapter can be used to estimate utility or operation costs based on values of the explanatory variables. Nevertheless, the application of the models is subject to a number of limitations. The models are derived from data drawn from a group of buildings, organisations and occupants at a particular point in time, so that generalising the results to other groups of buildings should be done with caution because conditions and relationships might differ (Hair *et al.*, 1995). Nor should the models be used to estimate beyond the range of explanatory variables found in the sample, because it cannot be assumed that the relationships are the same for values of the explanatory variables beyond those in the original sample (Hair *et al.*, 1995).

Instead, the contribution of this study is in the research methods and statistical techniques used to identify the factors influencing the relative functional and financial performance of the sample buildings. Occupier organisations could therefore replicate this study and carry out similar analyses on their own property portfolios (Hair *et al.*, 1995). This would allow them to highlight areas of potential obsolescence, for instance, by evaluating the physical characteristics of a portfolio with a view to determining whether buildings have particular physical characteristics that are currently, or prospectively, associated with low levels of functional or financial performance (Bottom *et al.*, 1999). Models developed using this approach could also be applied over time to allow functional or financial performance to be determined for particular combinations of physical and occupant/occupancy characteristics. Such information could be used to inform the renewal, disposal or acquisition of buildings, for instance by highlighting characteristics that are associated with particularly high operation costs and low workplace utility (Bottom *et al.*, 1999). The potential applications of the models and the ways in which they could be improved through further research are discussed in more detail in the next chapter.

References

Baum, A. (1991) *Property investment depreciation and obsolescence*, Routledge, London.

BMI (1998) *Standard form: Property occupancy cost analysis*, The Royal Institution of Chartered Surveyors, London.

Bootle, R. and Kalyan, S. (2002) *Property in business - a waste of space?*, The Royal Institution of Chartered Surveyors, London.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999) Appraising the functional performance characteristics of office buildings, *Journal of Property Research*, **16** (4), 339-358.

Carlopio, J.R. and Gardner, D. (1992) Direct and interactive effects of the physical work environment on attitudes, *Environment and Behavior*, **24** (5), 579-601.

Field, A.P. (2000) *Discovering statistics using SPSS for Windows*, Sage Publications, London.

Fielding, J. and Gilbert, N. (2000) *Understanding social statistics*, Sage Publications, London.

Gerald Eve (2000) *Overcrowded, under-utilised or just right? A study of office occupational densities in the UK*, Gerald Eve Research.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C (1995) *Multivariate data analysis with readings*, Fourth Edition, Prentice Hall, London.

Hedge, A. (1982) The open-plan office: A systematic investigation of employee reactions to their work environment, *Environment and Behavior*, **14** (5), 519-542.

Leaman, A. (1995) Dissatisfaction and office productivity, *Facilities*, **13** (2), 13-19.

Leaman, A. and Bordass, B. (1999) Productivity in buildings: the 'killer' variables, *Building Research & Information*, **27** (1), 4-19.

Leather, P., Pyrgas, M., Beale, D. and Lawrence, C. (1998) Windows in the workplace: Sunlight, view and occupational stress, *Environment and Behavior*, **30** (6), 739-762.

Mallak, L.A., Lyth, D.M., Olson, S.D., Ulshafer, S.M. and Sardone, F.J. (2003) Culture, the built environment and healthcare organizational performance, *Managing Service Quality*, **13** (1), 27-38.

Miles, J. and Shevlin, M. (2001) *Applying regression & correlation*, Sage Publications, London.

Oldham, G.R. (1988) Effects of changes in workspace partitions and spatial density on employee reactions: A quasi-experiment, *Journal of Applied Psychology*, **73**, 253-258.

Oldham, G.R. and Brass, D.J. (1979) Employee reactions to an open-plan office: a naturally occurring quasi-experiment, *Administrative Science Quarterly*, **24**, 267-284.

Oldham, G.R. and Rotchford, N.L. (1983) Relationships between office characteristics and employee reactions: A study of the physical environment, *Administrative Science Quarterly*, **28**, 542-556.

Olson, J. (2002) Research about office workplace activities important to US business -And how to support them, *Journal of Facilities Management*, **1** (1), 31-47.

Pallant, J. (2001) *SPSS survival manual*, Open University Press, Buckinghamshire.

Purkis, H.J., How, R.F.C., Hooper, N.J. and Poole, M.T. (1977) *Occupancy costs of offices*, Current Paper CP 44/77, Building Research Establishment, Watford.

Sundstrom, E., Burt, R.E. and Kamp, D. (1980) Privacy at work: architectural correlates of job satisfaction and job performance, *Academy of Management Journal*, **23** (1), 101-117.

Sundstrom, E., Town, J.P., Rice, R.W., Osborn, D.P. and Brill, M. (1994) Office noise, satisfaction and performance, *Environment and Behavior*, **26** (2), 195-222.

Tomlinson, J., Lewis, J. and Kaka, A. (1996) Premises occupancy cost analysis – current practice and developments towards a universal taxonomy, *In proceedings of the RICS COBRA Conference*, Royal Institution of Chartered Surveyors, London.

Vogt, W.P. (1999) *Dictionary of statistics & methodology*, Sage Publications, London.

Wyon, D.P. (2000) Individual control at each workplace: the means and the potential benefits, *In Clements-Croome, D. (ed), Creating the productive workplace*, E & FN Spon, London.

Chapter 7 Conclusions

7.1 Introduction

A review of the existing published literature in Chapter 2 revealed that much of the background theory regarding obsolescence in buildings has its roots in the 1950s and 1960s, when the issues of urban decay and regeneration came to the fore in the UK. At that time, obsolescence in buildings was seen as a decline in performance arising from physical deterioration and ageing. It is only later that the literature begins to differentiate obsolescence as a relative decline in building performance that is caused primarily by changing occupier requirements, rather than wear and tear arising from physical deterioration, the action of the elements and use. At the same time, there has been growing awareness in the literature about the impact of obsolescence on the depreciation of property values.

Previous empirical studies into property depreciation and obsolescence have predominantly been grounded in the real estate and planning disciplines. In the planning discipline, researchers had tended to adopt a demand-side approach and examine the impact of changing occupier requirements on obsolescence in buildings at an urban or regional level. However, a critical review of these studies in Chapter 2 revealed that most were founded upon anecdotal evidence or poorly theorised case study work. As such, they provided little insight as to why some buildings might be more susceptible to obsolescence than others. Moreover, the handful of studies that adopted a more rigorous, explanatory approach, most notably Cowan *et al.* (1970) and Nutt *et al.* (1976), were largely constrained by a lack of suitable data or analytical techniques for measuring obsolescence. This was unsurprising, given that a lack of suitable data continues to be a perennial problem in property research (Lizieri, 2003).

Researchers in the real estate discipline had, by contrast, tended to adopt a supply-side approach and analyse the impact of obsolescence on the depreciation of property values in specific locations, such as the City of London. These studies used multivariate statistical techniques, such as multiple regression analysis, to estimate the differential impact of property depreciation using information about the physical or locational characteristics of buildings. This resulted in statistical models for explaining why buildings with certain characteristics experience higher rates of depreciation than others. However, the major limitation of these studies was that building performance was measured solely in terms of estimated rental value, that is to say from the perspective of the property owner.

A further gap in the existing body of knowledge concerns the fact that previous studies have tended to overlook the downstream impact of obsolescence on the workplace, people and the client or customer. This might be attributed to the traditional absence of techniques for measuring the utility (functional performance) of buildings or their financial performance from an occupier perspective. It might also because the issue of obsolescence has largely been ignored in the facilities management (FM), workplace management and business performance disciplines, despite growing anecdotal evidence to suggest that obsolescence can have an adverse impact on the performance of occupier organisations, for instance through decreased operational efficiency, reduced productivity or declining morale in the workplace.

The main conclusions arising from the literature review (Chapter 2) can therefore be summarised as follows. First, whilst the issue of obsolescence in buildings has been the subject of academic interest for a number of decades, the body of empirical research on the subject remains relatively small, particularly in relation to other property issues, such as brownfield land and urban regeneration. Furthermore, the empirical research that has been undertaken is, for the most part, limited in scope, with little coherence in the methodological approaches employed. Second, whilst there is a growing body of rigorous empirical research into property depreciation, the resultant analytical models are predominantly orientated towards property owners and investors; there are no comparable models for analysing the impact of obsolescence on occupier efficiency, even though the inefficient use of property is estimated to cost occupiers in the UK up to £18 billion a year (Bootle and Kalyan, 2002). The overall aim of this study was therefore to develop a framework for modelling the impact of obsolescence in buildings from an occupier perspective.

In order to fulfil this aim, the objectives of this study were to:

- develop a method for evaluating building performance from an occupier perspective, so that obsolescence could be measured over time or across groups of buildings; and
- identify factors that explain variability in the performance of buildings and, consequently, the differential impact of obsolescence over time or across groups of buildings.

The purpose of this chapter (Figure 7.1) is to examine the extent to which these objectives have been fulfilled by drawing conclusions from each of the previous five chapters.

The next section (Section 7.2) discusses the main findings and conclusions emanating from each chapter, focusing particularly on the results of the data analysis in Chapters 4, 5 and 6. This is followed by Section 7.3, which identifies the contribution to knowledge made by this study in the light of previous empirical research. Section 7.4 discusses the limitations of this study, with particular regard to the research method and results. This chapter concludes by identifying areas for further research (Section 7.5) and reflecting on the research process (Section 7.6).

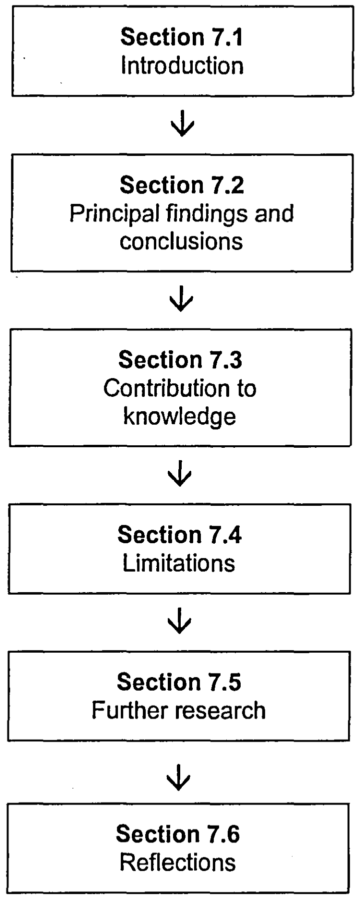

Figure 7.1: Structure of Chapter 7

7.2 Principal findings and conclusions

7.2.1 Evaluation of building performance

This study set out to develop a framework for modelling the impact of obsolescence in buildings from an occupier perspective. Obsolescence was defined in Chapter 2 as a decline in the performance of a building due to changing occupier requirements. Hence, the first objective of this study was devise a method for evaluating building performance from an occupier perspective, so that obsolescence could be measured over time or across groups of buildings. Building performance was seen to comprise three interrelated components: physical performance, utility (functional performance) and financial performance. Previous studies into obsolescence had focused on evaluating either the physical performance of buildings, measured in terms of physical deterioration, or their financial performance from an occupier perspective, measured in terms of depreciation. This study, by contrast, focused on evaluating the utility and financial performance of buildings from an occupier perspective.

Utility was conceptualised in this study as a measure of the attributes afforded by a building to the benefit, or otherwise, of its occupants. Focus groups with building occupants revealed that these attributes spanned a broad range of issues, from tangible ones, such as the standard of information and communications technology, through to more intangible issues, for instance whether the workplace feels bright and airy. However, statistical correlations between groups of these attributes suggested that workplace utility could be evaluated using 22 attributes and four distinct factors. These were:

- configuration, which was concerned with attributes such as amount of informal meeting space, potential for chance interaction and ease of circulation;
- environment, which comprised issues such as adequacy of ventilation, degree of individual control of temperature and responsiveness to changes in temperature;
- appearance, which included attributes such as the modernity of interior areas, exterior appearance and overall tidiness; and
- functionality, which comprised issues such as the level of conversational privacy, adequacy of workspace and potential to work free from distraction.

Performance across these four factors was determined through an essentially disconfirmationist survey approach, in which occupants were asked to rate their expectations and perceptions of the constituent attributes.

From an occupier perspective, the financial performance of a building can be conceptualised in terms of its occupancy costs and contribution to business profitability. Since the latter was difficult to quantify, occupancy costs were used in this study as an indicator of financial performance. The downside to this approach was that the collection of occupancy cost data has traditionally been fraught with problems, a fact confirmed in this study; of the 86 variables included in the occupancy cost survey, 53 were excluded from the analysis due to missing data. Analysis of the remaining variables therefore focused on the operation costs of buildings. Building operation costs relate to expenditure on minor improvements, cleaning, maintenance security and utilities. This approach had the advantage of avoiding buildings being lost from the analysis whilst leading to the elimination of unreliable variables, the use of which would have caused the models to over-fit the data. Such models would have been unsuitable for estimating the outcome variables based on new data (Hair *et al.*, 1995; Miles and Shevlin, 2001).

A key assumption underpinning this study was that obsolescence could be measured by evaluating the physical performance, utility and financial performance of a building over time (longitudinal analysis) or a group of buildings at one point in time (cross-sectional analysis). Since time and resource constraints precluded the use of a longitudinal study, cross-sectional data were used instead. The use of cross-sectional data was based on the premise that buildings of the same type vary in the way they perform because of differences in their physical characteristics and in the way that they are utilised by people and organisations. It was therefore hypothesised that such differences could be used to explain the differential impact of obsolescence, that is to say why some buildings exhibit higher levels of performance than others. The second objective of this research was to examine whether this was the case, by analysing data for a sample of buildings.

Empirical data were collected from a sample of 64 local authority office buildings, selected on the basis of availability and ease of access to data. Despite the limitations of availability sampling, particularly in terms of producing representative samples, it was deemed to be the most suitable method because it took into consideration the capability of participating local authorities to provide the required property data. This was critical since missing data can serve to undermine the validity and reliability of statistical techniques. Data were collected in respect of the physical characteristics of the sample buildings, the characteristics of the buildings' occupants and the occupancy characteristics of the occupier organisations. These characteristics were employed as explanatory variables in the analysis. Data were also collected in relation to the utility and operation costs (financial performance) of the sample buildings. These performance measures were employed as outcome variables in the analysis. The findings and conclusions emanating from the analysis are discussed below.

7.2.2 Modelling workplace utility

Analysis of the utility data for the sample buildings revealed a large number of scores below one for each of the four factors, indicating that occupants' expectations exceeded their perceptions of their workplace in the majority of cases. There was, however, considerable variability in scores across each of the four factors and the 22 attributes. For instance, scores tended to be higher, on average, for appearance attributes than for environment attributes. Similar variability was found in the average scores for the sample buildings, suggesting that different buildings in the sample had different levels of utility or functional performance. This supported the assumption that buildings of the same type vary in the way they perform basic functions. The bivariate statistical analysis reported in Chapter 5 therefore focused on explaining the variability in the utility of the sample buildings through differences in their physical characteristics and the characteristics of their occupants.

Workplace utility was found to be correlated with a range of construction, building services and workspace characteristics, as well as occupants' demographic characteristics, working practices and attitudes to workplace issues. As might have been expected, the results suggested that variability in the scores for different workplace attributes could be explained by different combinations of physical characteristics and occupant characteristics. For instance, the age and physical condition of the sample buildings correlated with scores on the appearance factors and attributes, but not with scores on the other three factors, which were explained by other building characteristics such as internal layout, type of engineering services and specification of interior and exterior finishes.

Chapter 6 examined whether a better explanation of these relationships could be attained through multivariate statistical analysis, in which the explanatory variables were analysed concurrently. Five multiple regression models were developed, interpretation of which confirmed that variability in scores on each of the four factors could be explained by different combinations of physical characteristics and occupant characteristics. The differences in composition of the models were to be expected, because each factor represents a distinct part of the workplace utility construct. Generally speaking, the composition of the models substantiated the results of the bivariate statistical analysis presented in Chapter 5, in that many of the same explanatory variables were found to correlate with the outcome variables. However, the regression models provided a much more parsimonious means of explaining variability in scores on the outcome variables, confirming the benefits of using multivariate techniques. The difference can be explained by the fact that multiple regression analysis takes account of the correlation between the outcome variable and each explanatory variable, whilst controlling for the influence of other explanatory variables. It also enables the relative importance of explanatory variables to be determined.

The relative contribution of the two groups of explanatory variables to the workplace utility models is summarised in Figure 7.2. The environment and configuration models were both comprised of a fairly equal combination of physical characteristics and occupant characteristics. However, variability in scores on the appearance factor was largely explained by physical characteristics, suggesting that they were much more important than occupant characteristics in explaining variability in appearance. In contrast, explanatory variables in the functionality model were predominantly occupant characteristics, indicating that variability in scores for attributes on this factor, such as conversational or visual privacy, were primarily explained by occupant characteristics.

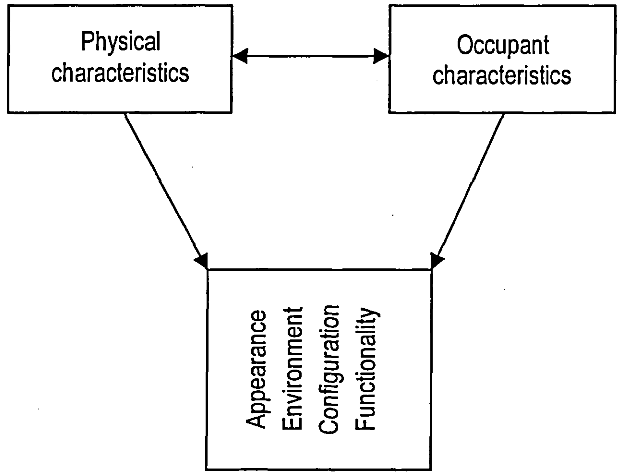

Figure 7.2: Relative contribution of physical characteristics and occupant characteristics to the workplace utility models

Occupants' job satisfaction was consistently found to be an important variable in explaining variability in the scores in the workplace utility models. Indeed, the only model in which job satisfaction did not feature was appearance. The importance of job satisfaction as an explanatory variable was not surprising, given that previous studies have consistently shown a positive relationship between occupants' perceptions of their working environment and job satisfaction. However, because of the cross-sectional nature of this study it was not possible to determine whether increased utility promotes a higher level of job satisfaction or vice versa, although the former explanation would seem more plausible in the light of the views put forward in the workplace literature (Oldham and Brass, 1979; Wells, 2000; Becker and Sims, 2001; Stokols *et al.*, 2002). Further research is therefore required to determine the direction of this relationship.

The multiple regression analysis also provided an indication as to how much of the variability of the outcome variables was explained by the explanatory variables. The workplace utility models derived from the multiple regression analysis explained some of the variability in the scores of the sample buildings, although there were differences in the level of explanation provided by each model. Moreover, a large proportion of the variability in scores remained unexplained in each model (Figure 7.3). The unexplained variance might be attributed to a number of factors, such as errors in measuring the outcome or explanatory variables, or the use of aggregate scores rather than scores for individual workplace attributes[43]. Other possible reasons are that there are explanatory variables that

[43] Given that the factors and attributes employed in this study were grounded in exhaustive focus group research, the low level of explanation might imply that a large element of workplace perception is tacit.

were overlooked in this study, particularly those relating to organisational or workplace culture, or non-linear relationships between some of the outcome and explanatory variables, which could have reduced the explanatory power of the regression models. Potential remedies for these problems are discussed as areas for further research below (Section 7.5).

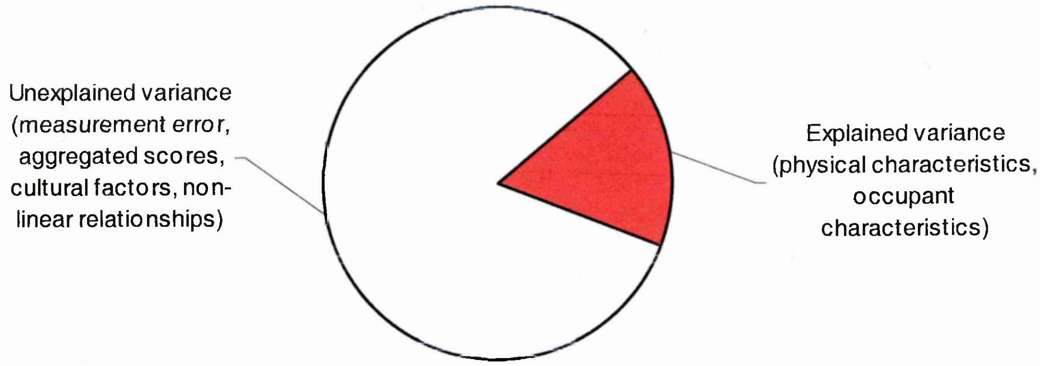

Figure 7.3: Possible factors affecting level of explanation in workplace utility models

The principal conclusions arising from the analysis of workplace utility can therefore be summarised as follows. First, whilst the results of the analysis lend support to the hypothesis that the physical characteristics of a building and the characteristics of its occupants can be used to explain its utility relative to a group of similar buildings, the inclusion of other additional explanatory variables might improve the level of explanation provided. These variables could take the form of cultural indicators, such as those used by Mallak *et al.* (2003). Interpretation of the results was also complicated by the fact that many building characteristics and occupant characteristics were intercorrelated, resulting in groups of statistical interdependencies that were difficult to disentangle. This problem could be overcome through the use of cluster analysis, the application of which is discussed in Section 7.5 below. Finally, the presence of non-linear relationships was also put forward as a possible reason for the low level of explanation provided by the models. This problem could be addressed by subjecting the data to neural network analysis. Neural network analysis replicates the learning processes of the human brain and avoids the non-linearity and outlier problems inherent in multiple regression analysis (Lenk *et al.*, 1997).

