New Generation of Innovation Management: An Integrated Framework for the Digital Era

By

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Candidate Declaration

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2. None of the material contained in the thesis has been used in any other submission for an academic award.

3. I am aware of and understand the University's policy on plagiarism and certify that this thesis is my own work. The use of all published or of other sources of material consulted has been properly and fully acknowledged.

4. The work undertaken towards the thesis has been conducted in accordance with the SHU Principles of Integrity in Research and the SHU Research Ethics Policy.

5. The word count of the thesis is **38748.**

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Abstract

The present research highlights the main developments in the generations of innovation management models and systems. Innovation defined as the process of transforming ideas into marketable products or services is vitally important to the industry since it can produce value to the customers and generate revenue for producers. The research aim is to develop a novel generation innovation framework for future digital economy which defines the lifecycle from idea generation to commercialization, illustrating the factors affecting such development and considering the current socio-economic environment, evolution of business processes, technological advancements and market trends.

A questionnaire is designed and administered to professionals in industry to elicit their feedback that can be used to validate the framework and to assess its usefulness to organisations. This questionnaire is an essential part of the research methodology. The questions are formulated in a format that allows a pair-wise comparison highlighting the item`s relative importance. Adequate guidance on answering questions is provided. The proposed innovation framework is applied to collect data and to carry out a pair-wise comparison between the components of the main criteria and sub-criteria. It triggers the innovation processes required to handle the demand-pull and to consider the digitalisation push.

The model is validated utilizing the practitioner’s contributions from seven countries, namely; the UK, UAE, USA, Germany, Japan, China, and Canada, The Analytical Hierarchy Process (AHP) is utiliesed, combining both quantitative and qualitative methods. The impact of digitalisation-push and of the demand-pull are considered as main criteria, with many sub-criteria associated with each criterion. The findings confirmed that the proposed framework is useful to industry professionals and organisations that focus on creating value for the customer who has become more aware of and demanding regarding lead time delivery services, product availability, and reliability. The model can also be applied to test the ideas of experts to obtain the appropriateness of the innovation framework for manufacturing, firms, and organisations.

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Nomenclature

IFW: Innovation Framework

S/CE: Simultaneous / Concurrent Engineering

NPSE: New Product Simultaneous Engineering

GII: Global Innovation Index

WIPO: World intellectual property indicators

DM: Decision-Making

MCDM: Multiple Criteria Decision Making

MODM: Multiple Objective Decision Making

OECD: Organisation for Economic Cooperation and Development

SAW: Simple Additive Weighting

AHP: Analytic Hierarchy Process

CR: Consistency Ratio

R&D: Research and Development

SA: Sensitivity Analysis

UN: United Nations

DE.P: Demand-Pull

DI.P: Digitalization-Push

S-E.Ts: Socio-Economic trends

SDGs: Sustainable Development Goals

ERs: Environmental Regulations

CAs: Competitive Advantages

GCI: Global Competitiveness Index

BM: Business Model

BMI: Business Model Innovation

OECD: Organization for Economic Co-Operation and Development

SE: Stakeholder Engagement

CSR: Corporate Social Responsibility

AA1000: AccounAbility1000

LLs: Living Labs

EC: European Commission

5Vs: volume, velocity, variety, veracity, and value-adding

AM: Additive manufacturing

AR: Augmented reality

VR: Virtual Reality

IoT: Internet of Things

H&VSI: Horizontal & Vertical System Integration

SI: System Integration

KM: Knowledge management

A.I. & D.S.S: Artificial Intelligence & Decision Support System

ON: Open Networking

SM: Simulation Modelling

IT: Information technology

ICT: Information Communication Technology

U.D-I: User Demands-Innovation

S.T. & I.S: Science, Technology and Innovation Strategy

Chapter 1

Introduction

1.1. Background

Following World War One, several generations of innovation management began to appear, and models emerged throughout this period primarily focusing on 'what generally constitutes an observably dominant model of best practice' (Rothwell & Wissema, 1986). Moreover, Schumpeter's analysis (1934) reveals that the economic development concepts were directly attributed to strategic stimulus during this era. This indicates that the force of innovation was beginning to be considered a recursive tool for commercial or industrial applications and less of a broad indicator of the success of political or private-sector projects (Cunningham, 2010; Elliott, 2017). Furthermore, Schumpeter elaborated on this new perspective by describing how a transformation of an economic structure requires new influences and opportunities and the "destruction of the old".