Despite the relatively low level of explanation provided by the regression models, the analysis still served to provide an insight into which combinations of physical and occupant characteristics are associated with higher or lower scores on particular factors and attributes. For instance, Chapter 4 drew attention to the potential conflict between interaction and distraction in the workplace, whereby occupants generally placed a high level of importance on interacting with their colleagues, but also on being able to work free from distraction. Olson (2002), who also identified the potential conflict between interaction and distraction, concluded that the use of open plan workspace was the problem and cellular workspace the most practical solution, enabling occupants to interact without disturbing others[44]. However, the results presented in Chapter 5 did not support this conclusion. As might be expected, chance interaction was negatively correlated with cellular workspace, but positively correlated with open plan workspace, suggesting that open plan workspaces were more conducive to chance interaction. Similarly, both conversational and visual privacy were positively and negatively correlated with cellular and open plan workspace, respectively, indicating that cellular workspaces provided higher levels of privacy. However, there was no correlation between distraction and cellular or open plan workspace. Indeed, group workspace (4-12 workstations) was found to be positively correlated with scores on the distraction attribute.

The results arising from the analysis of workplace utility substantiated the findings of previous empirical studies described in Chapter 2, in that the physical condition of buildings provided only a limited explanation of obsolescence relative to other building characteristics (Baum, 1991; Khalid, 1994; Bottom *et al.*, 1999). This could have implications for the management of buildings, because whereas physical deterioration can usually be remedied through the replacement of like with like, the treatment of obsolescence often requires introducing new features into a building, which might not be feasible because of economic or technical constraints, such as a restricted floor-to-ceiling height or an inflexible floor layout (Salway, 1986). What is more, for some workplace attributes, particularly those on the functionality factor, improvements in functional performance might only be attainable through changes in occupant characteristics and working practices, rather than changes to building characteristics.

[44] Haynes and Price (2002) also identified the dichotomy between interaction and distraction in the workplace, although the authors draw different conclusions about the implications for workplace design (Clark *et al.*, Forthcoming).

7.2.3 Modelling building operation costs

Analysis of the building operation cost data in Chapter 4 revealed that there was considerable variability in costs and cost efficiency of the sample buildings, suggesting that different buildings in the sample exhibited different levels of financial performance. The bivariate statistical analysis reported in Chapter 5 therefore focused on explaining the variability in the operation costs of the sample buildings through differences in their physical characteristics and occupancy characteristics. As was expected, total operation costs and individual cost items were positively correlated with the spatial characteristics of the sample buildings, such as floor area and the number of floors. The cost efficiency of the sample buildings tended to be correlated with a different group of physical characteristics, such as window characteristics, building services provisions and common amenities. The results of the analysis were therefore an improvement over those from previous research by Purkis *et al.* (1977), who analysed data for 28 government office buildings and concluded that 'there was little correlation between costs and the physical characteristics of the buildings'. This improvement might be due to the wider range of physical characteristics analysed in this study.

The cost efficiency of the sample buildings was also found to be correlated with a number of occupancy characteristics, such as occupant density and occupation type. Indeed, the results of this study tend to support the established view that leasehold occupation is associated with higher cost efficiency than freehold occupation. This is a significant finding, given that most of the buildings in the sample were occupied on a freehold basis, reflecting the findings of the Audit Commission's (2000) own research into local government property holdings. Moreover, the proportion of freehold property in the sample is much higher than in the private sector or central government, where, on average, 64% of property is owner-occupied (Bootle and Kalyan, 2002). The less efficient use of freehold property might reflect the fact that there is no rent to remind occupiers that their property is not 'free' or the expectation that capital appreciation will compensate for inefficient utilisation. Indeed, local authorities have, in the past, been criticised for viewing their property in this way (Audit Commission, 1988a; 1988b; 2000).

Occupant density was also positively correlated with cost efficiency, a potential conflict given that occupant density was negatively correlated with utility. This suggests that increasing occupant density to improve cost efficiency is likely to be false economy if it leads to reduced functional performance, given that property occupancy costs are relatively insignificant in comparison with staff and other business costs (Williams, 2003). The implementation of new working practices, such as hot desking and home working, might provide a possible solution to this conflict[45]. There is clearly potential for introducing such working practices, in view of the fact that most occupants in the sample were in the main office- and desk-based, with only a small proportion working from home on a regular basis. This supports the view that, despite the existence of technology to permit employees to work from home or other locations, many local authorities have yet to embrace flexible working as way of improving utilisation of their office buildings, even though experience from local authorities that have introduced flexible working indicates that office space can be reduced by up to one-quarter (Audit Commission, 2000; Price, 2001).

Chapter 6 examined whether a better explanation of building operation costs could be attained through multivariate statistical analysis. Three models were developed, interpretation of which revealed that a high proportion of the variability in operation costs was explained by the multiple regression analysis. The total operation costs model provided the highest level of explanation (85%) and the total operation costs per floor area model the lowest (39%). The unexplained variance in the models might be attributed to measurement error, arising from different cost management systems or missing data, which resulted in a number of explanatory variables being excluded from the analysis, for example those that relate to organisational working practices (Chapter 4). Nevertheless, the explanation provided by the models compared favourably with models developed in previous research by Purkis *et al.* (1977), which only utilised a limited range of physical characteristics.

As well as explaining a higher proportion of variance, the property operation cost models were also more parsimonious than the workplace utility models, indicating that variability in property operation costs can be explained by a relatively small number of explanatory variables. Unsurprisingly, the net internal area of buildings provided a very good estimate of total operation costs, with larger buildings having, on average, higher operation costs. The inclusion of occupant density and occupancy type (freehold or leasehold) as statistically significant explanatory variables in the cost per area and cost per person models was also to be expected, in the light of previous empirical studies and the results of the bivariate analysis presented in Chapter 5.

In conclusion, therefore, the cost and cost efficiency of the sample buildings can be explained by differences in the physical characteristics and occupancy characteristics of the sample buildings. However, the level of explanation varied from model to model. The unexplained variance in the cost efficiency regression models might be attributed to differences in organisational working practices, information about which could not be

[45] Variables concerning new working practices were not included in the analysis in this study because of missing data (see Chapter 4).

provided by the local authorities. Missing cost data may have also have contributed to a fall in explanation. Indeed, even though property costs are the second biggest business cost after salaries, access to accurate and comprehensive occupancy cost data remains poor, reflecting the findings of the Audit Commission's (2000) study of local authorities. The lack of such data clearly represents a major barrier to the efficient use of office buildings.

7.3 Contribution to knowledge and practical applications

The primary contribution of this study is in the research methods and statistical techniques used to identify the factors that explain the relative functional and financial performance of the sample buildings. A recent report by the Workplace Forum (DEGW, 2002) noted that whilst there is general appreciation that some buildings are 'good' or 'bad', either overall or in particular aspects, there has been less focus on identifying, at micro-level, the role of building characteristics on performance. The same report went on to stress the need for a methodology to allow occupiers to assess whether particular buildings are 'good', from their point of view, rather than from the perspective of developers or investors. This study has gone some way towards addressing these issues by providing an insight into which building characteristics are associated with higher or lower levels of utility (functional performance) and financial performance from an occupier perspective.

Occupier organisations could replicate this study and carry out similar analyses on their own property portfolios. This would allow them to highlight areas of potential obsolescence, for instance, by evaluating the physical characteristics of a portfolio with a view to determining whether buildings have particular physical characteristics that are currently, or prospectively, associated with low levels of utility or financial performance. Models developed using this approach could also be applied over time to allow utility or financial performance to be determined for particular combinations of physical and occupant/occupancy characteristics. Such information could be used to inform the renewal, disposal or acquisition of buildings, for instance by highlighting characteristics that are associated with particularly high operation costs and low workplace utility (Bottom *et al.*, 1999). Additional building performance measures could also be devised and incorporated into the models, where necessary.

This study also constitutes an extension to the existing body of knowledge into property depreciation and obsolescence. Whilst the issue of obsolescence in buildings has been the subject of academic interest for a number of decades, the body of empirical research on the subject remains relatively small. When studies have been undertaken they have, for the most part, been limited in scope, with little coherence in the methodological approaches employed. Moreover, although there has been a growing body of rigorous empirical research into property depreciation over the last two decades, the resultant analytical models have been orientated towards property owners and investors, rather than occupiers. This study has utilised many of the principles developed in the analysis of property depreciation and has applied them to the analysis of obsolescence. In doing so, this study has overcome many of the methodological problems experienced in earlier studies of obsolescence, particular with regards to accessing primary data. This study can also be differentiated from previous studies of property depreciation and obsolescence in that it is the first to focus on public sector buildings.

Public sector office buildings are valuable assets that can provide long and high-quality service if managed effectively. Delaying or minimising obsolescence in buildings should therefore be seen as an important way of optimising returns on public assets (Building Research Board, 1993). In the UK, central Government has, for some time now, been exhorting public bodies to maximise the value gained from their property assets (Audit Commission, 2000). For local authorities in England and Wales, this pressure has come through the introduction of Best Value, a policy that compels local authorities to review how they utilise their property and determine whether it represents value for money. Best Value also requires local authorities to adopt a more strategic and challenging approach to the management of their property assets (Audit Commission, 2000). The framework developed in this study could therefore be used to inform Best Value reviews and the development of asset management plans by identifying office buildings that are under-performing and in need of disposal or refurbishment.

The analysis of building operation costs conducted in this study represents an improvement over previous empirical studies, notably that which was undertaken by Purkis *et al.* (1977). The latter analysed data for 28 government office buildings and concluded that 'there was little correlation between costs and the physical characteristics of the buildings'. However, this study has demonstrated that building cost and cost efficiency can be estimated using a combination of building characteristics and occupancy characteristics. Moreover, by modelling workplace utility and operation costs in tandem, it has been possible to identify areas of divergence between utility and financial performance. Such information could be of use during the design and refurbishment of buildings. For instance, design characteristics or utilisation strategies that are associated with higher costs but lower utility could be changed or omitted.

This study makes a contribution to the FM discipline, which has frequently been criticised for lacking a rigorous body of empirical research. For example, Nutt (1999) argued, *inter alia*, that the field of FM makes claims for itself that are mainly untested, is not yet supported by an adequate knowledge base and is grossly under-researched. Nutt (1999) attributed these problems to a number of interrelated factors, including the fact that FM is a relatively immature field of management, is invisible on the agenda of national research councils and lacks identity as a professional discipline. Similarly, Cairns (2003) suggested that much of what is currently held forth as theory in the field has little or no empirical foundation to justify its transfer into knowledge. This study, by contrast, is a thorough and rigorous investigation into the empirical relationships between organisations, buildings and their occupants, the foundations of which have been endorsed through peer reviewed publication (Appendix P).

The final contribution that this study makes is to the existing body of research into the office workplace. The office workplace has been the subject of empirical research for a number of decades, particularly in the field of environmental psychology. Much of this research has focused on comparing occupants' perceptions of open-plan and cellular workspaces, the main conclusion being that occupants tend to be less satisfied with open-plan office environments. However, the findings of this study indicate that variability in occupants' perceptions of their workplace can be explained by a much broader range of building and occupant characteristics, many of which are inter-correlated. Moreover, the composition of these characteristics will change depending on which particular aspect of the workplace is being evaluated. At the same time, this study has served to highlight some of the boundaries of traditional approaches to evaluating the office workplace and the need to take account of other factors, such as workplace culture (Turner and Myerson, 1998). It has also intimated that occupants themselves do not explicitly conceptualise many of these factors, as was evidenced from the focus groups described in Chapter 3.

7.4 Limitations

The limitations of this study relate predominantly to the research method employed, the assumptions made in the research design and the scope of the data collection and analysis. One of the assumptions underpinning this study relates to epistemology. Building performance research has traditionally been rooted in the positivist epistemology, with its focus on the application of the scientific method and causal explanation based on a closed-system ontology. However, whilst these principles are compatible with measuring the physical performance of buildings, it is questionable as to whether it is valid to adopt the same approach towards the measurement of utility and financial performance, both of which are essentially social phenomenon operating in open-systems. This study therefore adopted a critical realist stance, which presupposes that the social world is made up of open-systems in which individuals respond differently in similar situations and on different occasions[46]. Hence, generalising the results of this study to other groups of buildings should be done with caution because conditions and relationships might differ. Nor should the models be used to extrapolate beyond the range of explanatory variables found in the sample, because it cannot be assumed that the relationships are the same for values of the explanatory variables that are beyond those in the original sample[47].

The theoretical framework employed in this study was based on a number of simplifying assumptions, which were necessary to make this study feasible. One of the principal assumptions was that occupancy costs could be used as a proxy for the financial performance of a building. In reality, however, the occupancy costs of a building constitute only one aspect of its financial performance. Arguably, the most important indicator of a building's financial performance is its contribution to business profitability (Haynes *et al.*, 2000). However, this was considered difficult to measure empirically because of the large number of confounding variables. Likewise, the 22 attributes used in the measurement of workplace utility provide only an indication as to a building's functional performance. A total of 55 attributes were derived from focus groups, measurement of which would provide a more holistic profile of a building's utility. The range of workplace attributes used in the evaluation might also vary for user groups other than building occupants. For instance, senior managers or executives in the occupier organisation, who may not occupy the building but have a management interest in it, or visitors, who may have business in the building, might employ a different array of attributes for evaluating the building's utility (Gray and Tippett, 1992).

The measurement of explanatory variables in this study was also subject to limitations. Physical characteristics were included on the basis that they were accessible, could be subject to visual inspection and measurable during a walk-through survey or from drawings. However, this precluded the measurement of many physical characteristics. Furthermore, physical characteristics were measured at the building level, thereby overlooking variations between different parts of buildings. For instance, one floor of a building may have been refurbished and would therefore be in better physical condition than other floors in the same building. In this study such differences were taken into account by providing an average score for the building. However, given the time and resources, measurement of physical characteristics could have been undertaken at a micro-level, enabling occupants' responses

[46] This issue is elaborated on in Section 7.6 below.

[47] For instance, the operation cost models should not be used to estimate the costs of office buildings with NIAs greater than 14,700m^2, since this was the NIA of the largest building in the sample. The data from such buildings would need to be incorporated into the original dataset and the regression models re-specified.

to be correlated with particular parts of buildings. This might have improved the level of explanation provided by the regression models.

A further limitation of this study was its scale. Resource constraints dictated that the sample size was restricted to 64 office buildings. Whilst this compares favourably with previous studies (Salway, 1986; Baum, 1991; Khalid, 1994; Bottom *et al.*, 1999; Yusof, 1999), a larger sample of data may have increased the level of explanation provided by the multiple regression models. The sample size was further limited by resource constraints on the participating local authorities, which meant that two local authorities were unable to take part in the occupant survey. Missing data were also a problem, particularly in the occupancy cost survey. Data analysis was therefore restricted to the operation costs of the sample buildings. The difficulties of collecting occupancy cost data in this study confirmed the findings from previous research (Tomlinson *et al.*, 1996; Audit Commission, 2000).

The method of sampling employed in this study was subject to limitations. This study focused solely on local authority office buildings in order to facilitate access to data and permit comparisons with previous studies. Local authorities were selected according to their capacity and willingness to provide access to buildings, occupants and occupancy cost data. The disadvantage of this approach was that it was not possible to estimate how representative the sample was, which means that the findings from this study cannot be considered representative of the research population[48]. However, this was not deemed to be a significant problem because the aim of this study was to develop a method for modelling obsolescence, rather than to make inferences about the research population.

7.5 Further research

On reflection and in view of the limitations outlined above, this study has highlighted a number of areas for further research. The concept of utility adopted in this study could be expanded to include the views of other building users, such as building owners, facilities managers and visitors. A new measurement scale could be developed to evaluate the views of these user groups. The survey of building characteristics could also be refined, with a greater focus on micro-level workplace measurements, such as the configuration of space, and variations within buildings, so that utility scores could then be linked to specific parts of buildings[49]. This study could be undertaken on an annual basis in order to create a

[48] The results from the operation cost survey could, however, be compared with those from Clark and Price's (2003) survey of 107 local authority office buildings, to determine whether the data from this study are representative of the larger sample.

[49] Space syntax could also be used to create explanatory variables for use in the analysis. The technique can be used to analyse the underlying patterns and structures of different spatial configurations in buildings (Hillier, 1996).

longitudinal dataset, enabling changes in the utility and operation costs of the sample buildings to be analysed over time[50].

There is growing anecdotal evidence to suggest that obsolescence can have an adverse impact on the performance of an occupier organisation, for instance through decreased operational efficiency, reduced output or declining morale in the workplace (Building Research Board, 1993). Nevertheless, difficulties in establishing a relationship between the performance of buildings and either individuals' productivity or organisational outcomes mean that this claim is has been hard to substantiate (Haynes *et al.*, 2000; EKOS Limited and Ryden Property Consultants, 2001). This is partly because the work output of building occupants is impossible to measure directly (Leaman and Bordass, 1999). Future research could, however, utilise scales of perceived productivity, similar to those developed by Wilson and Hedge (1987). The results from such scales could be used to determine whether there is a relationship between workplace utility and perceived productivity, or particular building characteristics and perceived productivity, whilst controlling for differences in occupant characteristics.

Additional explanatory variables could also be included in any future study as a means of improving the level of explanation provided by the workplace utility and building operation cost models. The workplace utility models could, for instance, incorporate indicators of organisational culture as explanatory variables. Organisational culture refers to the set of values specific to a work unit or organisation, values which embody assumptions about work, working together and how things should be done in a specific context (Mallack and Kurstedt, 1996; Turner and Myerson, 1998; Mallack *et al.*, 2003). These cultural values could be evaluated using the competing values framework, a method for generating cultural profiles of organisations that was developed by Quinn (1988). The level of explanation provided by the operation cost efficiency models could be improved by collecting data on building utilisation, data for which was missing in this study. Further research could also examine whether office buildings with lower occupancy costs have lower rates of rental depreciation, as hypothesised by the British Council for Offices (BCO, 2000).

Interpretation of the results in this study was complicated by the fact that many explanatory variables were intercorrelated, resulting in groups of statistical interdependencies. One way of overcoming this problem would be to subject the data to cluster analysis, a statistical technique for grouping objects based on their characteristics. The clusters of buildings and

[50] Such an approach to monitoring ongoing workplace performance would be useful in view of the fact that facilities managers need to cope with perpetual change in work processes and business practices (Bradley and Hood, 2003).

occupants resulting from such an analysis would exhibit high internal homogeneity (within-cluster) and high external (between-cluster) heterogeneity (Hair *et al.*, 1995). For example, cluster analysis of the physical characteristics data in this study might discriminate between institutional buildings, such as Victorian town halls, traditionally constructed office buildings with wet heating systems and natural ventilation, and more recently constructed steel and concrete frame office buildings with air-conditioning systems. These clusters could then be used as additional explanatory variables in the analysis.

Finally, this study could be repeated using data from a larger sample of office buildings or different building types. Sample size has a direct impact on the statistical power of multiple regression analysis and also affects the degree to which the results can be generalised (Hair *et al.*, 1995). Hence, analysis of a larger sample of data might highlight additional, but potentially weak statistically significant relationships between the outcome and explanatory variables. This is particularly important for the operation cost modelling, because missing data can drastically reduce the number of valid cases and, in turn, the level of explanatory power.

7.6 Reflections

The research presented in this thesis was originally started with a view to examining the environmental impact of obsolescence in buildings, the rationale being that increasing obsolescence and shorter building life cycles might represent inefficiency in the use of physical resources (Salway, 1986). However, it soon became apparent that, given the lack of empirical research in the subject area, it was first necessary to develop a better understanding of the factors that impact on the physical, functional and financial performance of buildings and, hence, obsolescence. In doing so, the author approached the problem from what might best be described as a traditional building surveying perspective, that is to say with a focus on the property aspects of the problem. One of the key lessons that the author has therefore taken from this research is the need to move beyond this traditional approach towards evaluating buildings and the workplace. Clearly, the findings of this study have implications for the surveying profession which, if it is to contribute to the workplace debate, may need to stop thinking solely in terms of property and focus more on the cultural and social aspects of workplace performance[51].

On a more personal level, by undertaking this study the author has developed a range of applied research skills, which have since been deployed effectively in other research and

[51] The findings of this study, which are grounded in exhaustive focus group research, also raise the question of whether occupants are able to fully articulate aspects of the workplace that constitute to its usefulness. Further research is required to answer this question.

consultancy projects. Carrying out this study has underlined some of the practical problems in conducting empirical research in this subject area, such as access to good quality data, as well as ways of overcoming or lessening the impact of these problems. Indeed, one of the most important lessons that the author has also learnt from this study is that research is, essentially, 'a messy process' (Blaxter *et al.*, 1999; p.192), one that requires patience, perseverance and flexibility to be carried out successfully. Finally, the author hopes that the findings and conclusions emanating from this study will provide the foundation for further research in the subject area.

References

Audit Commission (2000) *Hot property: getting the best from local authority assets*, Audit Commission, London.

Audit Commission (1988a) *Local Authority Property: A Management Overview*, HMSO, London.

Audit Commission (1988b) *Local Authority Property: A Management Handbook*, HMSO, London.

Baum, A. (1991) *Property investment depreciation and obsolescence,* Routledge, London.

BCO (2000) *Best practice in the specification for offices*, Third Edition, British Council for Offices, Reading.