Emerging concept of 'creative capitalism and the destruction of old ideas placed more pressure on organisations to increase their innovation capabilities' (Granstrand & Sjölander, 1990; Aghion, *et al.*, 2014). Moreover, this trend is considered by many scholars to be responsible for giving birth to the concept of free-market capitalism, with new products and industries invented as a by-product of these competitive conditions (Louis., 2008). However, today's market environment is complex, unlike the original requirements that create these incentives to drive creativity. According to some researchers, this may mean that unmanaged innovation is no longer sufficient for an organisation to retain a competitive advantage (İzadi, *et al.*, 2013).

Furthermore, as will be explored in the literature review of this study, models of conscious innovation management throughout the 1960s and 1970s are described using different terms, including paradigm, sequence, and process, with the word 'model' – akin to other recurrent industry systems – almost wholly avoided. Moreover, although authors after the 1970s did begin to use the word 'model' when describing observations of innovation process flow or attempted innovation activities, it is unclear whether this referred to complete conscious innovation management (Žižlavský, 2013). However, to whichever extent organisations since the 1960s have consciously planned innovation management activities, an organisation's innovative nature has always been perceived as a tool for reducing competition and maintaining a competitive advantage. Furthermore, Rothwell & Wissema (1986) strongly popularised the concept of innovation management and attempted to construct a model of innovation management that replicated the historical conditions in successful past organisations.

In addition to the aforementioned studies, other existing literature on the theoretical and empirical contents of innovation management includes the contemporary management practice of activity-based costing (R. S. Kaplan, 1998), the concepts of innovation as being a series of collaborative organisation and interactive learning processes, and the idea of exchanging knowledge between organisations involved in innovation processes (Edquist, 2001; Wallace, 2004).

Digital innovation prompts businesses to act rapidly in a short time frame. The processes of creating key performance indicators to measure digital marketing, personalising and encouraging innovation in digital marketing are facilitated to adopt digital technologies. Digital and innovation go hand in hand and present a positive focus for digital transformation and innovation in line with the current market and user demand (Ullah et al., 2021). That leads to economic growth, defined as a progressive rise in output, including the accumulation of production factors labour reflecting a quantifiable measurement of global improvement, referred to as global economic growth (Meyer & Meyer, 2020).

Companies and industries operating in today's market are experiencing many challenges, such as the globalisation of the market and technologies. From the market point of view, digital technologies permit companies to offer new digital solutions for customers based on services embedded in products. However, various countries have created local systems to boost the development and adoption of Industry 4.0 technologies. In Germany, where this concept was originated, this program was called "*High-Tech Strategy 2011*", in the United States, it was termed the "*Advanced Manufacturing Partnership*", in China, the "*Made in China 2025*" program was created and in France, the "*La Nouvelle France Industrielle*" was designed (Xu *et al.*, 2018; Dalenogare *et al.*, 2018; Ras *et al.*, 2017). Hence, the global marketplace needs companies that innovate promptly and flexibly and continue to transform the market needs. To affect the competitive environment, *Research & Development* conditions indicate the need for further adaptation of best practices in response to the spike in digital development in the 21st century. Moreover, companies need variables to acquire digital technologies aligned with competition and innovation by emphasising the development of digital manufacturing. Consequently, today industries and companies require a new digital innovation process for digital product-service systems to fulfil the user innovation needs, requiring a digital innovation framework for the adequate digital era.

1.2. What is innovation, and why is it an imperative approach for any organisation

The term “innovation” can often describe an output; however, it is also used simultaneously as a collective noun for an idea, creation, invention, research and development, prototyping a new product, technique or service. Joseph Schumpeter (1934), positions each innovation and traces its progression (through intrapreneurship) from the start as an idea, to its zenith (its alpha value) as an innovation and to its beta value, as innovations enter the market that diffuses the original innovation’s value. Schumpeter’s theory of creative destruction is enduring, and it is relevant to this thesis that Schumpeter is credited with being the first scholar to theorise on entrepreneurship from the perspective of innovation (Chesbrough, 2007). Tauber (1974) stressed the necessity to build innovation competencies that require not only technological capabilities but also organisational efficiency, which encompasses four dimensions of practices:

- Leading and organisation innovation,
- Innovation strategy design,
- Innovation management processes, and
- Innovation networking (Quadros et al., 2017)

Innovation also refers to socially acceptable change, defined as an improvement toward a socially desirable objective “*an innovation is the adoption of new change to an organisation and the relevant environment*” (Press, 2019). Therefore, it has been emphasised that four categories of innovations are highly interrelated so that innovation of one type is very likely to create additional organisation changes:

- Product and Service Innovation,
- Production-process Innovation,
- Organisational-structure Innovation, and
- People Innovation,

Pedersen *et al.*, (2018) referred to interactions among internal and external stakeholders to lead innovation processes.

Schumpeter described the development as a historical process of structural changes substantially driven by innovation (Śledzik, 2013; Dekkers *et al.*, 2014); the following are the primary innovation types and categories:

1) Product innovation: the beginning of a new good or a new quality of being good.
2) Process innovation: the beginning of a new method or way of production, which can be founded upon scientific discovery, or a new way of managing a commodity commercially.
3) Opening a new market: entering a market that had not previously been accessed.
4) Use of raw materials or semi-products: conquering a new supply source of raw materials or half-manufactured goods.

The main concepts of innovation reported in the literature are summarised in Table 1.1.

Table 1-1 Review of innovative concepts

Author	Innovation Concepts
Fagerberg, (2003); John E. Elliott, (2017)	Schumpeterian trilogy concepts (invention, innovation, and diffusion) encompass generating a new idea, developing it into a marketable product and then modifying it according to its stage in the technological process. Thus, the pioneer of this field defined innovation as a process of creative destruction. Less-calibrated offers and outdated solutions are replaced by innovative new solutions to the same market dilemma, which has the unexpected by-product of discovering previously unrealised industry categories for the consumer.
Freeman & Perez (1988)	Although the force of innovation can be described in its power to change and improve existing organisations and product categories, past studies have also argued that invention includes a secondary responsibility to force the re-evaluation of new product categories and changes to the operational models of organisations to improve efficiency for the end consumer.
Fussler (1996)	Several studies describe innovation as one of the top five criteria that enables an organisation to compete in modern markets and maintain a competitive advantage, including shorter-term and broader competitive strategies.
Papinniemi (1999)	The importance of innovation is also described as driven by four elements: the customer's approach to the business and manufacturing process, product design, process, and technological advancement. Moreover, studies describe the four' innovation essentials' as having linkages and interdependencies between them.
Organisation for Economic Cooperation	According to Solbes, an organisation's performance in its ability to innovate is vital to competitiveness, productivity, and national progress. Moreover, this study describes how the by-product of innovations in the private sector can be 'recycled' to tackle global challenges such as world poverty and climate change.

and Development (OECD) Solbes (2007)	
Hekkert & Negro (2009)	Innovations within the organisation are also described as changes that affect other components of the economy at the internal and external levels; these include national, sectoral, and regional roles.
Gallouj & Savona (2009)	The innovation capacity in an organisation refers to its ability to generate significant value for the customer by solving resource-intensive problems and removing costs by compressing traditionally time-consuming activities.
Gunday *et al.* (2011)	Innovation is also described as transforming a conceptualised solution into a marketable product calibrated to the current market environment. As this can make individual organisations responsible for significant transformations in productivity and efficiency, this can create contention between organisations, regions and even countries.
Joe Tidd *et al.* (2016)	The core conceptions of innovation are also described within the literature as being manifested in four zones: Incremental innovation, Modular innovation, Discontinuous innovation, and Architectural innovation. Moreover, there are also links between knowledge elements, as they focus on the following 4Ps of innovation: Product innovation, Process innovation, Position innovation, and Paradigm innovation.
Lopes *et al.* (2018)	Innovation is known as a force of 'sustainable transition'. Performance leads to more balanced competitiveness and value delivery in the workplace. It suggests that innovation not only includes the ability of an organisation to transmit *outward* change into the market environment; by extension, it creates new *inward* efficiencies that can transform business models into other business models and further gains in the dimensions of sustainability.

1.3. Digital era and its characteristics

The digitalisation era refers to the increasing use of digital thechnology in all aspects of society (Frank, Mendes, et al., 2019). It is also a process of converting information, processes or projects into a digital format (Yuana et al., 2021). This involves the use of digital technologies to transform traditional analogs or physical forms into digital ones (Xin et al., 2021), making them more efficient and easier to work with. Some examples of digitalisation include converting paper documents into digital files, using digital tools to automate business processes, or using digital sensors to monitor and control physical systems (Aguiar et al., 2019). Digitalisation can also involve the use of digital platforms, such as the internet or cloud-based systems to facilitate communication, collaboration, and data exchang (Ballestar et al., 2020)

1.4. Innovation Framework in the Digitalisation Era

The process of influencing factor changes in innovation is complex having to deal with uncertainty. Cooper (2006) observed, “It is war: innovate or die”; innovation is also one of the essential core competencies required to stay relevant in the current market environment. The importance of innovation in the companies’ agendas has proportionally increased over the last decade (Taferner, 2017). Due to rapid technological developments and changes in customer trends, products have an increasingly short life cycle. Consequently, innovation is necessary for a product or for the realisation processes to become essential regardless of the nature of the business, the market sector or the size they are involved in (Lacom & Florence, 2017).