Becker, F. and Sims, W. (2001) *Offices that work: Balancing communications, flexibility and cost*, Cornell University, International Workplace studies program.

Bootle, R. and Kalyan, S. (2002) *Property in business - a waste of space?*, The Royal Institution of Chartered Surveyors, London.

Blaxter, L., Hughes, C. and Tight, M. (1999) *How to research*, Open University Press.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999) Appraising the functional performance characteristics of office buildings, *Journal of Property Research*, **16** (4), 339-358.

Bradley, S. and Hood, C. (2003) Delivering minimalist workplaces that improve corporate agility, *Journal of Facilities Management*, **2** (1), 68-84.

Building Research Board (1993) *The fourth dimension in building: strategies for minimizing obsolescence,* National Academy Press, Washington D.C.

Cairns, G. (2003) Seeking a facilities management philosophy for the changing workplace, *Facilities*, **21**, (5/6), 95-105.

Clark, L. and Price, I. (2003) *Office benchmarking*, Local Government Facilities Management Research and Application Forum, Facilities Management Graduate Centre, Sheffield Hallam University, Sheffield.

Clark, L., Haynes, B., Pinder, J. and Price, I. (Forthcoming) The boundaries to workplace evaluation, Paper submitted to the *Futures in Property and Facility Management II Conference*, 26 March 2004, London.

Cowan, P., Nutt, B., Sears, D. and Rawson, L. (1970) *Obsolescence in the built environment, Report 3: Some empirical studies*, Joint Unit for Planning Research, London.

DEGW (2002) *Research for occupiers: Priority issues*, Occupier.org, http://www.occupier.org

EKOS Limited and Ryden Property Consultants (2001) *Obsolete commercial and industrial buildings*, Scottish Executive Central Research Unit, Edinburgh.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C (1995) *Multivariate data analysis with readings*, Fourth Edition, Prentice Hall, London.

Haynes, B. and Price, I. (2002) Quantifying the complex adaptive workplace, *Proceedings of the CIB W70 2002 Global Symposium*, Glasgow.

Haynes, B., Matzdorf, F., Nunnington, N., Ogunmakin, C., Pinder, J. and Price, I. (2000) *Does property benefit occupiers? An evaluation of the literature*, Report No. 1, http://www.occupier.org.

Hillier, B. (1996) *Space is the machine: A configurational theory of architecture*, Cambridge University Press, Cambridge.

Gray, J. and Tippett, H. (1992) *Office space: a primer for managers*, Centre for Building Performance Research, Victoria University of Wellington, New Zealand.

Khalid, G. (1994) Obsolescence in hedonic price estimation of the financial impact of commercial office buildings: The case of Kuala Lumpa, *Construction Management and Economics*, **12**, 37-44.

Leaman, A. and Bordass, B. (1999) Productivity in buildings: the 'killer' variables, *Building Research & Information*, **27** (1), 4-19.

Lenk, M.M., Worzala, E.M. and Silva, A. (1997) High-tech valuation: should artificial neural networks bypass the human valuer? *Journal of Property Valuation & Investment*, **15** (1), 8-26.

Lizieri, C. (2003) Occupier requirements in commercial real estate markets, *Urban Studies*, **40** (5/6), 1151-1169.

Mallak, L.A. and Kurstedt, H.A. (1996) Using culture gap analysis to manage organizational change, *Engineering Management Journal*, **8** (2), 35-41.

Mallak, L.A., Lyth, D.M., Olson, S.D., Ulshafer, S.M. and Sardone, F.J. (2003) Culture, the built environment and healthcare organizational performance, *Managing Service Quality*, **13** (1), 27-38.

Miles, J. and Shevlin, M. (2001) *Applying regression & correlation*, Sage Publications, London.

Nutt, B. (1999) Linking FM practice and research, *Facilities*, **17** (1/2), 11-17.

Nutt, B., Walker, B., Holliday, S., and Sears, D. (1976) *Obsolescence in housing: theory and applications*, Saxon House, Farnborough.

Oldham, G.R. and Brass, D.J. (1979) Employee reactions to an open-plan office: a naturally occurring quasi-experiment, *Administrative Science Quarterly*, **24**, 267-284.

Olson, J. (2002) Research about office workplace activities important to US business – And how to support them, *Journal of Facilities Management*, **1** (1), 31-47.

Price, I. (2001) *Flexible working policies and environments in UK local authorities: Current practice*, COPROP and ACES.

Purkis, H.J., How, R.F.C., Hooper, N.J. and Poole, M.T. (1977) *Occupancy costs of offices*, Current Paper CP 44/77, Building Research Establishment, Watford.

Quinn, R.E. (1988) *Beyond rational management*, Jossey-Bass, San Francisco

Salway, F. (1986) *Depreciation of commercial property,* The College of Estate Management, Reading.

Stokols, D., Clitheroe, C. and Zmuidzinaz, M. (2002) Qualities of work environments that promote perceived support for creativity, *Creativity Research Journal*, **14** (2), 137-147.

Tomlinson, J., Lewis, J. and Kaka, A. (1996) Premises occupancy cost analysis – current practice and developments towards a universal taxonomy, *In proceedings of the RICS COBRA Conference,* Royal Institution of Chartered Surveyors, London.

Turner, G. and Myerson, J. (1998) *New workspace, new culture: Office design as a catalyst for change*, Gower Publishing Limited, Aldershot.

Wells, M.M. (2000) Office clutter or meaningful personal displays: The role of office personalization in employee and organizational well-being, *Journal of Environmental Psychology*, **20**, 239-255.

Wilson, S. and Hedge, A. (1987) *The Office Environment Survey*, Building Use Studies, London.

Williams, B. (2003) *Facilities economics in the UK,* Building Economics Bureau Ltd, Bromley.

Yusof, A.M. (1999) Modelling the impact of depreciation: a hedonic analysis of offices in the city of Kuala Lumpur, Malaysia, PhD, University of Aberdeen.

Appendix A: Summary of occupier research

Author	Facility type	Research method	Principal findings
Medhurst and Lewis (1969)	Office, industrial and retail	Questionnaire survey of 24 occupier organisations to ascertain reasons for vacating property.	Occupier organisations moved because of rising rents, low adaptability of buildings, lack of parking facilities and other traffic problems.
Hendry (1970)	Residential	Questionnaire survey of occupiers.	Identified factors that contribute to obsolescence and impact on conservation.
Cowan *et al.* (1970b)	Office and residential	Questionnaire survey of 537 occupier organisations to ascertain reasons for vacating office property. Case study of occupier organisations to enable longitudinal analysis of organisational change in office buildings. Survey of residential occupiers.	Occupier organisations moved because of spatial constraints, financial constraints and constraints on organisational change.
Emery (1971)	Residential	Questionnaire survey of occupiers.	Identified factors that contribute to obsolescence and impact of education provision.
Nutt *et al.* (1976)	Residential	Secondary analysis of data from local government surveys of 10,000+ residential buildings. Questionnaire survey of 600 owner-occupiers to identify reasons why they had adapted buildings.	Building condition and household characteristics used to estimate probability of decision to adapt a building.
Fulcher and Gallagher (1977)	Industrial	Structured interviews with 42 occupier organisations to determine impact of obsolescence on productivity and occupancy costs.	Irregular and badly designed layouts, poor access to the building and inadequate space identified as key sources of obsolescence. Obsolescence perceived to impact on productivity and costs.
Williams (1985)	Industrial	Case studies of industrial buildings in Leicester and London to identify good and bad practice in adaptive re-use.	Identified common barriers to adaptive re-use of industrial property and highlighted need for proactive management of obsolescence.

Pugh (1991)	Retail	Case studies of shopping centres to identify causes of obsolescence and the feasibility of refurbishment.	Demonstrated costs and benefits of refurbishment decisions.
Building Research Board (1993)	All	Case studies of existing buildings and interviews with practitioners and academics.	Recommendations for the effective management of obsolescence through the service life of buildings.
Aikivuori (1996)	Residential	Questionnaire survey of 181 property owners to determine the relative influence of physical deterioration and obsolescence on residential refurbishment activity.	Obsolescence shown to be overwhelmingly more important than physical deterioration as a cause of refurbishment.
Bryson (1997)	Office	Case studies of refurbished office buildings in Nottingham.	Refurbishment a superior option than redevelopment in marginal development locations.
Ohemeng (1998)	All	Questionnaire survey of 84 property owners and developers to determine the factors behind renewal decisions and the relative weighting of the different factors. Data analysed using Multiattribute Utility Theory.	Decision framework to facilitate the selection of renewal (refurbishment or redevelopment) options.
Scottish Executive (2000)	Office and industrial	Interviews with 13 organisations and case studies of major Scottish towns and cities.	Obsolescence will become a significant problem in the next recession.
Slaughter (2001)	All	Interviews with property professional to determine physical characteristics and refurbishment costs for 48 buildings.	Flexible design added less than two per cent to construction costs, reduced overall construction time and provided a two per cent saving on refurbishment costs. Many buildings were less flexible than was previously thought.

Appendix B: Summary of property research

Author	Property type	Method of analysis	Principal findings
Bowie (1983)	Office and industrial	Analysis of hypothetical valuation data.	Building and site values used to estimate time to economic obsolescence.
Salway (1986)	Office, industrial and retail	Questionnaire survey of 70 occupier organisations to identify problems in older property.	Obsolescence more important than physical deterioration as a cause of depreciation.
		Questionnaire survey of 120 property owners and advisors to reveal appraisal practices.	Development of a depreciation-sensitive appraisal technique.
		Cross-sectional analysis of hypothetical valuation data for 57 locations.	Age used to estimate depreciation.
Jones Lang Wootton (1987)	Office and industrial	Cross-sectional analysis of valuation data	Age used to estimate depreciation.
Baum (1991)	Office and industrial	Interviews with property agents to identify important physical characteristics.	Age and four physical characteristics (building qualities) used to estimate depreciation.
		Questionnaire survey of occupier organisations to weight physical characteristics.	
		Cross-sectional analysis of valuation data and physical characteristics for 250 buildings, using multiple regression analysis.	
Khalid (1994)	Office	Questionnaire survey of 100 occupier organisations and property managers to identify and weight important physical characteristics.	Age and 21 physical characteristics used to estimate depreciation (financial impact of building obsolescence).
		Hedonic price analysis of valuation data and physical characteristics for 136 buildings.	
Barras and Clark (1996)	Office	Cross-sectional and longitudinal analysis of transactions data from the Investment Property Databank (IPD), covering 150 buildings.	Age used to estimate depreciation.

Baum (1997)	Office	Cross-sectional analysis of valuation data and longitudinal analysis of buildings from Baum's (1991) study.	Age and four physical characteristics (building qualities) used to estimate depreciation. Relative importance of physical characteristics shown to change over time.
Yusof (1999)	Office	Semi-structured interviews with occupier organisations and property managers to identify and weight important physical characteristics. Cross-section analysis of valuation data and physical characteristics for 100 buildings, using hedonic price analysis and principal component analysis.	Age and eight physical characteristics used to estimate depreciation (financial impact of building obsolescence).
Dixon *et al.* (1999)	Office, industrial and retail	Longitudinal analysis of IPD data for 728 buildings. Case study analysis of 33 buildings.	Age and geographical location used to estimate depreciation.
Bottom *et al.* (1999)	Office	Walk-through survey of 100 buildings to assess their physical characteristics. Questionnaire survey of 270 occupier organisations to elicit their perceptions of the buildings and their organisational characteristics. Questionnaire survey of property owners to ascertain general information about the buildings. Cross-sectional analysis (using multiple regression analysis and neural network analysis) of functional performance data, building characteristics, organisational characteristics and valuation data.	Age, physical characteristics and occupancy characteristics used to estimate functional performance and depreciation.
Dunse and Jones (2002)	Industrial	Hedonic price analysis of valuation data (2750 cases) from the Scottish Property Network.	Age, physical characteristics and geographical location used to estimate depreciation.

Appendix C: Schedule of characteristics covered by building surveys

Item	Heading	Characteristic	Notes
1	Survey details		
1.1	Auto start time		
1.2	Date of survey		
1.3	Building address		
1.4	Name of organisation		
2	Site and location		
2.1	On-site car parking	– No provision	
		– Indoor parking	
		– Outdoor parking	
		– Attended control station	
		– Intermittent guard patrol	
		– Barrier control	
		– Controlled by signage	
		– Uncontrolled	
		– User text	
2.2	No. of on-site car parking spaces		
2.3	Site condition and environs	– Very clean and tidy. Paved areas in as-new condition. Exterior furniture in as-new condition. No litter or graffiti.	
		– Clean and tidy. Paved areas in good condition. Exterior furniture has a looked after appearance. No litter or graffiti.	

		– Dirty and untidy. Paved areas and exterior furniture in poor condition. Some litter or graffiti.
		– Very dirty and untidy. Paved areas and exterior furniture are in very poor condition. Much litter or graffiti.
		– User text
2.4	Soft landscaping	– Extensive landscaping, regularly maintained.
		– Adequate landscaping, occasional maintenance.
		– Minimal landscaping.
		– No provision
		– User text
2.5	Distance to public car parking (m)	
2.6	Distance to bus stops/station (m)	
2.7	Distance to train station (m)	
2.8	Distance to tram/light rail stop/station (m)	
2.9	Distance to shopping precinct/centre (m)	
2.10	Distance to public park/open space (m)	
3	Building structure	
3.1	Type of structure	– Load bearing walls
		– Steel/concrete frame
		– User text
3.2	Arrangement of structure	– Atrium
		– Courtyard
		– Deep plan (12-18m from perimeter to core)
		– Medium depth (approx. 15m depth)

		– Shallow depth (approx. 10m depth)
		– Podium and tower
		– User text
3.3	Type of core	– No provision
		– Concentrated
		– Semi-dispersed
		– Dispersed: stairs more prominent
		– Dispersed: lifts more prominent
		– User text
3.4	Number of floors	
4	Building enclosure	
4.1	Exterior walls	– Stone
		– Masonry
		– Concrete
		– Cladding
		– Curtain wall
		– Timber cladding
		– User text
4.2	Exterior windows	– Aluminium, single glazed
		– Aluminium, double glazed
		– Timber, single glazed
		– Timber, double glazed
		– PVCu, single glazed

		– PVCu, double glazed	
		– User text	
4.3	Exterior doors	– Aluminium, fully-glazed	Principal and ancillary access doors only (exclude goods access etc.)
		– Aluminium, semi-glazed	
		– Aluminium	
		– Timber, fully-glazed	
		– Timber, semi-glazed	
		– Timber	
		– PVCu, fully-glazed	
		– PVCu, semi-glazed	
		– PVCu	
		– User text	
4.4	Identity of principal entrance	– No features, entrance blends with facade	
		– Emphasised at ground floor level (colour, materials etc.)	
		– Emphasised at several levels (colours, materials etc.)	
		– Entrance emphasised by structural design at ground floor level	
		– Entrance emphasised by structural design on several levels	
		– User text	
5	Reception/foyer		
5.1	Draught exclusion	– No provision	Draught exclusion provided at principal entrance(s)
		– Double doors, space between not exceeding 3m	
		– Revolving doors, diameter not exceeding 3m	

		– Double doors, space between exceeding 3m – Revolving doors, diameter exceeding 3m – User text	
5.2	Disabled access	– No provision – Ground level entrance/level access – Wide entrance (>840mm) – Access ramp – Special lift facilities – Manual opening, automatic closing doors – Automatic opening and closing, signal control (e.g. buzzer) – Automatic opening and closing, hands free signal (IR) – User text	Provisions for disabled access at principal entrance(s)
5.3	Security	– No provision – Visual – Door control (buzzer/intercom) – Formal control (security guard) – CCTV – Combination/key lock – Swipe card – User text	Security provisions at principal entrance(s)
5.4	Reception desk	– Yes – No	

6	Common services and amenities	
6.1	Location of common services	– Decentralised/minimal
		– Centralised
		– Floor-by-floor/departmental
		– User text
6.2	Type of common services	– Wet heating system, natural ventilation
		– Wet heating system, mechanical ventilation, extract, filtered input
		– Dry heating system, mechanical ventilation, extract, filtered input
		– Full air conditioning (heating, cooling, humidity etc.)
		– Mixed-mode air conditioning and natural ventilation (BMS)
		– User text
6.3	Typical no. w.c. units per floor	
6.4	Disabled toilets on each floor	– Yes
		– No
6.4	Catering facilities	– No provision
		– Vending machines
		– Kitchenettes
		– Single kitchen/lunchroom for several floors
		– Kitchens/lunchrooms on each floor occupied
		– Cafeteria/restaurant
		– User text

6.5	Finishes and fittings	– Basic non-resistant finishes and basic fittings – Floor tiles (or similar purpose finish) – Floor and wall tiles, partial cover – Floor and wall tiles, complete cover – Complete tiling and integrated furniture/fittings – User text
6.6	Location of reprographics	– No provision – Centralised – Decentralised – Floor-by-floor/departmental – User text
6.7	Location of mail room	– No provision – Centralised – Decentralised – Floor-by-floor/departmental – User text
6.8	Seating away from work areas	– No provision – Casual seating in common areas – Casual seating outdoors – Central lounge/break out area – Lounge/break out area on each floor – Lounge/break out area in each organisational unit – User text

6.9	Additional on-site staff facilities	– No provision – Shower/changing facilities – Smoking rooms/areas – Day care/crèche facilities – Gym/fitness facilities – Bar/social club – Shop(s) – User text	
7	Common areas and circulation		
7.1	Number of passenger lifts		Excluding dedicated goods lifts
7.2	Total passenger lift capacity (persons)		
7.3	Number of staircases		Excluding dedicated goods staircases
7.4	Average width of staircase(s) (mm)		
7.5	Average width of corridors (mm)		
7.6	Direction changes from lifts/stairs to furthest work area		
7.7	Distance from stairs/lifts to furthest work area (m)		
7.8	Disabled circulation	– No provision – Level access – Wide doors (>840mm) – Access ramps – Special lift facilities – Manual opening, automatic closing doors	Provisions for disabled circulation on principal route(s)

		– Automatic opening and closing, signal control (e.g. buzzer)	
		– Automatic opening and closing, hands free signal (IR)	
		– User text	
7.9	Internal sub-division	– Stone/masonry/concrete, largely permanent party walls, solid or glazed. Bricks, blocks or storey-height panels. Not easily demountable and wet construction.	Method of sub-division of main corridors/circulation routes
		– Stud and sheet systems. Sheets of plasterboard 'egg-box' construction, compressed straw or wood wool slabs, chipboard, or metal secured to and supported by concealed timber of metal studs.	
		– Lightweight, demountable system. Frame and panel, dry construction.	
		– Movable/instantly demountable partitions. Sliding, sliding/folding with ceiling track, or removable panels locked against floor and ceiling.	
		– User text	
7.10	Wall finish	– Stone/rigid tiling	
		– Plaster and finish	
		– Timber	
		– Decorative papers/fabrics	
		– User text	
7.11	Floor finish	– Granolithic/terrazzo	
		– Stone/concrete/quarry/ceramic tiles	
		– Woodblock/parquet	
		– Rubber/plastics/cork/lino	
		– Carpet/carpet tiles	

		– User text	
7.12	Ceiling finish	– Plaster and finish	
		– Metal tiles	
		– Mineral fibre tiles	
		– Plaster and PVC tiles	
		– User text	
7.13	Elements, fixtures and fittings	– Impeccable, new or like new. All items are free from dirt, stains and defects. First class condition, sparkling clean and in smooth working order.	Presentation and condition of internal elements, fixtures and fittings, including physical state, cleanliness, staining etc.
		– Above average condition or fairly new. All items are free from marks, stains and defects. Some items (0-25%) are dirty or dusty, and require additional cleaning.	
		– Functional in appearance and image, with no defects. Some items (0-25%) have marks or stains, requiring specialist cleaning or replacement. Many items (25-50%) are dirty or dusty	
		– Damaged or worn. Some items (0-25%) are defective or inoperable. Many items (25-50) are marked or stained. Most items (50-75%) are dirty, dusty or streaked.	
		– Extensively worn or badly damaged. Many items (25-50%) are defective or inoperable. Most items (50-75%) have marks or stains). Nearly all items (75-100%). are dirty, dusty, streaked or grimy	
		– User text	
7.14	Interior planting	– Yes	
		– No	
8	Working environment		
8.1	Heating control	– No provision/Centralised	

		– Per floor level/departmental	
		– Per large space (>150m^2)	
		– Per medium space (40-150m^2)	
		– Per small space (<40m^2)	
		– User text	
8.2	Mechanical ventilation control	– No provision/Centralised	
		– Per floor level/departmental	
		– Per large space (>150m^2)	
		– Per medium space (40-150m^2)	
		– Per small space (<40m^2)	
		– User text	
8.3	Natural ventilation	– Non-openable windows/all sealed	
		– Restricted openable windows/locked	
		– Every other window unit opens (or less)	
		– All window units have opening sections	
		– All window units open, fully adjustable	
		– Trickle vents	
		– User text	
8.4	Percentage of window units that open		
8.5	Average repetitive window width (mm)		
8.6	Average repetitive window height (mm)		
8.7	Average repetitive window sill height (mm)		
8.8	Average distance between windows units		Average distance between windows

	(mm)		units suitable for fixing partitions (mm)
8.9	Approx. window area per floor space occupied (m^2)		
8.10	% open plan (without screens/partitions)		
8.11	% open plan (with screens/partitions)		
8.12	% cellular		
8.13	Screens/lightweight partitions	– No provision	
		– All permanent partitions, difficult to move	
		– Mostly permanent, few moveable	
		– Mostly moveable partitions, few permanent	
		– All moveable partitions	
		– All moveable and re-usable	
		– User text	
8.14	Average of height of screens/partitions (mm)		
8.15	Typical office depth from perimeter (m)		
8.16	Floor-to-ceiling height (mm)		
8.17	Average width of perimeter wall sections (mm)		
8.18	Distance between columns (mm)		
8.19	Wall finish	– Stone/rigid tiling	
		– Plaster and finish	
		– Timber	
		– Decorative papers/fabrics	
		– User text	

8.20	Floor finish	– Granolithic/terrazzo – Stone/concrete/quarry/ceramic tiles – Woodblock/parquet – Rubber/plastics/cork/lino – Carpet/carpet tiles – User text	
8.21	Ceiling finish	– Plaster and finish – Metal tiles – Mineral fibre tiles – Plaster and PVC tiles – User text	
8.22	Fittings, fixtures and furniture	– Impeccable, new or like new. All items are free from dirt, stains and defects. First class condition, sparkling clean and in smooth working order. – Above average condition or fairly new. All items are free from marks, stains and defects. Some items (0-25%) are dirty or dusty, and require additional cleaning. – Functional in appearance and image, with no defects. Some items (0-25%) have marks or stains, requiring specialist cleaning or replacement. Many items (25-50%) are dirty or dusty – Damaged or worn. Some items (0-25%) are defective or inoperable. Many items (25-50) are marked or stained. Most items (50-75%) are dirty, dusty or streaked. – Extensively worn or badly damaged. Many items (25-50%) are defective or inoperable. Most items (50-75%) have marks or stains). Nearly all items (75-100%). are dirty, dusty, streaked or grimy	Presentation and condition of internal fixtures, fittings and furniture, including physical state, cleanliness, staining etc.

		– User text
8.23	Cable distribution	– Flexible extension leads from the ceiling
		– Simple perimeter/ceiling trunking
		– Continuous ceiling track with tap-off
		– Skirting trunking
		– Under slab trunking with wire duct
		– Floor trunking system
		– Fixed wall/column system
		– Dado or bench trunking
		– Flat-wire cable from perimeter
		– Access flooring
		– User text
8.24	Interior planting	– Yes
		– No
10	Survey end	
	Ancillary questions	

Condition/presentation	– Impeccable, new or like new. All surfaces are free from dirt, stains and defects. First class condition, sparkling clean and fresh looking. – Above average condition or fairly new. All surfaces are free from marks, stains and defects. Dirty or dusty in places (0-25% of surface area), some areas require additional cleaning. – Functional in appearance and image, with no defects. Marks or stains in places (0-25% of surface area), requiring specialist cleaning. Many areas (25-50% of surface area) are dirty or dusty – Damaged or worn, with defects in places (0-25% of surface area). General marks or stains (25-50% of surface area). Most areas are dirty, dusty or streaked (50-75% of surface area). – Extensively worn or badly damaged, with a significant number of defects (25-50% surface area). Most areas have marks or stains (50-75% surface area). Surface is uniformly dirty, dusty, streaked or grimy (75-100% of surface area) – User text	Presentation and condition of surfaces, including physical state, cleanliness, staining etc.

Appendix D: Occupancy cost survey instrument

Sheffield Hallam University

fm research
facilities management graduate centre

Survey of Local Government Office Building Occupancy Costs

Purpose of this survey

The purpose of this survey is to collect occupancy costs data for a sample of local government office properties. The data you provide will be used for benchmarking comparisons, and to develop a model for estimating and reducing the costs of obsolescence in local government office property.

Confidentiality

All information from this survey that relates to an identifiable individual, property or organisation will remain confidential. Any published material will only present the data as a component in aggregated statistics.

Guidance notes

Please complete this questionnaire for <u>**each**</u> of the properties included in the sample. Sections A and B ask for information about you, your organisation and the characteristics of the property. Section C focuses on the occupancy costs for the property, and Section D the occupancy characteristics of the property. All questions may be answered either by (i) ticking the boxes provided (ii) a short written response. Please answer all of the questions in the space provided. If a question is not applicable, please leave it blank. To help ensure comparability across the sample, terms in bold type are defined in a table at the end of this questionnaire.

Contact details

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Section A: General information

1. Please provide the following information:

a. Address of the property ______________________________

b. Name of your organisation ______________________________

c. Your name ____________________

d. Your job title ____________________

e. Your telephone number ____________________

f. Your email address ____________________

Section B: Property characteristics

1. What is the age of the property? __________

2. Is the property listed? Yes ☐ No ☐

3. Please give details of the property characteristics by providing a figure for each of the following:

a. **Gross internal area** of the property ______________m^2

b. **Net internal area** of the property ______________m^2

c. **Occupied net internal area** of the property ______________m^2

d. **Vacant net internal area** of the property ______________m^2

e. **Sub-let net internal area** of the property ______________m^2

4. What is the **net internal area** of **democratic space** in the property? __________m^2

5. What is the **gross internal area** of your organisation's office estate/portfolio? __________m^2

Section C: Occupancy costs

1. How many years has your organisation occupied the property? __________

   If 6 years or less, what **acquisition costs** were incurred by your organisation? £________

2. Please provide details of the **occupation costs** incurred by your organisation for the property for the financial year 2000/2001:

a. **Rent** £____________ or **Notional rent** £__________

b. **Unitary charges** £____________

c. **Local property taxes** £____________

d. **Associated car parking** £____________

e. **Associated facilities** £____________

3. How many years is it since the property was last refurbished? __________

   If 8 years or less:

   What **fit-out and improvement** costs were incurred by your organisation? £________

   What **furniture and equipment** costs were incurred by your organisation? £________

4. Has your organisation incurred any other **fit-out and improvement** costs on the property within the last 8 years? Yes ☐ No ☐

   If yes, what costs were incurred £_______________

5. Has your organisation incurred any other **furniture and equipment** costs on the property within the last 6 years? Yes ☐ No ☐

   If yes, what costs were incurred £_______________

6. Please provide details of the **operation costs** incurred by your organisation for the property for the financial year 2000/2001:

a. **Insurance** £_______________

b. **Internal repair and maintenance** £_______________

   What proportion of this expenditure was planned? ________%

c. **M&E repair and maintenance** £_______________

   What proportion of this expenditure was planned? ________%

d. **External and structural repair and maintenance** £_______________

e. What proportion of this expenditure was planned? ________%

f. **Minor improvements** £_______________

   What proportion of this expenditure was planned? ________%

g. **Internal moves** £_______________

   What proportion of this expenditure was planned? ________%

h. **Dilapidations** £_______________

i. **Cleaning** £_______________

   What proportion of this expenditure was on internal cleaning? _______%

j. **Security** £_______________

k. **Waste disposal** £_______________

l. **Internal plants and flowers** £_______________

m. **Grounds maintenance** £_______________

n. **Water and sewerage** £_______________

o. **Electricity** £______________

p. **Gas** £______________

q. **Oil** £______________

r. **District heating** £______________

7. Please provide details of the **business support costs** incurred by your organisation for the property for the financial year 2000/2001:

a. **Telephones** £______________

b. **Catering** £______________

c. **Reception services** £______________

d. **Post room services** £______________

e. **Reprographics** £______________

8. Please provide details of the **management costs** and fees incurred by your organisation for its office estate/portfolio for the financial year 2000/2001:

a. **Real estate management** £______________

What proportion of this expenditure was on out-sourced REM? ________%

b. **Facilities management** £______________

What proportion of this expenditure was on out-sourced FM? ________%

9. Please provide details of the **net income received** by your organisation (from tenants, employees etc.) for the property for the financial year 2000/2001:

a. **Associated car parking** £______________

b. **Associated facilities** £______________

c. **Catering** £______________

d. **Rent** £______________

Section D: Occupancy characteristics

1. Does your organisation?

Own the property ☐
Lease the property from an external landlord ☐
Lease the property under the Private Finance Initiative ☐
Lease the property from a serviced office provider ☐

1. Does your organisation charge space users an **internal rent** for the use of space?

Yes ☐ No ☐

If Yes, what is the basis of the charge?

Area occupied ☐
Personnel headcount ☐
Functional identity ☐
Overhead contribution ☐
Other ☐

If other, please specify?

____

3. Are other occupancy costs charged out to space users? Yes ☐ No ☐

If yes, which costs are charged out?

____
____
____
____

4. How many floors of the property are occupied by your organisation? __________

5. How would you describe the property in relation to others occupied by your organisation? (e.g. main headquarters/back office) ______________________________

6. Please give details of the occupancy characteristics for the property by providing a figure for each of the following:

a. **Full time equivalent staff** __________
b. **Number of workstations** __________
c. **Number of people moves** __________
d. **Building opening hours** __________

7. Was the number of people moves in the property in the financial year 2000/2001:

Higher than normal ☐
Normal ☐
Lower than normal ☐

8. Please indicate whether any of the following working practices are used in the property and, if so, by what percentage of full time equivalent staff:

Home working	☐	__________%
Hot desking	☐	__________%
Hotelling	☐	__________%
Mobile office	☐	__________%
Team working	☐	__________%

Thank you for completing this questionnaire. Please return it in the envelope provided.

Term	Definition
Acquisition costs	Any other costs associated with the acquisition of the property, particularly taxes and duties (e.g. stamp duty). Fees associated with acquisitions are entered as real estate or facilities management fees.
Associated car parking	The rent or licence paid together with any local property taxes (e.g. rates) charged on any on-site or off-site car parking associated with the property, whether part of the overall lease agreement or paid separately.
Associated facilities	The rent or license fee paid together with any local property tax charged (e.g. rates) on any on-site or off-site leisure or any other ancillary facilities directly associated with the property, whether part of the overall lease agreement or paid separately. Includes off-site file storage arrangements and contracts.
Building opening hours	The total number of hours in a typical working day the property is open and available for use by the majority of staff. The property would normally be fully serviced during these times.
Catering	Total net cost of providing all catering and vending services, taking into account income generated through charging and any costs that are incurred through directly or indirectly employed staff and consumables. This should include the full cost of food and drinks, including preparation, storage and services, and any income derived from the licensing of catering space as part of a catering contract.
Cleaning	The annual costs associated with the cleaning of internal and external areas of the property. It includes the full costs of employment, special equipment, materials and other associated costs as well as all contractor costs. All ancillary spaces, toilets, staircases, landing and lobby areas are included. It includes relevant regular items to be cleaned, such as windows, glazed partitions, desks, partitions, floors, carpets, bins, receptions desk, chairs, hand rails, WC's and urinals. It also includes periodic special cleaning (e.g. acoustic ceilings and lighting, IT equipment, deep cleaning and shampooing of carpets, deep cleaning of toilets and general pest control). It excludes any costs associated with the repair and replacement of defective component parts.
Democratic space	Space used for members, members offices, chambers, electoral register and committee suite for members only. Includes mayor's suite of offices and meeting space.
Dilapidations	The actual costs in the year incurred arising from external landlords' claims under lease terms either for breach of contract or for remedial work to reinstate the condition of the leased property.
District heating	The total annual cost of all district heating supplies to the property. It excludes repair and improvements to associated equipment and facilities.
Electricity	The total annual cost of all electricity supplies to the property. It excludes repair and improvements to associated equipment and facilities.
External and structural repair and maintenance	Annual costs associated with the repair and maintenance of the building fabric and any part of the exterior (i.e. all integral structural parts of the property, including roofs, walls fenestration, external drainage and foundations). It includes redecoration of external finishes and repair of external cladding and finishes. It also includes the full costs of employment, special equipment, materials and other associated costs as well as all design and contractor costs. It excludes major items of external and structural repair and replacement amounting to over £100,000.

Facilities management	Includes the management of all activities associated with adaptation and equipment costs (fit-out and improvement, furniture and equipment), building operation costs (insurance, internal repair and maintenance etc.) and business support costs (catering, reception services etc.).
Fit out and improvement	The total cost of fit-out and improvement including partitioning, access control systems, building management systems, cabling, carpeting, electrical installation, air conditioning, space heating, fixtures, fittings, flooring, floor coverings, tiling, false ceilings, woodwork and joinery, wall linings, lighting, uninterrupted power supply, signage, kitchen and canteen areas. Includes all associated professional and project management fees. Excludes telephone and security systems. Also excludes items of repair (putting something back into good or acceptable condition). The cost of any physical extension should be accounted for under rent although the fit-out costs of the extension should be included here. Includes major items of repair and replacement amounting to over £100,000.
Full time equivalent staff	The number of permanently employed, temporary and contract office staff from your organisation that work in the property, counted in terms of full time equivalents. This is calculated as follows:

Staff employed on a regular basis >30 hours per week	1.00
Staff employed on a regular basis 20-30 hours per week	0.75
Staff employed on a regular basis 15-20 hours per week	0.50
Staff employed on a regular basis <15 hours per week	0.25

To qualify as a member of office staff working in the property, staff must use the property as their main base and also expect to work in the property for at least some part of a typical working week

Furniture and equipment	The total cost of all furniture and equipment relating to office, sales, production, storage, reception, workstation, meeting, training, boardroom and kitchen areas. Includes desks, chairs, tables, soft furnishing, lighting units, pedestals, screens, curtains, drapes, blinds, shelving, storage cabinets, works of art, storage binds, mechanical handling equipment, waste compactors, cookers, freezers and other kitchen equipment. Excludes IT and computer equipment.
Gas	The total annual cost of all gas supplies to the property. It excludes repair and improvements to associated equipment and facilities.
Gross internal area (m^2)	The area of the property measured to the internal face of the perimeter wall at each floor level. It includes areas occupied by internal walls and partitions, columns, piers and other internal projections, internal balconies, stairwells, toilets, lift lobbies, fire corridors, atria measured at base level only, and covered plant rooms. It excludes the perimeter wall thickness and external projections, external balconies and external fire escapes.
Grounds maintenance	The annual costs of maintenance of grounds and external areas. It includes car parking areas, roadways, pavement areas, shrubs, flowers, window boxes, borders, lawns, playing fields, pavilions and snow/litter clearance. It also includes the full costs of employment, special equipment, materials and other associated costs as well as all contractor costs. It excludes repair and maintenance work conducted in association with the provision of grounds maintenance.
Home working	Where members of staff spend some of their time in the office but work for perhaps two or three days at home, having little or no need of the facilities in the office for a significant portion of time.

Hotelling	Where members of staff are not assigned a workspace, but must instead 'reserve' a workspace for those times when they are in the office.
Hot desking	Where members of staff do not have a specific desk allocated to them in the property, but use any desk that is free, keeping their personal belongings in lockers or filing cabinets.
Insurance	The annual costs of premiums for insuring the property to include all building insurance and contents policies, also to include liability for excess. It includes premiums for terrorism, loss of rent, liability under the Health and Safety at Work regulations, floor, burst pipes, subsidence, fire, explosion and insurance premium tax. It excludes insurance for loss of trade, public liability, damage or theft of computers and disaster recovery. Organisations who wholly self-insure, thereby bearing the risks themselves, will have a nil cost for this item.
Internal moves	The direct revenue costs primarily associated with space reorganisation in the property. It includes associated redecoration costs, movement of internal partitions, telephone and PC reconnections and movement of furniture and filing. It also includes the full costs of employment, special equipment, materials and other associated costs, as well as all contractor costs.
Internal plants and flowers	The annual cost of provision and maintenance of flowers to include dusting, cleaning, pruning, feeding and water. It includes the full costs of employment, special equipment, materials and other associated costs as well as all contractor costs.
Internal rent	A charge made by one part of the organisation to another for the use and occupation of property. They are a form of cost allocation of transfer pricing.
Internal repair and maintenance	The annual expenditure for all items of internal repair and maintenance, including regular redecoration, internal wall and ceiling finishes, furniture, equipment, storage units and signage. It also includes the full costs of employment, special equipment, materials and other associated costs as well as design and contractor costs. It excludes M&E, internal moves, dilapidations, maintenance costs for manufacturing or business processes, and major items of internal repair and replacement amounting to over £100,000.
Local property taxes	The current annual payment for property taxes (e.g. rates) for the occupation of the property, including any phasing provisions. Excludes the effects of rebates received.
M&E repair and maintenance	Annual costs associated with the repair, servicing and maintenance of mechanical and electrical equipment (i.e. normal building services such as air conditioning units, electrical power and lighting, lifts, and escalators). It includes maintenance or renewal of subsidiary/component parts of equipment as well as fire services, water and plumbing, and sprinkler systems. It also includes the full costs of employment, special equipment, materials and other associated costs, as well as all design and contractor costs. It excludes total renewal, alteration or replacement, and major items of M&E repair and replacement amounting to over £100,000.
Minor improvements	The annual costs of minor improvements (typically less than £10,000 in value) to the property charged to the revenue (non-capital) account. It includes the full costs of employment, special equipment, materials and other associated costs as well as all design and contractor costs. It excludes expenditure primarily causes by internal moves.
Mobile office	Where members of staff travel between locations (e.g. other organisations, other premises, home or touchdown centres). Members of staff can move around physically while remaining in easy contact via email, voice mail, fax or telephone. Mobile workers have access to all the

	on-line data they need, although hard copy information may only be available at certain sites.
Net internal area (m^2)	The usable area within a property measured to the internal face of the perimeter walls at each floor level. It includes kitchens and cleaners cupboards (atria and entrance halls should be measured separately). It excludes toilets, stairwells, plant rooms, fire corridors, and internal structural walls, columns, internal projections and vertical ducts.
Notional rent	Notional open market rent equivalent in order that the opportunity cost rent is captured. For freeholds and other leaseholds (where there is no full market rent paid (e.g. ground rent) or where a premium has been paid), the rental charge should represent the current open market rental value for existing use. Premiums and purchase prices should be ignored. In the case of properties where no evidence of open market rental value is available use a value in the form of a depreciated replacement cost (using a decapitalisation rate set at 2% over the Bank of England base lending rate). Any rent paid or attributable to extras (e.g. car parking, leisure facilities etc) should be excluded. Landlords' improvements will generally be included in the calculation of rent whereas tenants' improvements will be excluded. Management fees/disaster recovery space are excluded.
Number of people moves	The total number of people moves from one workstation to another in a year. Count new arrivals to the property as a person move.
Number of workstations	The number of designated 'desk' or other workplaces and positions within the property, including both occupied and vacant positions, but excluding any within designated meeting rooms or areas
Occupied net internal area (m^2)	The part of the net internal area of the property that is occupied by your organisation.
Oil	The total annual cost of all oil supplies to the property. It excludes repair and improvements to associated equipment and facilities.
Post room services	The total cost of all post room staff including outsourced staff, directly employed staff and supervision. It includes opening, collating, distributing, packaging, stamping, recording and despatching mail.
Real estate management	Includes the management of all activities associated with occupation costs (rent, unitary charges, acquisition costs, local property taxes, associated car parking and associated facilities) for the property.
Reception services	The total cost of reception services including directly and indirectly employed staff, recruitment, training and relief costs for absences. It also includes costs of all consumables and uniforms, and reception services for dedicated meeting rooms/conference/audio-visual facilities. It excludes telephone and security items.
Rent	The actual current open market rent payable, where negotiated in the last five years. For leaseholds where a full market rent is payable subject to a review period of seven years or less, record the current rent paid. Any rent paid or attributable to extras (e.g. car parking, leisure facilities etc) should be excluded. Premiums and purchase prices should be ignored. Where there is a rent-free period or other inducement at the beginning of a lease, the effect of this should be rentalised by dividing the total rent commitment by the number of years up to the date of the next rent review at which the full market rent is payable. Landlords' improvements will generally be included in the calculation of rent whereas tenants' improvements will be excluded. Management fees/disaster recovery space are excluded. In the case of properties where no evidence of open market rental value is available use notional rent.
Reprographics	The total cost of all reprographic equipment, either leased or annualised

	purchase costs, together with the costs of any dedicated staff, services and consumables (e.g. paper and toner). It includes equipment maintenance and service call outs. It excludes printing costs.
Security	The annual costs of securing the property. It includes the costs of security contractors and employed staff as well as the regular costs associated with the maintenance of systems (usually in the form of a maintenance contract). It includes annual depreciation and maintenance costs of intruder detection systems, such as alarms, detectors, central control and CCTV. It also includes access control systems, badges/identity cards, swipe card readers, proximity passes, access gates/huts, vehicular access control, uniforms, communications equipment, tannoy and loudspeakers. Expenditure incurred as a result of a security breach should be recorded against the relevant category.
Sub-let net internal area (m^2)	The part of the net internal area of the building that is let by your organisation to sub-tenants.
Team working	Where members of staff from different divisions or departments work together to solve problems or complete tasks. Membership of teams may change over time.
Telephones	Includes annualised costs of PABX, central control box, switchboard systems, all system cards, handsets, direct dial and voicemail. Includes staff cost of telephone answering, switchboard and communications services, the cost of all telephone line charges and maintenance to the telephone system and network including handsets, cabling and PABX and voicemail. Exclude costs of all telephone calls and all costs of mobile phones.
Unitary charges	Net unitary or serviced office charges which incorporate a total property services package should be included without an individual cost breakdown but exclude separately charged extra services such as consumables, telephone call charges, secretarial services, food and beverage, meeting and board room charges.
Vacant net internal area (m^2)	The part of the net internal area of the property (leased/owned by your organisation) that is vacant.
Waste disposal	The annual costs of refuse collection and the disposal of confidential, sanitary and toxic waste. It includes the full costs of employment, special equipment, materials and other associated costs as well as all contractor costs. It excludes repair and improvement work conducted in associated with the provision of waste disposal.
Water and sewerage	Total annual revenue expenditure incurred at the property for water supply, treatment and sewerage. It excludes repair and improvement work conducted in associated with the provision of water and sewerage.
Note on service charges	The annual service charge paid to an external landlord for the delivery of services under the terms of the lease. Normally exists to provide for services that are common to tenants in a multi-let building. It is recommended that any service charges should be included in accordance with items listed elsewhere in this questionnaire. At present it is simply not advisable to compare service charges on different buildings since lease terms vary considerably in relation to the services offered.

Appendix E: Focus group guide

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Focus group – You and your office accommodation

Purpose of this focus group

At this stage of the project my focus is on the issue of office building utility. My objective is to establish the criteria that occupants use to evaluate the usefulness of their office accommodation.

1. How does this office building affect the way you do things round here?
2. Do you think that any features of this office building affect your ability to carry out your job effectively?
3. Do you think that any features of this office building affect the efficiency (or ease) with which you carry out your job?
4. Do you think that any features of this office building affect your job satisfaction?
5. In what ways, if at all, have your work activities changed over time and how has this office building supported or constrained these changes?
6. Do you think that particular characteristics of this office building affect the way that you interact with your colleagues?
7. What do you see has being the essential characteristics of a 'good' office building?
8. Which features of an office building do you see has being most important?
9. What would you change in this office building to increase your personal productivity?
10. Are there any other issues relating to this office building that we may have missed but that you feel are important?

Thank you for your assistance. If you would like to receive a copy of the final report for this research please email me at the address provided below.

Appendix F: Schedule of scale items generated from focus groups

Item	Description
1.	Comfortable temperature
2.	Control over temperature
3.	Comfortable humidity
4.	Feel fresh and airy
5.	Feel well-ventilated
6.	Control over ventilation
7.	Operable windows
8.	Free from draughts
9.	Place to make a hot drink
10.	Place to go to relax
11.	A place away from desk to eat their lunch
12.	Good quality drinking water
13.	Up-to-date information technology
14.	Up-to-date telecommunications services
15.	Reliable telecommunications services
16.	Visual privacy in workspace
17.	Conversational privacy in workspace
18.	A place to work free from distraction
19.	Facilitate chance interaction with colleagues
20.	A place to socialise with colleagues
21.	A place to smoke if desired
22.	Adequate toilet facilities
23.	Conveniently accessible toilet facilities
24.	Comfortable office facilities
25.	Modern appearance
26.	Visually appealing
27.	Feel happy with their office facilities
28.	Feel bright and airy
29.	Adequate internal planting
30.	Be clean in appearance
31.	Look well maintained
32.	Convenient access to marker boards and other display surfaces
33.	Be tidy in appearance
34.	Sufficient amount of on-site car parking
35.	Conveniently accessible on-site car parking
36.	Adequate on-site catering facilities
37.	Conveniently accessible on-site catering facilities
38.	Sufficient desk space

39. Adequate storage space
40. Conveniently accessible storage space
41. Sufficient number of electrical outlets
42. Conveniently accessible electrical outlets
43. Flexible enough to office furniture to be rearranged
44. Areas where visitors can work
45. Convenient access to their colleagues
46. Facilitate collaboration and teamwork
47. Feel part of a team
48. Facilitate communication between occupants
49. Clear and efficient layout
50. Easy to find your way around
51. Conveniently accessible entrance/reception
52. Good signage internally
53. Clearly defined reception areas
54. Clearly defined thoroughfares
55. Clearly defined workspaces
56. Well planned out
57. Sufficient formal meeting space
58. Convenient access to formal meeting space
59. Sufficient informal meeting space
60. Convenient access to informal meeting space
61. Convenient access to office equipment (printers, photocopiers)
62. Suitable waiting areas for visitors
63. Reliable lifts
64. Sufficient number of lifts
65. Adequate natural lighting
66. Control over the level of natural lighting
67. Adequate artificial lighting
68. Control over the level of artificial lighting
69. View of the outside world
70. Able to personalise workspace
71. Balance between corporate and team identities
72. Balance between team and personal identities
73. Able to talk privately with colleagues
74. Feel safe and secure
75. Comfortable distance between colleagues
76. Adequate amount of workspace
77. Adequate amount of space for team projects
78. Ease of movement in common areas
79. Look modern from the outside
80. Visually appealing from the outside

81. Easily accessible for visitors
82. Feel spacious
83. Convenient access to reference materials
84. Place to consult reference materials
85. Adequate artificial lighting externally
86. Flexible enough to accommodate changes in teams
87. Relaxing atmosphere

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OCCUPANT SURVEY

Thank you for taking part in this survey. This questionnaire is made up of two sections. The first section deals with your perceptions of your office facilities and involves indicating your level of agreement with each of the statements listed. The second section deals will your expectations of office facilities and, again, involves indicating your level of agreement with a series of statements.

This questionnaire should not take more than 15 minutes to complete. Your answers will be completely confidential and anonymous. When you have completed this questionnaire please return it in the envelope provided.

SECTION A

This section relates to your feelings about **your office facilities**. Please show the extent to which you believe your offices have the feature described by each statement. Do this by picking one of the seven numbers next to each statement. If you strongly agree that your offices have that feature, circle '7'. If you strongly disagree that your offices have that feature, circle '1'. If your feelings are not strong, circle one of the numbers in the middle. There are no right or wrong answers – all I am interested in is a number that best shows your perceptions of your office facilities

	Strongly Disagree						Strongly Agree
1. My office has a heating/cooling system that is responsive to changes in temperature	1	2	3	4	5	6	7
2. My office facilitates collaboration/interaction with colleagues	1	2	3	4	5	6	7
3. My office feels well ventilated	1	2	3	4	5	6	7
4. My office has a modern appearance	1	2	3	4	5	6	7
5. My office is visually appealing	1	2	3	4	5	6	7
6. My office is flexible enough to allow me to reconfigure my workspace	1	2	3	4	5	6	7
7. My office functions at a comfortable humidity	1	2	3	4	5	6	7
8. My office contains up-to-date IT/telecommunications services	1	2	3	4	5	6	7
9. My office functions at a comfortable temperature	1	2	3	4	5	6	7
10. My office has an adequate amount of space for team projects.	1	2	3	4	5	6	7
11. I am able to personalise my office	1	2	3	4	5	6	7
12. I have a place in my office where I can work free from distraction	1	2	3	4	5	6	7
13. I have conveniently accessible storage space in my office	1	2	3	4	5	6	7
14. I have adequate natural lighting in my office	1	2	3	4	5	6	7
15. I have a place in my office where I can have a break/relax	1	2	3	4	5	6	7
16. I feel safe/secure in my office	1	2	3	4	5	6	7
17. I have convenient access to informal meeting space	1	2	3	4	5	6	7
18. I have control over the level of natural lighting in my office	1	2	3	4	5	6	7
19. I have convenient access to marker boards/display surfaces	1	2	3	4	5	6	7
20. I have convenient access to formal meeting space	1	2	3	4	5	6	7
21. I have control over the temperature of my office	1	2	3	4	5	6	7
22. I have convenient access to common amenities (toilets, catering facilities etc.)	1	2	3	4	5	6	7
23. I have adequate storage space in my office	1	2	3	4	5	6	7
24. I have a view of the outside world from my office	1	2	3	4	5	6	7
25. I have convenient access to office equipment (printers, photocopiers etc.)	1	2	3	4	5	6	7
26. I have adequate artificial lighting in my office	1	2	3	4	5	6	7

27. I have control over the ventilation of my office	1	2	3	4	5	6	7
28. I have control over the level of artificial lighting in my office	1	2	3	4	5	6	7
29. I have an adequate amount of workspace in my office	1	2	3	4	5	6	7
30. I feel comfortable in my office	1	2	3	4	5	6	7
31. I have visual privacy in my office	1	2	3	4	5	6	7
32. I have conveniently accessible electrical outlets in my office	1	2	3	4	5	6	7
33. I have a place in my office where I can consult reference materials	1	2	3	4	5	6	7
34. I have a sufficient number of electrical outlets in my office	1	2	3	4	5	6	7
35. I have conversational privacy in my office	1	2	3	4	5	6	7
36. I am able to open windows in my office if I desire	1	2	3	4	5	6	7
37. I convenient access to reference materials	1	2	3	4	5	6	7
38. The office building has sufficient formal meeting space	1	2	3	4	5	6	7
39. The office building is visually appealing from the outside	1	2	3	4	5	6	7
40. The office building facilitates chance interaction in common areas	1	2	3	4	5	6	7
41. The office building has good signage internally	1	2	3	4	5	6	7
42. The office building looks modern from the outside	1	2	3	4	5	6	7
43. The office building has a layout that facilitates circulation/movement							
44. The office building is tidy in appearance	1	2	3	4	5	6	7
45. The office building has conveniently accessible on-site car parking	1	2	3	4	5	6	7
46. The office building is flexible enough to accommodate changes in teams	1	2	3	4	5	6	7
47. The office building has a sufficient number of lifts	1	2	3	4	5	6	7
48. The office building has adequate artificial lighting externally	1	2	3	4	5	6	7
49. The office building has reliable lifts	1	2	3	4	5	6	7
50. Office buildings has good quality common amenities (toilets, catering facilities etc.)	1	2	3	4	5	6	7
51. The office building has a conveniently accessible entrance/reception area	1	2	3	4	5	6	7
52. The office building has sufficient informal meeting space	1	2	3	4	5	6	7
53. The office building has a sufficient amount of on-site car parking	1	2	3	4	5	6	7

SECTION B

This section deals with your opinions of **office facilities.** Please show the extent to which you think offices should possess the feature described by each statement. Once again, circling a '7' means that you strongly agree that offices should possess a feature, and circling a '1' means that you strongly disagree. You may circle any of the numbers in the middle that show how strong your feelings are. There are no right or wrong answers – all I am interested in is a number that best shows your expectations about office facilities.

		Strongly Disagree						**Strongly Agree**
1.	Offices should have a heating/cooling system that is responsive to changes in temperature							
2.	Offices should facilitate collaboration/interaction between colleagues	1	2	3	4	5	6	7
3.	Offices should feel well ventilated	1	2	3	4	5	6	7
4.	Offices should have a modern appearance	1	2	3	4	5	6	7
5.	Offices should be visually appealing	1	2	3	4	5	6	7
6.	Offices should be flexible enough to allow occupants to reconfigure their workspace	1	2	3	4	5	6	7
7.	Offices should function at a comfortable humidity	1	2	3	4	5	6	7
8.	Offices should contain up-to-date IT/telecommunications services	1	2	3	4	5	6	7
9.	Offices should function at a comfortable temperature	1	2	3	4	5	6	7
10.	Offices should have an adequate amount of space for team projects	1	2	3	4	5	6	7
11.	Occupants should be able to personalise their offices	1	2	3	4	5	6	7
12.	Occupants should have place in their offices where they can work free from distraction	1	2	3	4	5	6	7
13.	Occupants should have conveniently accessible storage space in their offices							
14.	Occupants should have adequate natural lighting in their offices	1	2	3	4	5	6	7
15.	Occupants should have a place in their offices where they can go to relax	1	2	3	4	5	6	7
16.	Occupants should feel safe/secure in their offices	1	2	3	4	5	6	7
17.	Occupants should have convenient access to informal meeting space	1	2	3	4	5	6	7
18.	Occupants should have control over the level of natural lighting in their offices	1	2	3	4	5	6	7
19.	Occupants should have convenient access to marker boards/display surface	1	2	3	4	5	6	7
20.	Occupants should have convenient access to formal meeting space	1	2	3	4	5	6	7

21. Occupants should have control over the temperature of their offices..1 2 3 4 5 6 7
22. Occupants should have convenient access to common amenities (toilets, catering facilities etc.)..................................1 2 3 4 5 6 7
23. Occupants should have adequate storage space in their offices..1 2 3 4 5 6 7
24. Occupants should have a view of the outside world from their offices..
25. Occupants should have convenient access to office equipment (printers, etc.)...1 2 3 4 5 6 7
26. Occupants should have adequate artificial lighting in their offices..1 2 3 4 5 6 7
27. Occupants should have control over the ventilation of their offices..1 2 3 4 5 6 7
28. Occupants should have control over the level of artificial lighting in their offices...1 2 3 4 5 6 7
29. Occupants should have an adequate amount of workspace in their offices... 1 2 3 4 5 6 7
30. Occupants should feel comfortable in their offices..................... 1 2 3 4 5 6 7
31. Occupants should have visual privacy in their offices................1 2 3 4 5 6 7
32. Occupants should have conveniently accessible electrical outlets in their offices.. 1 2 3 4 5 6 7
33. Occupants should have a place in their offices where they can consult reference materials..1 2 3 4 5 6 7
34. Occupants should have a sufficient number of electrical outlets in their offices... 1 2 3 4 5 6 7
35. Occupants should have conversational privacy in their offices...1 2 3 4 5 6 7
36. Occupants should be am able to open windows in their offices if they desire...
37. Occupants should have convenient access to reference materials...1 2 3 4 5 6 7
38. Office buildings should have sufficient formal meeting space....1 2 3 4 5 6 7
39. Office buildings should be visually appealing from the outside..1 2 3 4 5 6 7
40. Office buildings should facilitate chance interaction in common areas...1 2 3 4 5 6 7
41. Office buildings should have good signage internally.................1 2 3 4 5 6 7
42. Office buildings should look modern from the outside............... 1 2 3 4 5 6 7
43. Office buildings should have a layout that facilitates circulation/movement... 1 2 3 4 5 6 7
44. Office buildings should be tidy in appearance............................1 2 3 4 5 6 7
45. Office buildings should have conveniently accessible on-site car parking..1 2 3 4 5 6 7

46. Office building should be flexible enough to accommodate changes in teams........ 1 2 3 4 5 6 7

47. Office buildings should have a sufficient number of lifts........ 1 2 3 4 5 6 7

48. Office buildings should have adequate artificial lighting externally........ 1 2 3 4 5 6 7

49. Office buildings should have reliable lifts........ 1 2 3 4 5 6 7

50. Office buildings should have good quality common amenities (toilets, catering facilities etc.)........ 1 2 3 4 5 6 7

51. Office buildings should have a conveniently accessible entrance/reception area........ 1 2 3 4 5 6 7

52. Office buildings should have sufficient informal meeting space........ 1 2 3 4 5 6 7

53. Office buildings should have a sufficient amount of on-site car parking........ 1 2 3 4 5 6 7

Thank you for taking part in this survey. Please return the questionnaire in the envelope provided.

Appendix H: Occupant survey questionnaire (Version 2)

Sheffield Hallam University

fm research
facilities management graduate centre

Workplace Survey

Thank you for taking part in this survey. This questionnaire is made up of three sections. **Your contribution to this survey will only be valid if you complete all three sections.** The information will be used to improve the quality of your working environment.

Section A deals with **your perceptions** of your office facilities and involves indicating the extent to which you believe your offices have the feature described by each statement.

Section B deals asks for **background information** about you and your working practices.

Section C deals with **your expectations** of office facilities and involves indicating the extent to which you believe offices should have the feature described by each statement.

This questionnaire should not take more than 10 minutes to complete. When you have finished please return the questionnaire in the envelope provided. **Your responses will be anonymous.**

Section A: Your perceptions

In this section please tick one box next to each statement. If you strongly agree that your offices have that feature, tick box '7', if you strongly disagree tick box '1'. If your feelings are not strong, tick one of the buttons in the middle. If a statement is not applicable tick 'NA'. There are no right or wrong answers - all we are interested in is a number that best shows your perceptions of your office facilities.

	Strongly disagree 1	2	3	4	5	6	Strongly agree 7	NA
My office:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**NA**
1. has a heating/cooling system that is responsive to changes in temperature	☐	☐	☐	☐	☐	☐	☐	☐
2. feels well ventilated	☐	☐	☐	☐	☐	☐	☐	☐
3. has a modern appearance	☐	☐	☐	☐	☐	☐	☐	☐
4. is visually appealing	☐	☐	☐	☐	☐	☐	☐	☐
5. functions at a comfortable humidity	☐	☐	☐	☐	☐	☐	☐	☐
6. functions at a comfortable temperature	☐	☐	☐	☐	☐	☐	☐	☐
7. has an adequate amount of space for team projects	☐	☐	☐	☐	☐	☐	☐	☐
I have:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**NA**
8. a place in my office where I can work free from distraction	☐	☐	☐	☐	☐	☐	☐	☐
9. conveniently accessible storage space in my office	☐	☐	☐	☐	☐	☐	☐	☐
10. convenient access to informal meeting space	☐	☐	☐	☐	☐	☐	☐	☐
11. control over the temperature of my office	☐	☐	☐	☐	☐	☐	☐	☐
12. an adequate amount of storage space in my office	☐	☐	☐	☐	☐	☐	☐	☐
13. control over the ventilation of my office	☐	☐	☐	☐	☐	☐	☐	☐
14. an adequate amount of workspace in my office	☐	☐	☐	☐	☐	☐	☐	☐
15. visual privacy in my office	☐	☐	☐	☐	☐	☐	☐	☐
16. conversational privacy in my office	☐	☐	☐	☐	☐	☐	☐	☐
My office:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**NA**
17. is visually appealing from the outside	☐	☐	☐	☐	☐	☐	☐	☐
18. has common areas that allow chance interaction	☐	☐	☐	☐	☐	☐	☐	☐
19. looks modern from the outside	☐	☐	☐	☐	☐	☐	☐	☐
20. has a layout that enables circulation/movement	☐	☐	☐	☐	☐	☐	☐	☐
21. is tidy in appearance	☐	☐	☐	☐	☐	☐	☐	☐
22. has a sufficient amount of informal meeting space	☐	☐	☐	☐	☐	☐	☐	☐

Section B: Background information

To help us classify your responses in the previous section please answer the following questions:

1. Where is your office?

Building 1	☐	Building 2	☐
Building 3	☐	Building 4	☐
Building 5	☐		

2. What is your age?

20 years or under	☐	21 – 30 years	☐
31 – 40 years	☐	41 – 50 years	☐
51 – 60 years	☐	Over 60 years	☐

3. What is your gender? Male ☐ Female ☐

4. What scale are you?

APT&C 1-6	☐	Senior Officer 1-2	☐
Management 1-4	☐	Senior Manager 1-4	☐

5. How many years have you worked for this organisation?

0-1 year	☐	1-2 years	☐	2-3 years	☐
3-4 years	☐	4-5 years	☐	5-6 years	☐
6-7 years	☐	7-8 years	☐	8-9 years	☐
9-10 years	☐	More than 10	☐		

6. How many years have you worked in this office building?

0-1 year	☐	1-2 years	☐	2-3 years	☐
3-4 years	☐	4-5 years	☐	5-6 years	☐
6-7 years	☐	7-8 years	☐	8-9 years	☐
9-10 years	☐	More than 10	☐		

7. How long have you worked at your current desk position?

0-1 year	☐	1-2 years	☐	2-3 years	☐
3-4 years	☐	4-5 years	☐	5-6 years	☐
6-7 years	☐	7-8 years	☐	8-9 years	☐
9-10 years	☐	More than 10	☐		

8. How many people do you share your office with? _________

Consider your day at work yesterday. Based on this, please can you estimate:

9.	The number of hours that you spent in your office?	0-1 hour	☐	1-2 hours	☐	2-3 hours	☐
		3-4 hours	☐	4-5 hours	☐	5-6 hours	☐
		6-7 hours	☐	7-8 hours	☐	More than 8	☐
10.	The number of hours that you spent at your desk?	0-1 hour	☐	1-2 hours	☐	2-3 hours	☐
		3-4 hours	☐	4-5 hours	☐	5-6 hours	☐
		6-7 hours	☐	7-8 hours	☐	More than 8	☐

		Low						High
11.	The proportion of time that you spent doing repetitive/routine tasks....................................	☐	☐	☐	☐	☐	☐	☐
12.	The proportion of time that you spent using a computer..	☐	☐	☐	☐	☐	☐	☐
13.	The proportion of time you spent using a telephone..	☐	☐	☐	☐	☐	☐	☐
14.	The proportion of time that you spent working in a group(s)..	☐	☐	☐	☐	☐	☐	☐
	What was the average size of this group(s)? __________							
15.	The proportion of time that you spent working from home..	☐	☐	☐	☐	☐	☐	☐
16.	The proportion of time that you spent working the office..	☐	☐	☐	☐	☐	☐	☐
17.	Your need for space (for paper, filing etc.)..........	☐	☐	☐	☐	☐	☐	☐
18.	The importance of interacting with your colleagues..	☐	☐	☐	☐	☐	☐	☐
19.	Your satisfaction with your current job...............	☐	☐	☐	☐	☐	☐	☐

20. Was yesterday a typical working day for you? Yes ☐ No ☐

21. If **no**, why was yesterday was not typical? ____

____

Section C: Your expectations

Again in this section please select a button next to each statement. If you strongly agree that offices should have that feature, select '7', if you strongly disagree select '1'. If your feelings are not strong, select one of the buttons in the middle. There are no right or wrong answers - all we are interested in is a number that best shows your expectations of office facilities.

		Strongly disagree 1	2	3	4	5	6	Strongly agree 7
Offices should:		**1**	**2**	**3**	**4**	**5**	**6**	**7**
1.	have heating/cooling systems that are responsive to changes in temperature..............	☐	☐	☐	☐	☐	☐	☐
2.	feel well ventilated...	☐	☐	☐	☐	☐	☐	☐
3.	have a modern appearance...............................	☐	☐	☐	☐	☐	☐	☐
4.	be visually appealing...	☐	☐	☐	☐	☐	☐	☐
5.	function at a comfortable humidity...................	☐	☐	☐	☐	☐	☐	☐
6.	function at a comfortable temperature.............	☐	☐	☐	☐	☐	☐	☐
7.	have an adequate amount of space for team projects...	☐	☐	☐	☐	☐	☐	☐

Which of the above features do you consider to be **most important** _____ and **least important** _____

		1	2	3	4	5	6	7
Occupants should have:		**1**	**2**	**3**	**4**	**5**	**6**	**7**
8.	a place in their office where they can work free from distraction...	☐	☐	☐	☐	☐	☐	☐
9.	Conveniently accessible storage space in their office..	☐	☐	☐	☐	☐	☐	☐
10.	convenient access to informal meeting space....	☐	☐	☐	☐	☐	☐	☐
11.	control over the temperature of their office.......	☐	☐	☐	☐	☐	☐	☐
12.	an adequate amount of storage space in their office..	☐	☐	☐	☐	☐	☐	☐
13.	control over the ventilation of their office..........	☐	☐	☐	☐	☐	☐	☐
14.	an adequate amount of workspace in their office..	☐	☐	☐	☐	☐	☐	☐
15.	visual privacy in their office...............................	☐	☐	☐	☐	☐	☐	☐
16.	conversational privacy in their office.................	☐	☐	☐	☐	☐	☐	☐

Which of the above features do you consider to be **most important** _____ and **least important** _____

Office buildings should:		**1**	**2**	**3**	**4**	**5**	**6**	**7**
17.	be visually appealing from the outside..............	☐	☐	☐	☐	☐	☐	☐
18.	Have common areas that allow chance interaction..	☐	☐	☐	☐	☐	☐	☐
19.	look modern from the outside...........................	☐	☐	☐	☐	☐	☐	☐
20.	have a layout that enables circulation/ movement..	☐	☐	☐	☐	☐	☐	☐
21.	be tidy in appearance.......................................	☐	☐	☐	☐	☐	☐	☐
22.	have a sufficient amount of informal meeting space..	☐	☐	☐	☐	☐	☐	☐

Which of the above features do you consider to be **most important** _____ and **least important** _____

Please write any other comments that you feel would help to guide this research in the future

____

____

Thank you for taking part in this survey. Please return the questionnaire in the envelope provided.

Appendix I: Schedule of variables excluded from occupancy cost analysis

Variable	Valid cases
Acquisition costs	1
Rent	11
Notional rent	19
Unitary charges	19
Local property taxes	26
Associated car parking	6
Associated facilities	10
Years since last refurbishment	12
Fit-out and improvement costs	15
Furniture and equipment costs	7
What costs fit out and improvement costs were incurred	13
Other fit-out and improvement	21
Other furniture and equipment	19
What furniture and equipment costs were incurred	11
Internal repair and maintenance	26
Proportion planned internal repair and maintenance	21
M&E repair and maintenance	25
Proportion planned M&E repair and maintenance	25
External and structural repair and maintenance	8
Proportion planned external and structural repair and maintenance	3
Proportion planned minor improvements	19
Internal moves	11
Proportion planned internal moves	3
Dilapidations	13
Internal plants and flowers	17
District heating	16
Telephones	26
General support	10
Catering	22
Reception services	4
Post room services	11
Reprographics	1
Real estate management	3
Proportion out-sourced REM	2
Facilities management	18
Proportion out-sourced FM	13
Associated car parking income	17

Associated facilities income	17
Catering income	7
Rental income	17
What charged out	11
Number of workstations	19
Number of people moves	13
Home working	23
Hot desking	19
Hotelling	0
Mobile office	1
Team working	3
Percentage home working	10
Percentage hot desking	6
Percentage hotelling	0
Percentage mobile office	1
Percentage team working	4

Appendix J: Summary of statistical techniques

J.1 Spearman's Rank Order Correlation (rho)

A statistical test that shows the *strength* and *direction* of relationship between two continuous variables that are arranged in rank order (Pallant, 2001). Spearman's rho is a non-parametric statistical test, that is to say it is designed to be used when data are not normally distributed, and is based on the ranks of data if there are no ties (Vogt, 1999). Values of Spearman's rho range from –1.00 to 1.00, where:

- 0 indicates no relationship;
- 1.0 indicates a perfect positive relationship; and,
- –1.0 indicates a perfect negative relationship (Pallant, 2001).

Statistically significant relationships were those for which $p < 0.05$. Interpretation of the test statistic was based on the guidelines provided by Cohen (1988), where correlations of:

- 0.01 to 0.29 (or –0.01 to –0.29) indicate a weak relationship;
- 0.30 to 0.49 (or –0.30 to –0.49) indicate a moderate relationship; and,
- 0.50 to 1.0 (or –0.50 to –1.0) indicate a strong relationship.

For example, analysis of the relationship between the age and utility of the sample buildings using Spearman's correlation coefficient revealed significant correlations with two factors (Table J.1). Interpretation of the results revealed a weak positive correlation between age and appearance, which suggests that the most recently constructed buildings in the sample had the highest utility scores for this factor. There was, however, a negative relationship between age and functionality, suggesting that older buildings in the sample had higher levels of functional utility than buildings that had been constructed more recently (Spearman's rho, $p < 0.01$).

Table J.1: Correlation between utility and age of building

Spearman's rho	All factors	Environment	Appearance	Configuration	Functionality
Period of construction			.115(*)		-.124(*)

* Correlation is significant at the 0.01 level (2-tailed).

J.2 Mann-Whitney *U* Test

A statistical test that is used to identify significant differences between two groups (Vogt, 1999). Like Spearman's rho, the Mann-Whitney *U* Test is a non-parametric statistic. It is used when data for two groups are measured on an ordinal scale (Vogt, 1999). The test works by looking at differences in the ranked positions of scores in the two groups, the group with lowest mean ranking being the one with the greatest number of lower scores. Conversely, the group with highest mean ranking is the one with the greatest number of higher scores. The Mann-Whitney *U* Test can therefore be used to determine which group had significantly higher scores, where $p < 0.05$ (Field, 2000).

For example, occupants were asked a series of questions about their working practices, based on their activities the previous day. To validate their responses, occupants were asked whether the previous day had been a 'typical' working day. For the majority of occupants the previous day had been typical (84%). However, before occupant working practices could be subjected to further analysis it was necessary to test for significant differences between the working practices of occupants based on whether their previous working day had been 'typical' or not. Analysis of the two groups revealed significant differences on five variables (Table J.2).

Table J.2: Differences in working practices between typical and untypical working days

Working practice	Mean rank	
	Typical	Untypical
No. people shared workspace with**	424	469
Hours in office*	468	357
Hours at desk*	462	389
Repetitive & routine tasks*	459	389
Work out of office*	415	500

* Mann-Whitney, $p < 0.01$
** Mann-Whitney, $p < 0.05$

The values of the mean rankings indicate that occupants whose previous working day had not been typical had shared their office with more people (Mann-Whitney, $p < 0.05$). They had also spent fewer hours in their office and at their desk, and less time doing repetitive and routine tasks (Mann-Whitney, $p < 0.01$). The 16% of occupants who had indicated that their previous working day had not been typical were therefore excluded from the analysis on these five variables.

J.3 Kruskal-Wallis Test

A statistical test that is used to identify significant differences between more than two groups (Vogt, 1999). The Kruskal-Wallis test is an extension of the Mann-Whitney *U* Test (see above). As with the Mann-Whitney *U* Test, scores are converted to ranks and the mean rank for each group is compared (Pallant, 2001).

For instance, Table J.3 shows the association between the utility scores and structural characteristics of the sample buildings. The value of the mean rankings indicate that buildings with deep plan floor plates or atria exhibited significantly higher levels of utility than shallow and medium depth buildings, or buildings with courtyards. Buildings with medium depth floor plates exhibited the lowest aggregate utility scores. This pattern was found across all four factors (Kruskal-Wallis, $p < 0.01$).

Table J.3: Association between utility and structural characteristics

Arrangement of structure	Mean rank				
	All factors*	Environment*	Appearance*	Configuration*	Functionality*
Shallow depth	479	494	474	461	449
Medium depth	420	395	431	454	422
Deep plan	756	781	483	757	827
Courtyard	436	451	435	401	488
Atrium	605	634	569	631	525

* Kruskal-Wallis, $p < 0.01$

J.4 Multiple regression analysis

An extension of simple linear regression, which is based on the following equation:

$$Y = a + bX + E$$

In this equation, the outcome variable (Y) can be estimated using the value of the explanatory variable (X) multiplied by a coefficient (b) plus a constant (a) (Fielding and Gilbert, 2000). The constant corresponds to the expected value of the outcome variable when the explanatory variable is zero (Miles and Shevlin, 2001). An error component (E) is also included in the equation, representing the difference between the estimated score and the actual value of Y (Field, 2000). This difference corresponds to the variance in the outcome variable that is unexplained by the explanatory variable (Miles and Shevlin, 2001).

The equation is extended in multiple regression analysis to include two or more explanatory variables:

$$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n + E$$

Here the value of b represents the relationship between the explanatory variable and the outcome variable, when the values of the other explanatory variable(s) are held constant.

For example, variance in total operation costs per floor area (costarea) can be explained by the following equation:

$$costarea = 1.7 + 0.02(occdens) + 0.05(ftcheigh) + 11.6(dumoccup) + E$$

This suggests that the expected operation costs of the sample building was £1.7m^2 when occupant density (occdens), floor-to-ceiling height (ftcheigh) and occupancy type (dumoccup) were all zero. Although all three explanatory variables are positively correlated with the outcome variable, occupancy type has by far the strongest relationship. The *b* value for the *dumoccup* variable (coded 1 = freehold, 0 = leasehold) indicates that, when the other explanatory variables were held constant, the total operation cost of buildings occupied on a freehold basis was on average £11.6/m^2 higher than for buildings occupied on a leasehold basis.

References

Cohen, S.S. (1988) *Practical statistics*, Edward Arnold.

Field, A.P. (2000) *Discovering statistics using SPSS for Windows*, Sage Publications, London.

Fielding, J. and Gilbert, N. (2000) *Understanding social statistics*, Sage Publications, London.

Miles, J. and Shevlin, M. (2001) *Applying regression & correlation*, Sage Publications, London.

Pallant, J. (2001) *SPSS survival manual*, Open University Press, Buckinghamshire.

Vogt, W.P. (1999) *Dictionary of statistics & methodology*, Sage Publications, London.

Appendix K: Analysis of utility attributes and workplace characteristics

Table K.1: Correlation between utility attributes and building age

Spearman's rho	Period of construction
Environment	
Control over temperature	-.106(*)
Control over ventilation	-.116(*)
Appearance	
Visually appealing	.099(**)
Tidy appearance	.271(*)
Functionality	
A place to work free from distraction	-.116(**)
Accessible storage space	-.087(*)
Amount of storage space	-.071(*)
Visual privacy	-.213(**)
Conversational privacy	-.218(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table K.2: Correlation between appearance attributes and building condition

Spearman's rho	Modern appearance	Visually appealing	Visually appealing from the outside	Modern from the outside	Tidy appearance
Exterior					
Site				-.177(**)	
Walls				-.217(**)	
Windows				-.266(**)	
Doors			-.106(**)	-.311(**)	
Common areas					
Walls	-.165(**)	-.079(*)			.101(**)
Ceilings	-.174(**)	-.071(*)			
Floors	-.219(**)	-.195(**)			-.155(**)
Fixtures and fittings	-.265(**)	-.186(**)			-.203(**)
Workspace areas					
Walls	-.232(**)	-.160(**)			-.116(**)
Ceilings	-.173(**)	-.116(**)			-.072(*)
Floors	-.158(**)	-.092(**)			
Fixtures and fittings	-.170(**)	-.067(**)			.105(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table K.3: Association between environment attributes and structural characteristics

Characteristic	Mean rank					
	Responsive to changes in temperature*	Well ventilated*	Comfortable humidity*	Comfortable temperature*	Control over temperature*	Control over ventilation*
Type of structure						
Timber frame	464	588	530	604	537	552
Steel/concrete frame	419	432	430	434	411	413
Loadbearing walls	493	491	491	485	525	523
Arrangement of structure						
Shallow depth	441	480	473	488	479	501
Medium depth	428	409	403	407	399	362
Deep plan	785	629	567	805	829	653
Courtyard	433	436	452	440	458	478
Atrium	575	644	613	585	540	594
Internal sub-division						
Lightweight demountable	399	392	399	392	382	365
Stone, masonry or concrete	494	513	505	503	502	521
Stud and sheet system	397	425	416	460	459	455

* Kruskal-Wallis, $p < 0.01$

Table K.4: Association between configuration attributes and structural characteristics

Characteristic	Mean rank				
	Amount of space for team projects*	Access to informal meeting space**	Common areas allow chance interaction*	Layout enables circulation and movement*	Amount of informal meeting space**
Type of structure					
Timber frame	360				317
Steel/concrete frame	415				430
Loadbearing walls	488				474
Arrangement of structure					
Shallow depth	444	437	458	447	442
Medium depth	416	440	439	463	446
Deep plan	769	788	460	649	707
Courtyard	429	434	387	384	415
Atrium	564	557	592	552	540
Internal sub-division					
Lightweight demountable	392		401		
Stone, masonry or concrete	479		467		
Stud and sheet system	430		468		

* Kruskal-Wallis, $p < 0.01$
** Kruskal-Wallis, $p < 0.05$

Table K.5: Association between functionality attributes and structural characteristics

Characteristic	Mean rank				
	A place to work free from distraction**	Accessible storage space**	Amount of workspace**	Visual privacy*	Conversational privacy*
Type of structure					
Timber frame				606	544
Steel/concrete frame				422	422
Loadbearing walls				498	485
Arrangement of structure					
Shallow depth	457			456	457
Medium depth	413			388	387
Deep plan	836			840	856
Courtyard	483			503	488
Atrium	487			514	519
Internal sub-division					
Lightweight demountable	421	433	419	406	408
Stone/masonry/concrete	464	471	471	473	464
Stud and sheet system	487	414	436	479	473

* Kruskal-Wallis, $p < 0.01$
** Kruskal-Wallis, $p < 0.05$

Table K.6: Association between environment attributes and exterior elements

Element	Mean rank					
	Responsive to changes in temperature	Well ventilated	Comfortable humidity	Comfortable temperature	Control over temperature	Control over ventilation
Walls*						
Timber cladding	468	547	482	510	526	534
Stone and masonry	656	637	618	677	765	672
Stone	493	560	541	538	505	527
Masonry	429	429	433	431	432	434
Curtain wall	412	447	535	432	493	201
Cladding	502	490	424	544	401	332
Glazing**						
Single	482	494	486	487	496	507
Double	420	428	430	432	420	416

* Kruskal-Wallis, $p < 0.01$
** Mann-Whitney, $p < 0.01$

Table K.7: Association between appearance attributes and exterior elements

Element	Mean rank				
	Modern appearance*	Visually appealing*	Visually appealing from the outside*	Modern from the outside*	Tidy appearance**
Walls					
Timber cladding			361	261	
Stone and masonry			364	446	
Stone			540	456	
Masonry			429	440	
Curtain wall			551	797	
Cladding			394	462	
Windows					
Timber			538	364	
PVCu			254	265	
Cast iron			365	336	
Aluminium			415	477	
Doors					
Timber				326	
Aluminium				484	

* Kruskal-Wallis, $p < 0.01$
** Kruskal-Wallis, $p < 0.05$

Table K.8: Correlation between configuration attributes and circulation characteristics

Spearman's rho	No. of lifts	Lift capacity	No. of staircases	Staircase width	Corridor width
Amount of space for team projects					
Access to informal meeting space					
Common areas allow chance interaction	-.114(**)	-.084(*)	-.140(**)		
Layout enables circulation and movement				.135(**)	-.075(*)
Amount of informal meeting space					

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table K.9: Correlation between environment attributes and spatial characteristics

Spearman's rho	GIA	NIA	Occupant density	Floor-to-ceiling height
Responsive to changes in temperature	-.134(*)	-.131(*)		.097(*)
Well ventilated	-.154(*)	-.108(*)		.146(*)
Comfortable humidity	-.163(*)	-.114(*)		.104(*)
Comfortable temperature	-.179(*)	-.114(*)		.106(*)
Control over temperature	-.216(*)	-.185(*)	.093(**)	.124(*)
Control over ventilation	-.285(*)	-.164(*)		.205(*)

* Correlation is significant at the 0.01 level (2-tailed).
** Correlation is significant at the 0.05 level (2-tailed).

Table K.10: Correlation between configuration attributes and spatial characteristics

Spearman's rho	GIA	NIA	Floor plate efficiency	Occupant density	Floor-to-ceiling height
Amount of space for team projects	-.119(**)		.149(**)	.145(**)	.171(**)
Access to informal meeting space				.168(**)	.080(*)
Common areas allow chance interaction		-.083(*)		.136(**)	.099(**)
Layout enables circulation and movement					
Amount of informal meeting space				.136(**)	.086(*)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table K.11: Correlation between functionality attributes and spatial characteristics

Spearman's rho	GIA	Floor plate efficiency	Occupant density
A place to work free from distraction	-.094(*)	.176(**)	.081(*)
Accessible storage space		.172(**)	.105(**)
Amount of storage space		.121(**)	.130(**)
Amount of workspace		.114(**)	.081(*)
Visual privacy	-.134(**)	.234(**)	.134(**)
Conversational privacy	-.086(*)	.202(**)	.157(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table K.12: Correlation between environment attributes and building services provisions

Spearman's rho	Wet heating	Dry heating	Natural ventilation	Air-conditioning (split units)	Air-conditioning (full)	Heating control	% openable windows
Responsive to changes in temperature	-.094(**)		-.101(**)	-.128(**)		.135(**)	.070(*)
Well ventilated	-.141(**)	.067(*)	-.101(**)			.129(**)	.137(**)
Comfortable humidity	-.142(**)		-.130(**)	-.079(*)		.155(**)	.131(**)
Comfortable temperature	-.160(**)		-.128(**)	-.100(**)		.179(**)	.119(**)
Control over temperature	-.172(**)	-.118(**)	-.216(**)	-.182(**)		.218(**)	.134(**)
Control over ventilation	-.266(**)		-.285(**)	-.099(**)	.075(*)	.272(**)	.252(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table K.13: Association between appearance attributes and finishes in common areas

Element	Mean rank				
	Modern appearance*	Visually appealing*	Visually appealing from the outside	Modern from the outside	Tidy appearance*
Walls					
Decorative papers/fabrics	419**	401			341
Exposed masonry, stone or concrete	313**	279			283
Plaster and finish	458**	464			472
Floors					
Carpet or carpet tiles	455	453			458
Rubber, plastic, cork or lino	368	348			339
Stone, concrete, quarry or ceramic tiles	269	293			636
Woodblock or parquet	484	528			439
Ceilings					
Metal tiles	473	490			404**
Mineral fibre tiles	287	234			392**
Plaster and finish	432	480			438**
Plaster and PVC tiles	492	471			434**
Sprayed-on concrete	392	401			487**

* Kruskal-Wallis, $p < 0.01$
** Kruskal-Wallis, $p < 0.05$

Table K.14: Correlation between utility attributes and type of workspace

Spearman's rho	Type of space		
	Open plan	Group	Cellular
Environment			
Responsiveness to changes in temperature			
Well ventilated			-.083(*)
Comfortable temperature	.068(*)		-.080(*)
Comfortable humidity			
Control over temperature	-.075(*)	.134(**)	
Control over ventilation	-.091(**)	.164(**)	
Appearance			
Modern appearance	.152(**)	-.128(**)	-.125(**)
Visually appealing	.077(*)		-.096(**)
Visually appealing from the outside			
Modern from the outside	.159(**)	-.157(**)	-.106(**)
Tidy appearance	.150(**)	-.147(**)	-.123(**)
Configuration			
Amount of space for team projects		.083(*)	
Access to informal meeting space			-.089(**)
Common areas allow chance interaction	.117(**)		-.177(**)
Layout enables circulation and movement	.181(**)	-.110(**)	-.180(**)
Amount of informal meeting space			-.110(**)
Functionality			
A place to work free from distraction		.077(*)	
Accessible storage space		.093(**)	
Amount of storage space		.082(*)	
Amount of workspace		.075(*)	
Visual privacy	-.137(**)	.145(**)	.097(**)
Conversational privacy	-.136(**)	.146(**)	.099(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Appendix L: Analysis of utility attributes and occupant characteristics

Table L.1: Correlation between appearance attributes and occupant characteristics

Spearman's rho	Modern appearance	Visually appealing	Visually appealing from the outside	Modern from the outside	Tidy appearance
Demographics					
Gender	-.148(**)	-.101(**)	-.077(*)		
Grade	.137(**)	.075(*)	.092(**)	.109(**)	
Years at organisation					-.085(*)
No. people shared workspace with		-.108(**)	-.093(*)		-.083(*)
Working practices					
Hours at desk	-.073(*)				
Hours in office			.076(*)		-.078(*)
Repetitive & routine tasks	-.104(**)	-.075(*)		-.091(*)	
Using computer	-.133(**)	-.116(**)			-.140(**)
Using telephone	-.100(**)		-.070(*)	-.091(**)	
Working in groups	.101(**)	.096(**)	.098(**)	.068(*)	
Size of groups					.140(**)
Attitudes to workplace issues					
Workspace requirements	-.104(**)	-.109(**)	-.079(*)	-.071(*)	-.131(**)
Interaction with colleagues	-.082(*)	-.104(**)			
Job satisfaction	.073(*)	.072(*)	.108(**)	.099(**)	.071(*)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table L.2: Correlation between environment attributes and occupant characteristics

Spearman's rho	Responsive to changes in temperature	Well ventilated	Comfortable humidity	Comfortable temperature	Control over temperature	Control over ventilation
Demographics						
Gender	-.161(**)	-.118(**)	-.132(**)	-.120(**)	-.102(**)	-.142(**)
Grade	.078(*)		.097(**)	.084(*)	.090(**)	.135(**)
Years at organisation		-.070(*)	-.090(**)	-.066(*)		
Years in building	-.100(**)		-.098(**)	-.082(*)		-.077(*)
No. people shared workspace with	-.107(**)	-.137(**)	-.146(**)	-.108(**)	-.142(**)	-.119(**)
Working practices						
Hours at desk	-.141(**)	-.083(*)	-.090(*)	-.099(**)		-.078(*)
Repetitive & routine tasks	-.119(**)	-.088(*)	-.138(**)	-.104(**)	-.103(**)	-.181(**)
Using computer	-.192(**)	-.137(**)	-.142(**)	-.198(**)	-.106(**)	-.136(**)
Using telephone			-.075(*)		-.114(**)	-.091(**)
Working in groups	.094(**)		.079(*)		.120(**)	.095(**)
Size of groups	.105(**)					
Attitudes to workplace issues						
Workspace requirements	-.095(**)	-.085(*)	-.124(**)	-.106(**)	-.139(**)	
Interaction with colleagues	-.175(**)	-.130(**)	-.149(**)	-.177(**)	-.140(**)	-.167(**)
Job satisfaction		.068(*)	.099(**)	.081(*)	.108(**)	.139(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table L.3: Correlation between configuration attributes and occupant characteristics

Spearman's rho	Amount of space for team projects	Access to informal meeting space	Common areas that allow chance interaction	Layout that enables circulation and movement	Amount of informal meeting space
Demographics					
Gender		-.082(*)			
No. people shared workspace with	-.142(**)				
Working practices					
Using computer			-.074(*)	-.091(**)	
Using telephone	-.139(**)	-.115(**)	-.106(**)	-.085(*)	-.122(**)
Size of groups	-.085(*)				
Working from home	-.095(*)			-.085(*)	
Working out of office		-.069(*)			-.068(*)
Attitudes to workplace issues					
Workspace requirements	-.259(**)	-.192(**)	-.102(**)	-.131(**)	-.162(**)
Importance of interacting with colleagues	-.177(**)			-.080(*)	-.111(**)
Job satisfaction	.095(**)		.112(**)		

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table L.4: Correlation between functionality attributes and occupant characteristics

Spearman's rho	A place to work free from	Accessible storage	Amount of storage space	Amount of workspace	Visual privacy	Conversational privacy

	distraction	space				
Demographics						
Gender		-.072(*)	-.093(**)		-.102(**)	-.078(*)
Grade	.102(**)	.090(**)		.083(*)	.175(**)	.087(**)
Years at desk		-.083(*)				
No. people shared workspace with	-.131(**)	-.131(**)	-.135(**)	-.106(**)	-.227(**)	-.200(**)
Working practices						
Hours at desk					-.076(*)	
Repetitive & routine tasks	-.080(*)	-.107(**)	-.098(**)	-.102(**)	-.172(**)	-.101(**)
Using computer	-.083(*)				-.126(**)	-.088(**)
Using telephone	-.158(**)	-.194(**)	-.178(**)	-.185(**)	-.149(**)	-.111(**)
Working in groups	.085(*)				.115(**)	.121(**)
Working out of office			-.082(*)			
Attitudes to workplace issues						
Workspace requirements	-.191(**)	-.289(**)	-.369(**)	-.304(**)	-.151(**)	-.172(**)
Interaction with colleagues	-.088(**)	-.088(**)	-.102(**)	-.108(**)	-.137(**)	-.116(**)
Job satisfaction	.151(**)	.080(*)	.084(*)	.149(**)	.111(**)	.075(*)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Appendix M: Analysis of operation costs and physical characteristics

Table M.1: Correlation between operation cost items and spatial characteristics

Spearman's rho	GIA	NIA	Floor plate efficiency	Number of floors	Floor-to-ceiling height
Cost					
Insurance	.601(**)	.687(**)		.451(**)	
Minor improvements		.630(**)		.349(*)	
Cleaning	.832(**)	.791(**)	.375(*)	.657(**)	
Security	.733(**)	.738(**)	.446(*)	.564(**)	
Waste disposal	.491(**)	.504(**)			
Grounds maintenance	.447(*)	.496(**)			
Water and sewerage	.807(**)	.778(**)		.576(**)	
Electricity	.773(**)	.757(**)		.571(**)	
Gas	.852(**)	.786(**)	.459(*)	.758(**)	
Oil					
Cost per floor area					
Insurance					
Minor improvements					
Cleaning		-.363(*)			
Security					
Waste disposal					
Grounds maintenance					
Water and sewerage			-.408(*)		
Electricity					
Gas				.310(*)	
Oil					
Cost per person					
Insurance					
Minor improvements					
Cleaning					.320(*)
Security	.441(*)	.461(*)	.429(*)		
Waste disposal					
Grounds maintenance					
Water and sewerage					.310(*)
Electricity					
Gas					
Oil					

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table M.2: Correlation between operation costs items and age of building

Spearman's rho	Period of construction
Cost	
Insurance	.349(*)
Cleaning	.333(*)
Security	.411(*)
Water and sewerage	.356(*)
Cost per floor area	
Security costs per floor area	.368(*)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table M.3: Correlation between operation cost items and circulation characteristics

Spearman's rho	No. of lifts	Lift capacity	No. of staircases	Staircase width	Corridor width	Travel distance
Cost						
Insurance	.476(**)	.502(**)		.379(*)		.501(**)
Minor improvements	.340(*)	.346(*)				
Cleaning	.546(**)	.502(**)	.505(**)	.314(*)		.318(*)
Security	.459(*)	.388(*)				
Waste disposal			.367(*)			
Water and sewerage	.483(**)	.450(**)	.445(**)	.331(*)		.383(**)
Electricity	.563(**)	.478(**)	.471(**)			.321(*)
Gas	.552(**)	.534(**)	.502(**)		.363(*)	
Cost per floor area						
Gas					.313(*)	
Cost per person						
Insurance				.331(*)		
Minor improvements					.358(*)	
Cleaning					.362(*)	
Grounds maintenance					.396(*)	
Gas					.414(**)	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table M.4: Correlation between operation cost items and building services provisions

Spearman's rho	Wet heating	Dry heating	Dry heating/ cooling	Natural ventilation	Air-conditioning (split units)	Air-conditioning (full)
Cost						
Electricity			-.320(*)	.363(*)		
Gas		.322(*)			.308(*)	
Cost per floor area						
Electricity	.407(**)		-.332(*)			
Gas		.322(*)	-.318(*)		.302(*)	
Cost per person						
Electricity	.339(*)					-.318(*)
Gas		.330(*)			.414(**)	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table M.5: Correlation between operation cost items and security/car parking provisions

Spearman's rho	Cost		Cost per floor area		Cost per person	
	Insurance	Security	Insurance	Security	Insurance	Security
Security provisions						
No provision	.333(*)					
Security guard		-.544(**)	-.033	-.371(*)		-.410(*)
CCTV	-.363(*)					
Combination/key lock	.359(*)					
Swipe card	-.338(*)		-.438(**)			.428(*)
Reception desk		-.368(*)				
Car parking provisions						
Indoor parking	-.383(*)	-.434(*)				
Attended control station	-.341(*)	-.501(**)		-.417(*)		-.424(*)
Barrier control	-.317(*)					

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table M.6: Correlation between operation cost items and common amenities

Spearman's rho	No. of W.C units	No provision	Kitchenette(s)	Multiple kitchens/lunch rooms	Cafeteria/restaurant	Condition of floor finishes in common area
Cost						
Insurance	.617(**)		.456(**)	-.349(*)	-.338(*)	
Minor improvements	.336(*)		.408(*)			
Cleaning	.746(**)		.424(**)	-.582(**)	-.334(*)	.301(*)
Security	.660(**)	.394(*)			-.433(*)	
Waste disposal	.314(*)	.312(*)		-.335(*)		
Water and sewerage	.617(**)		.377(**)	-.488(**)	-.288(*)	
Electricity	.698(**)		.291(*)	-.374(**)	-.350(*)	
Gas	.624(**)		.327(*)	-.400(**)	-.361(*)	
Cost per floor area						
Security		.378(*)			-.402(*)	
Waste disposal		.312(*)				
Cost per person						
Cleaning			-.368(*)			
Security	.541(**)	.409(*)			-.418(*)	
Waste disposal		.317(*)				
Electricity			-.316(*)			

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Appendix N: Analysis of operation costs and occupancy characteristics

Table N.1: Correlation between occupancy characteristics and operation cost items

Spearman's rho	Floors occupied	Listed	Years occupied	Occupation type	FTE staff	Operating hours	Occupant density
Cost							
Insurance	.399(*)		.529(*)		.749(**)		
Minor improvements					.473(**)	.609(**)	
Cleaning	.686(**)				.808(**)		
Security	.485(*)		.579(**)		.644(**)	.568(*)	
Waste disposal	.401(*)				.413(**)		
Grounds maintenance			.516(*)				
Water and sewerage	.535(**)		.387(*)		.811(**)		
Electricity	.624(**)		.409(*)		.781(**)		
Gas	.789(**)				.655(**)		
Cost per floor area							
Insurance						-.562(**)	-.388(*)
Minor improvements						.567(**)	
Cleaning			-.657(**)			-.669(**)	-.620(**)
Security			.530(*)		.382(*)		
Waste disposal						-.366(*)	
Water and sewerage						-.561(**)	-.557(**)
Electricity						-.459(**)	-.447(**)

Table N.1 (continued)

Spearman's rho	Floors occupied	Listed	Years occupied	Occupation type	FTE staff	Operating hours	Occupant density
Cost per person							
Minor improvements						.673(**)	.380(*)
Cleaning				-.386(**)	-.484(**)		.426(**)
Security			.759(**)			.533(*)	
Waste disposal				-.361(*)			
Grounds maintenance			.502(*)	-.350(*)			.380(*)
Water and sewerage	-.362(*)			-.409(**)			
Gas		-.333(*)		-.358(*)	-.334(*)	.376(*)	.518(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Appendix O: Schedule of variables included in multiple regression analysis

Variable type	Variable group	Variable	Description
Outcome	Utility	logfact	Log of scores for all factors
		logenv	Log of scores for environment
		logapp	Log of scores for appearance
		logconf	Log of scores for configuration
		logfunc	Log of scores for functionality
	Operation costs	logcosts	Log of total operation costs
		perperso	Square root of total operation costs per person
		costarea	Total operation costs per floor area
Explanatory	Occupant characteristics	dumage1	Aged 20 or under
		dumage2	Aged 21 – 30
		dumage3	Aged 31 – 40
		dumage4	Aged 41 – 50
		dumage5	Aged 51 – 60
		dumgend	Gender (1 = males, 0 = female)
		dumgrade1	APT&C 1 – 6
		dumgrade2	Senior officer 1 – 2
		yearorg	Number of years worked for organisation
		yearbuil	Number of years worked in building
		yeardesk	Number of years worked at desk
		peopshar	Number of people shared workspace with
		hoursoff	Number of hours spent in office
		hoursdsk	Number of hours spent at desk
		repetask	Proportion of time spent doing repetitive & routine tasks
		computer	Proportion of time spent using a computer
		telephon	Proportion of time spent using a telephone
		groupwrk	Proportion of time spent working in groups
		groupsiz	Size of work groups
		homework	Proportion of time spent working from home
		outoffic	Proportion of time spent working out of the office
		needspce	Perceived space requirements
		interact	Importance of interacting with colleagues
		jobsatis	Job satisfaction
	Occupancy characteristics	dumlist	Listed building (1 = yes, 0 = no)
		dumoccup	Occupancy type (1 = freehold, 0 = leasehold)
		interent	Internal rent (1 = yes, 0 = no)
		yearsocc	Number of years occupied

	floorocc	Number of floors occupied
	ftestaff	Number of full time equivalent staff
	ophours	Building operating hours
	occdens	Occupant density
	invdens	Inverse of occupant density
	dumtype1	Back office
	dumtype2	Front-line office
Physical characteristics	nia	Net internal area
	gia	Gross internal area
	lognia	Log of net internal area
	flooreff	Floor plate efficiency
	dumcons1	Constructed pre-1900
	dumcons2	Constructed 1900 – 39
	dumcons3	Constructed 1940's
	dumcons4	Constructed 1950's
	dumcons5	Constructed 1960's
	dumcons6	Constructed 1970's
	dumcons7	Constructed 1980's
	carspace	Number of car parking spaces
	dumcar1	Indoor car parking
	dumcar2	Outdoor car parking
	dumcar3	Attended control station
	dumcar4	Intermittent guard patrol
	dumcar5	Controlled by signage
	sitecond	Condition of site and environs
	dumland1	Minimal landscaping
	dumland2	Adequate landscaping, occasional maintenance
	dumxwal1	Timber cladding
	dumxwal2	Stone and masonry
	dumxwal3	Stone
	dumxwal4	Masonry
	dumxwal5	Curtain wall
	dumxwin1	Timber window frames
	dumxwin2	PVCu window frames
	dumxwin3	Cast iron window frames
	dumxdr1	Timber doors
	dumxdr2	PVCu doors
	distcar	Distance from public car parking
	distbus	Distance from bus stop/station
	distrain	Distance from train station
	distshop	Distance from shops
	distopen	Distance from public park/open space

dumstru1	Timber frame construction
dumstru2	Steel or concrete frame construction
dumarrg1	Shallow depth construction
dumarrg2	Medium depth construction
dumarrg3	Deep plan construction
dumarrg4	Courtyard construction
dumsubd1	Lightweight demountable partitions
dumsubd2	Stone, masonry or concrete walls
offdepth	Average depth of workspace from perimeter
ftcheigh	Average floor-to-ceiling height
numfloor	Number of floors
conexwal	Condition of exterior walls
conexwin	Condition of exterior window frames
conexdor	Condition of exterior doors
dumsecu1	Visual
dumsecu2	Door control (buzzer/intercom)
dumsecu3	Security guard
dumsecu4	Closed-circuit television system
dumsecu5	Combination/key lock on main entrance
dumsecu6	Swipe card access
numunits	Number of w.c units per floor
liftnumb	Number of passenger lifts
liftcapa	Total passenger lift capacity
dumserv1	Wet heating system
dumserv2	Dry heating system
dumserv3	Dry heating and cooling system
dumserv4	Natural ventilation
dumserv5	Mechanical ventilation
dumserv6	Air-conditioning (split-units)
dumheat1	Centralised heating control
dumheat2	Floor-by-floor heating control
dumheat3	Per large space (> 150m^2) heating control
dumheat4	Per medium space (40 - 150m^2) heating control
dumvent1	Centralised ventilation control
dumvent2	Floor-by-floor ventilation control
dumvent3	Per large space (> 150m^2) ventilation control
dumvent4	Per medium space (40 - 150m^2) ventilation control
travdist	Distance from workspace to common areas
dumcwal1	Decorative paper or fabric
dumcwal2	Exposed masonry, stone or concrete
dumccei1	Carpet or carpet tiles

dumccei2	Granolithic or terrazzo
dumccei3	Rubber, plastic, cork or lino
dumccei4	Stone, concrete, quarry or ceramic tiles
dumcflr1	Metal tiles
dumcflr2	Mineral fibre tiles
dumcflr3	Decorative paper or fabric
dumcflr4	Plaster and finish
dumcflr5	Plaster and PVC tiles
concmwal	Condition of wall surfaces in common areas and amenities
concmcei	Condition of ceiling surfaces in common areas and amenities
concmflr	Condition of floor surfaces in common areas and amenities
concmfix	Condition of fixtures/fittings in common areas and amenities
dumame1	Vending machine(s)
dumame2	Kitchenette(s)
dumame3	Single kitchen or lunchroom
dumame4	Multiple kitchens or lunchrooms
dumseat1	Informal seating in common areas
dumseat2	Informal seating outdoors
dumseat3	*Central lounge or break-out area*
windperc	Percentage of windows units that open
windwidt	Average repetitive window width
windheig	Average repetitive window height
windsill	Average repetitive window sill height
winddist	Average distance between window units
windnumb	Average number of window units per floor
dumglaze	*Single glazed windows*
openspc	Proportion of open plan workspace
groupspc	Proportion of group workspace
cellspc	Proportion of cellular workspace
dumowal1	Decorative paper or fabric
dumowal2	Plaster and finish
dumoflr1	Metal tiles
dumcflr2	Mineral fibre tiles
dumcflr3	Decorative paper or fabric
dumcflr4	Plaster and finish
conwswal	Condition of wall surfaces in workspace areas
conwscei	Condition of ceiling surfaces in workspace areas
conwsflr	Condition of floor surfaces in workspace areas

A method for evaluating workplace utility

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Keywords *Factor analysis, Focus groups, Office buildings, Public sector organizations, United Kingdom*

Abstract *Acquiring office buildings that provide the required level of utility, and maintaining the buildings in that state, should be a priority for any organisation. Failure to do so may give rise to increased churn, reduced productivity, higher employee turnover, increased staff absenteeism and rising health care costs related to heightened stress. There is, however, no single measure of office building utility. Discusses the development of a valid and reliable scale for measuring the utility of public sector office buildings. Data collection involved the use of focus groups and an online survey of 1,800 building occupants. The findings suggest that the utility of public sector office buildings can be measured using a 22-item scale comprising four dimensions. The potential applications of the scale and its use in current research are examined.*

Introduction

Office buildings are a key resource for all types of organisations, both public and private (Gibson, 1994; Bruhns and Isaacs, 1992). There is a common understanding of an office building as a workplace that accommodates the information and knowledge processing activities of an organisation, including filing, planning, designing, supervising, analysing, deciding and communicating. Office buildings developed from the need to plan, co-ordinate and administer these activities (Aronoff and Kaplan, 1995). Acquiring and maintaining office buildings in a suitable state is an important function for any organisation (Bruhns and Isaacs, 1992). Failure to do so may have an adverse affect on building users. The users of office buildings include occupants (employees who work in the building), senior managers or executives in the organisation (who may not necessarily work in the building) and visitors, including members of the public, who have business in the building (Gray and Tippett, 1992).

Occupants are the true end users of office buildings. The notion is slowly taking hold that occupants should be treated as valued customers by the providers of the office facilities they occupy (Szigeti *et al.*, 1997). High priority should go to meeting the needs of occupants to ensure that their workplaces provide the required level of utility at an acceptable cost. The word "utility" is used in this paper to indicate "usefulness or a potential capacity to provide a

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1 of 12

service" (Salway, 1986, p. 50). Over time the level of utility provided by an office building will vary as shifting political, economic, social and technological conditions result in changing occupant expectations (Ohemeng and Mole, 1996). When the level of utility falls below that required by occupants, there is a risk that organisations will experience increased rates of churn[1], reduced productivity, higher employee turnover, increased staff absenteeism and rising health care costs related to on the job stress (Building Research Board, 1993; Baird *et al.*, 1996; Sutherland and Cooper, 2000; Clements-Croome and Kaluarachchi, 2000).

This risk is of concern to public sector organisations in the UK. Public sector office buildings are valuable assets that can provide long and high-quality service if managed effectively. Public sector organisations have a responsibility to make best use of their office buildings in order to obtain best value from public assets; failure to do so may impose significant costs on building occupants and, ultimately, the public at large (Building Research Board, 1993). In many public sector organisations this responsibility lies with facility managers, who are concerned with workplace issues that immediately affect building occupants (Avis *et al.*, 1993). The dynamic nature of change within the public sector means that it is critical that facility managers are able to determine whether office buildings are providing the level of utility required by occupants, enabling attention to be drawn to potential obsolescence (Bottom *et al.*, 1999).

The divergence of actual utility from required utility presents two problems for facility managers: first, to identify, and second, to quantify the difference in utility (Aikivuori, 1996). Techniques such as post-occupancy evaluation, ORBIT 2.1, real estate norm, serviceability and building quality assessment have been developed to provide consistent, reliable measures of various facets of office building performance (Baird *et al.*, 1996). However, none of these techniques are suitable for measuring workplace utility, as defined in this study because they are, in the main, expert-based techniques (Bottom *et al.*, 1999). In defining workplace utility there is a degree of subjectivity on the part of occupants, as the utility of a building is a function of individual perceptions and expectations (Williams, 1985). At the same time, it is often difficult for occupants to articulate their expectations and perceptions in language that can aid facility managers (Gray and Tippett, 1993).

The aim of the research discussed in this paper was to develop a scale that could be used by facility managers to elicit the opinions of occupants regarding the utility of their workplace. This paper reports the results of the research. It begins by explaining the background theory underpinning the measurement of utility in the research. This paper then discusses the data collection methods used for selecting and revising the scale items. The third section of this paper discusses the data analysis used to identify the critical factors and significant scale items. Concluding, this paper discusses the results of the research, the potential applications of the scale and areas for further study.

Research method

To fulfil the aim of the research involved:

(1) developing a valid and reliable scale for measuring the utility of public sector buildings; and

(2) testing the scale by evaluating the utility of a public sector office building.

The research method was based on Churchill's (1999) procedure for developing multi-item measures of social constructs (Table I). This procedure was used to ensure that the final scale was both valid and reliable. The first stage of the procedure (Table I) entailed specifying the domain of the construct being studied. This involved defining the concept of "utility". When applied to buildings, the word "utility" has traditionally been "used in the every-day sense of indicating usefulness or a potential capacity to provide a service" (Salway, 1986, p. 50). If a building is no longer useful, it is obsolete (Smith *et al.*, 1998).

According to Williams (1985) the utility of a building is a function of the expectations and perceptions of its occupants. The expectations of occupants vary enormously, placing a wide variety of potential demands on buildings. Even for a generic activity, such as office work, certain tasks place special demands on the physical environment in which they occur. Some occupants work in ways that are unique in certain respects and set them apart from others (Gray and Tippett, 1993). Moreover, occupants may have different priorities concerning attributes of the building. This means that the minimum standard of accommodation will vary with each occupant; one occupant may expect a high level of environmental control and high quality finishes, whereas others may only expect the minimum level of shelter and security. A building that is unsuitable for one occupant may therefore yield a high level of utility for another (Williams, 1985).

The utility of a building is also influenced by individual occupant perceptions. Williams (1985) argued that perceptions relate to all aspects of the building and its environment, and are affected by a range of factors including the knowledge and experience of occupants, their familiarity with other buildings and social context (Table II). Clearly, the assessment of the utility of a

Stage	Description	Technique or coefficient
1	Specify domain of construct	Literature search
2	Generate sample of items	Focus groups with building occupants
3	Collect data	Survey of building tenants
4	Purify measures	Cronbach's alpha, factor analysis
5	Assess reliability	Cronbach's alpha
6	Assess validity	Split/multiple samples
7	Develop norms	Statistics summarising distribution of scores

Source: Adapted from Churchill (1999, p. 463)

Table I.
Procedure for developing multi-item scales

Factor	Effect
Relativity	Relative conditions are easier to perceive than absolute conditions, this being in direct proportion to the magnitude of the relative difference. For instance, it is easier to judge that one building is in better condition than another than it is to judge the condition of a building in isolation
Significant aspects	Some aspects of a building are easier to perceive than others. For example, the decorative state of repair and the internal thermal environment are easier to perceive than structural performance or the adequate provision of fire exits. These aspects may have a disproportionate influence on the overall assessment of utility
Knowledge and past experience	These are important where the occupant has particular knowledge relating to the building itself or the activity in question. The occupant's experience of other buildings will also influence their perceptions
Level of involvement	Infrequent visitors are likely to perceive change as being at a higher rate than the occupants due to their discontinuous view of the building. Occupants may overlook lesser changes that would be perceptible to infrequent visitors. Visitors and occupants are also likely to perceive different aspects of the building
Social context	Where judgements are made by an occupant, either as part of a group or individually, but with knowledge of the group consensus, then the occupant's perception will tend to concur with that consensus more than if the occupant's perceptual judgement was formed in isolation. Hence, if a building has a poor reputation, it is likely to be perpetuated
Tastes and fashions	Fashion permeates all facets of life and experience suggests that whatever the long term view about a particular style, it will invariably fall out of favour in the medium term; changes in fashion provoke an adverse reaction against styles that characterised the preceding era (Salway, 1986)

Source: Adapted from Williams (1985)

Table II.
Factors influencing occupant perceptions

building with regard to the occupant's expectations is a complex decision-making process that is strongly influenced by individual occupant perceptions. The expectations and perceptions of building occupants are therefore a significant factor in measuring the utility of a building, and ultimately in ascertaining at what point a building is obsolete (Williams, 1985).

Data collection

The second stage of the research (Table I) involved conducting focus groups to generate a sample of items for inclusion in the scale. Focus groups are a qualitative research technique in which a small number of participants discuss elected topics as a group for approximately one or two hours, while the interviewer focuses the discussion onto relevant subjects in a non-directive manner (Tynan and Drayton, 1986). The technique is based on the premise that individuals' attitudes and beliefs do not form in isolation, and that people need to hear other opinions before forming their own (Marshall and Rossman, 1999).

Focus groups were used to identify the criteria by which occupants evaluate the utility of their workplace. Three focus groups, comprising a total of 20 people, were conducted with occupants of a public sector office building. An interview guide, containing ten questions, was used to direct the discussion. The results of the focus groups were recorded, transcribed, coded and analysed. In total, the focus groups generated 87 items representing attributes of the workplace utility construct. Each item was recast into two statements: one to measure occupant expectations of office buildings; and, the other to measure perceptions of the particular office building being assessed. A seven-point scale accompanied each statement, ranging from "strongly agree" (7) to "strongly disagree" (1), with no verbal labels for scale points 2 through 6. An additional category, "not applicable" (0), was also included. The expectation statements were grouped together and formed the first part of the survey instrument, whilst the corresponding perception statements formed the second half. A pilot study suggested the number of statements be reduced from 174 to 110 by eliminating and combining items.

Stage three of the research (Table I) involved collecting data from a sample of office building occupants to enable refinement of the 55-item scale. The URL[2] of the survey instrument was e-mailed to the 1,800 occupants of a public sector office building. The e-mail also served to explain the rationale and background to the study. Respondents were given two weeks in which to complete the survey instrument. Of the 1,800 recipients, 355 people responded within the specified time period, a 20 per cent response rate. This could be regarded as "low". However, when placed into context with response rates from comparable data collection techniques, for example the postal survey, it is to be expected. Factors believed to have had an impact on the response rate include the length and repetitive nature of the survey instrument and the inability to personalise the e-mail inviting respondents to participate.

Data analysis

The fourth stage of the research (Table I) involved analysing the survey data to produce a valid, reliable and parsimonious scale. Raw data used in the analysis were in the form of difference scores, with values ranging from 6 to –6. For each of the 55 items a difference score U (representing utility along that item) was defined as $U = P - E$, where P and E were the ratings on the corresponding perception and expectation statements, respectively. The idea of using difference scores to purify a multiple-item scale is not new and has been used in developing scales for other social constructs (Ford *et al.*, 1975; Parasuraman *et al.*, 1988; Hoxley, 2000). Missing data[3] were recoded and a missing value analysis was conducted using SPSS, which revealed that missing data were randomly distributed across the data matrix. Mean series values were then calculated and used to replace missing data, thereby maximising the number of valid cases in the analysis (Hair *et al.*, 1995). The replacement of missing data has the effect of "smoothing" individual variables so that the influence of extreme values is diminished. This approach could be regarded as "conservative", but given the potential drastic decline in cases due to the combined impact of missing values it was regarded as justifiable.

Analysis of the empirical data entailed examining the dimensionality of the 55-item scale using factor analysis[4] and testing the reliability of the set of items using Cronbach's alpha. Values of Cronbach's alpha, the most widely used reliability coefficient, can range from 0 to 1, with higher figures indicating greater scale reliability (Hoxley, 2000). Cronbach's alpha was calculated before and after the factor analysis. A total scale Cronbach's alpha of 0.96 indicated that the scale had very good reliability prior to factor analysis. However, values of Cronbach's alpha across the 55 items ranged from 0.35 to 0.66, suggesting that deletion of certain items would improve alpha values. Corrected item-to-item correlations were used to decide whether to delete an item (Churchill, 1979). Corrected item-to-item correlations were plotted by decreasing order of magnitude. None of the items had very low correlations (near zero), nor did they produce a substantial or sudden drop in the plotted pattern (Churchill, 1979). All 55 variables were therefore included in the factor analysis.

The suitability of the data had to be determined before factor analysis could be used. Inspection of the correlation matrix, which shows the correlations between the variables, revealed a considerable number of correlations exceeding 0.30, suggesting that the matrix was suitable for factoring (Hair *et al.*, 1995). The anti-image correlation matrix was also examined, indicating that all measures of sampling adequacy were well above the acceptable level of 0.50 (Coakes and Steed, 2001). Finally, the Bartlett test of sphericity, a statistical test for the presence of correlations between variables, was significant and the Kaiser-Meyer Oklin measure of sampling adequacy was 0.93, well above the acceptable level of 0.50 (Coakes and Steed, 2001). These measures all indicated that factor analysis was appropriate.

Factor analysis of the 55 variables, using principle axis factoring and oblique rotation, revealed 32 variables loaded across eight factors, representing 62 per cent of the total variance. All 32 variables had a communality of 0.50 or more and a factor loading of 0.25 or more; variables with factor loadings less than 0.25 were considered insignificant. Interpretation of the pattern matrix (Table III) resulting from the factor rotation revealed four definable factors, representing 22 variables. This suggested that workplace utility could be measured along four dimensions:

(1) Factor 1 was concerned with space "configuration" issues, such as amount of informal meeting space, potential for chance interaction and ease of circulation.

(2) Factor 2 was loaded with six "environment" related variables, such as adequacy of ventilation, degree of individual control of temperature and

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Convenient access to informal meeting space	0.555			
Sufficient amount of informal meeting space	0.552			
Adequate amount of space for team projects	0.437			
Common areas that allow chance interaction	0.384			
Layout that enables circulation movement	0.261			
Functions at a comfortable temperature		–0.884		
Functions at a comfortable humidity		–0.813		
Feels well ventilated		–0.795		
Responsive heating/cooling system		–0.775		
Control over the temperature of office		–0.692		
Control over the ventilation of office		–0.631		
Looks modern from the outside			0.816	
Has a modern appearance			0.791	
Is visually appealing from the outside			0.732	
Is visually appealing			0.696	
Is tidy in appearance			0.423	
Conversational privacy in office				0.708
A place where can work free from distraction				0.638
Visually privacy in office				0.638
Conveniently accessible storage space				0.452
Adequate amount of storage space				0.377
An adequate amount of workspace				0.367

Table III. Factor loadings of variables

responsiveness to changes in temperature. This grouping is not surprising, since previous research (Leaman and Bordass, 2000) identified these as being key variables in the evaluation of office facilities.

(3) Factor 3 was concerned with the "appearance" of the office building, and includes variables such as the modernity of interior areas, exterior appearance and tidiness.

(4) Factor 4 was comprised of six variables that relate to the "functionality" of the building, including the level of conversational privacy, adequacy of workspace and potential to work free from distraction.

The final part of the analysis involved assessing the validity of generalising the results to the population and reliability of the 22-item scale for use in future research. Reliability was evaluated by calculating Cronbach's alpha for each of the four dimensions and for the scale as a whole (Table IV). These figures were all high and comparable to those of other survey instruments developed using this procedure (Parasuraman *et al.*, 1988; Nelson and Nelson, 1995; Hoxley, 2000). The total scale alpha of 0.93 indicated that the scale has very good reliability. Validation of the scale involved splitting the sample into two samples and re-estimating the factor models to test for comparability and generalisability. The two factors solutions were by and large comparable across the four dimensions, boosting confidence in the application of the results to the sample population.

Discussion

The 22-item scale developed in the research can be used by facility managers to evaluate the appearance, configuration, environment and functionality of public sector office buildings. The utility of an office building can be determined by dividing perceptions scores by expectations scores, an approach that has been used in previous building evaluation research (Bottom *et al.*, 1999). Mean values can then be computed for each of the four factors. The resultant values range from 0 and 7, where values higher than 1 represent above minimum acceptable utility (perceptions exceed expectations), 1 indicates minimum acceptable utility (perceptions match expectations) and values less than 1 represent below minimum acceptable utility (expectations exceed perceptions).

Figure 1 illustrates the distribution of data from a pilot evaluation of a ten storey, 1970s office building. The building had an irregular layout, with multiple wings and courtyards, and large floor areas (typically in the 2500-3500m^2 range), resulting in long travel distances (in excess of 75m) and numerous (5-7) direction changes between work spaces, and public areas and common amenities. Building services provision comprised a wet heating system, which was controlled centrally by means of a building management system, and natural ventilation via openable windows.

The boxplots in Figure 1 show the distribution of scores (cross-hairs), interquartile range (box) and median values (middle line) for each of the four factors. Interpretation of indicates that for the majority of occupants, the office building exhibited below minimum acceptable utility across all four factors. There is, however, variation within and between factors. Comparing the four boxplots, there was much greater variability in the utility of the first factor (appearance), its median value was higher (0.67), as was the number of scores with a value greater than 1 (minimum acceptable utility). The third factor (environment) had the least utility of the four factors, with the lowest median value (0.46) and the highest number of scores below 1. The variation within and between the four factors could be further analysed by comparing the

Dimension	Factor	Number of items	Cronbach's alpha
Configuration	1	5	0.83
Environment	2	6	0.90
Appearance	3	5	0.87
Functionality	4	6	0.87
Entire scale	All	22	0.93

Table IV.
Scale reliability

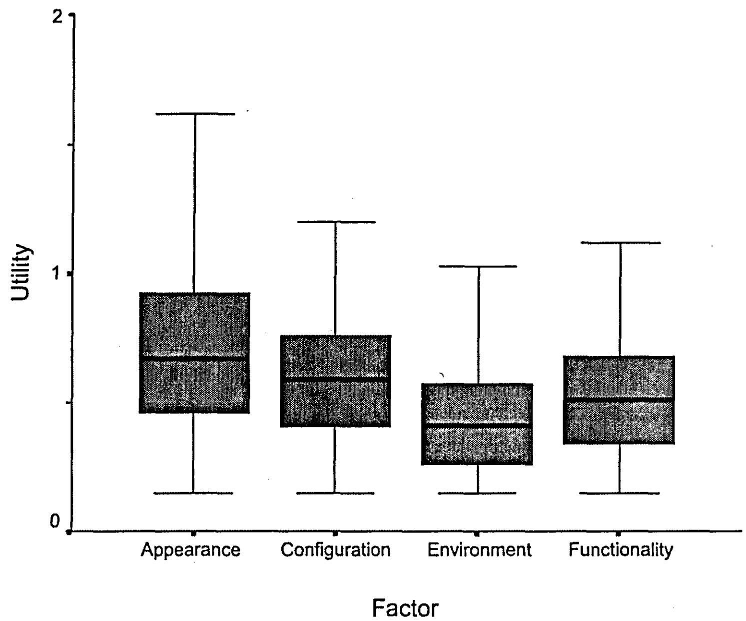

Figure 1.
Utility measurements from the pilot evaluation

differences between occupant expectations and perceptions for each of the 22 items.

The pilot evaluation served to test the effectiveness and usefulness of the scale developed in the research. However, the conclusions that can be drawn about the utility of the office building are strictly limited. This is because a raw score on a measuring scale is not particularly informative about the position of a given object on the characteristic being measured, since the units in which the scale is expressed are unfamiliar (Churchill, 1979). To assess the position of an object on a characteristic it is necessary to compare the object's score with the score achieved by other objects (Churchill, 1979), a process known as "developing norms" (Table I). The scale developed in this study should therefore be used to evaluate the utility of a larger sample of public sector office buildings. This would enable the determination of standards to explain what scores on the scale constitute "high", "low", "standard" and "optimum" utility, and confirm whether or not the scale is generalisable to a wider population.

According to Churchill (1979), it is often necessary to develop distinct norms for separate groups of respondents. Hence, in future research, the 22-item scale should be administered with an additional set of questions to ascertain specific information about the objectives of respondents, such as their job characteristics and working practices[5]. This would enable the researcher to account for possible variations in perceptions and expectations arising from occupant specific factors, such as knowledge and experience, level of involvement or social context. A further weakness of the pilot evaluation is the inability properly to explain variations in utility across for the various aspects of the office building. Future research could address this problem by collecting data on the physical characteristics of the office building(s) being evaluated. These data could then be correlated with results from the utility scale to try to identify physical characteristics that give rise to particularly "high" or "low" levels of workplace utility.

Conclusion

The utility of an office building is a measure of its usefulness, and is a function of the expectations and perceptions of the building's users. The objectives of the research discussed in this paper were to develop a valid and reliable scale that could be used to measure the utility of public sector office buildings, and test the effectiveness of the scale by conducting a pilot evaluation. These objectives have been fulfilled. The 22-item scale developed in this study can be used to elicit the expectations and perceptions of occupants regarding the appearance, configuration, environment and functionality of their office accommodation. Further analysis showed the scale to be both valid and reliable. Application of the scale in a pilot evaluation served to highlight variations in the utility of the four different aspects of the office building. The results of the evaluation indicated that the internal environment, in particular, failed to meet the expectations of the building's occupants. However, further research is required to test the generalisability of the scale to larger population of public sector office buildings and to provide a benchmark for the pilot evaluation.

Notes

1. "The percentage of an office's population that changes location in a year" (Brand, 1994, p. 168).
2. Uniform resource identifiers (URLs) are the standard way of specifying the location of a web page on the Internet and the form of address used on the World Wide Web (Howe, 1993).
3. Values of 0, representing "not applicable", were recorded as "system missing" to prevent extreme scores skewing the results.
4. A statistical technique for condensing many variables into a few underlying factors or dimensions.
5. A revised instrument containing the 22-item scale and additional questions for identifying sub-groups is currently being used to evaluate the utility of 65 local authority office buildings.

References

Aikivuori, A. (1996), "Periods and demand for private sector housing refurbishment", *Construction Management and Economics*, Vol. 14, pp. 3-12.

Aronoff, S. and Kaplan, A. (1995), *Total Workplace Performance*, WDL Publications, Ottawa.

Avis, M., Braham, R., Crosby, N., French, N., Gane, D., Gibson, V.A., Temple, M. and Whitman, A. (1993), *Property Management Performance Monitoring*, GTI and Oxford Brookes University, Oxford.

Baird, G., Gray, J., Isaacs, N., Kernohan, D. and McIndoe, G. (1996), *Building Evaluation Techniques*, McGraw-Hill, London.

Bottom, C.W., McGreal, W.S. and Heaney, G. (1999), "Appraising the functional performance characteristics of office buildings", *Journal of Property Research*, Vol. 16 No. 4, pp. 339-58.

Brand, S. (1994), *How Buildings Learn*, Phoenix Illustrated, London.

Bruhns, H. and Isaacs, N. (1992), "The role of quality assessment in facilities management", in Barrett, P. (Ed.), *Facilities Management Research Directions*, RICS Books, London.

Building Research Board (1993), *The Fourth Dimension in Building: Strategies for Minimizing Obsolescence*, National Academy Press, Washington, DC.

Churchill, G.A. (1979), "A paradigm for developing better marketing constructs", *Journal of Marketing Research*, Vol. 16, February, pp. 64-73.

Churchill, G.A. (1999), *Marketing Research: Methodological Foundations*, 7th ed., Dryden Press, Hinsdale, IL.

Clements-Croome, D. and Kaluarachchi, Y. (2000), "Assessment and measurement of productivity", in Clements-Croome, D. (Ed.), *Creating the Productive Workplace*, E. & F.N. Spon, London.

Coakes, S.J. and Steed, L.G (2001), *SPSS Without Anguish*, John Wiley & Sons, Chichester.

Ford, N.M., Walker, O.C. and Churchill, G.A. (1975), "Expectations specific measures of the intersender conflict and role ambiguity experienced by industrial salesmen", *Journal of Business Research*, Vol. 3, April, pp. 95-112.

Gibson, V.A. (1994), "Strategic property management: how can local authorities develop a property strategy", *Property Management*, Vol. 12 No. 3, pp. 9-14.

Gray, J. and Tippett, H. (1992), *Office Space: A Primer for Managers*, Centre for Building Performance Research, Victoria University, Wellington.

Gray, J. and Tippett, H. (1993), *Building Quality Assessment: A Prerequisite to Economic Analysis*, Center for Building Performance Research, Victoria University, Wellington.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C (1995), *Multivariate Data Analysis With Readings*, 4th ed., Prentice-Hall, London.

Howe, D. (1993), "Free on-line dictionary of computing", available at: www.foldoc.org

Hoxley, M. (2000), "Measuring UK construction professional service quality: the what, how, when and who", *International Journal of Quality & Reliability Management*, Vol. 17 No. 4/5, pp. 511-26.

Leaman, A. and Bordass, W. (2000), "Productivity in buildings: the "killer" variables", in Clements-Croome, D. (Ed.), *Creating the Productive Workplace*, E. & F.N. Spon, London.

Marshall, C. and Rossman, G.B. (1999), *Designing Qualitative Research*, 3rd ed., Sage Publications, London.

Nelson, S.L. and Nelson, T.R. (1995), "RESERV: an instrument for measuring real estate brokerage quality", *The Journal of Real Estate Research*, Vol. 10 No. 1, pp. 99-114.

Ohemeng, F.A. and Mole, T. (1996), "Value-focused approach to built asset renewal and replacement decisions", in *Proceedings of the Royal Institution of Chartered Surveyors COBRA Conference*, Royal Institution of Chartered Surveyors, London.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1988), "SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality", *Journal of Retailing*, Vol. 64 No. 1, pp. 12-40.

Salway, F. (1986), *Depreciation of Commercial Property*, The College of Estate Management, Reading.

Smith, M., Whitelegg, J. and Williams, N. (1998), *Greening the Built Environment*, Earthscan Publications, London.

Sutherland, V. and Cooper, C.L. (2000), "Stress and the changing nature of work", in Clements-Croome, D. (Ed.), *Creating the Productive Workplace*, E. & F.N. Spon, London.

Szigeti, F., Davis, G., Atherton, A. and Henning, D.A. (1997), "Changes in the relationships between customers and providers of facilities", *Proceedings of the CIB W92 Symposium*, Montreal.

Tynan, A.C. and Drayton, J.L. (1986), "Conducting focus groups: a guide for first-time users", Working Paper No. 86/20, Department of Business Studies, University of Edinburgh, Edinburgh.

Williams, A.M. (1985), *Obsolescence and Re-use: A Study of Multi-storey Industrial Buildings*, School of Land and Building Studies, Leicester Polytechnic, Leicester.

12