Boehm and Fredericks (2010) maintained that the firms had to adapt to the new technological changes and the product life cycles. These changing environments dominated how innovation was identified and delivered as a result of recognised and distinguished different socio-economic backgrounds over several decades. They illustrated how the companies adapted their products and processes to become leading-edge innovators of their times based on the seven generations of innovation frameworks from the 1950s till the 2000s. There has been a further adaptation to how innovation is carried out, mainly driven by development in computer systems and enhanced network integration. Due to its distinct differences from generation models, many have termed this development the new generation innovation framework (Barbieri & Álvares, 2016; Boehm & Fredericks, 2010).

In the last half of the 20th century, technology and technical progress were primary drivers for fostering long-run growth. The Industrial Revolution 4.0 changed the human condition (Lucas *et al.*, 2002). In the illumination of modern theories on endogenous growth, the internet has accelerated economic growth by simplifying the expansion and adoption of innovation processes (Salahuddin & Gow, 2016). However, science and innovation are essential for digital technologies that drive digital transformation (Kurniawati, 2020).

1.5. Innovation within Demand Pull

Demand pull instruments were dominant but dramatically changed in the 21st century. It was evident that expectations regarding the market prospects for any industry lead to changes in innovative performance, drawing a long-term sustainability strategy and image of the organisation; on the other hand, they integrate complete harmony and alignment with the competitive advantages approach. Nevertheless, research has characterised the substantial role of Science, Technology, and Innovation (STI), accounting for a proportion rise in economies of scale that leads to speedy competitive advantages and development (Olalekan & Grobler, 2020).

The level of competitiveness is one of the discernments in sustainable economic growth (Saleh et al., 2020). Core competitiveness is the foundation for the competitive advantage of a sustainable organisation and stable operation. Accordingly, the competitive advantage of an enterprise is an essential tool in market competition (Feng et al., 2020). Additionally, according to Schumpeter (1934), Granstrand & Sjölander (1990) and Dalfovo *et al.* (2011), the development of the market is a particular form of organisation of scientific advances that ensures competitive advantage and technological progression (Barros et al., 2012) .

Moreover, it will accelerate industry growth and transmutation and promote the deep integration of global industrial reform in the digital era. Maier *et al.* (2017) stated that the importance of innovation for enterprises is felt especially by fierce competitiveness both locally and globally and that innovation becomes mandatory for all industries. Consequently, industrial sectors using digital innovation will improve efficiency, operational costs, and extra business income. Under these circumstances, and from the perspective of globalisation, the digitalisation of innovation plays a critical role in integrating developed countries; besides, it is evident that all efforts are now underway to digitise the entire economic system; nevertheless, digital innovation is at the forefront of efficiency gains: the more competitiveness, the more effective the production process will be; it could offer better service; thus, it exceeds the costumer’s expectation.

Furthermore, Drucker (2015) reported that “the only competitive advantage of the developed countries is the skilled labour resources. The difference between skilled and unskilled workers is that the skilled own the means of production: they are the bearers of knowledge” (Abdurakhmanova et al., 2020). Thus, we need to drastically turn towards developing the digital that boosts equipping the products and services available to customers and adjusts the competitive atmosphere (Ferreira et al., 2015). Companies need to distinguish their offerings from their digital counterparts to prosper in this milieu; Hence, the position of innovations is crucial for generating competitive advantages (Palmqvist & Unevik, 2015). Every firm has a particular competitive advantage track; however, as markets change, the situation forces companies to innovate to preserve present advantages or to create new ones. Although innovations imply a competitive advantage, they are only provisional, specifically in technology-intensive industries and industries where distinction and innovation are easy to imitate (Morris, *et al.*, 2005). Innovation is beneficial not only for large companies but also for the survival and growth of SMEs.

To conclude, the industrial sectors that utilize digital innovation can improve their efficiency and reduce operational costs together with additional business income. It is demonstrated that innovation plays a decisive role in the globally coordinated efforts toward creating a sustainable future. It is essential for economic development and competitiveness. Moreover, it is central to the policy of maintaining strong economic sustainable growth in an era defined by the globalization of competition and the complex global market, as well as significant economic and demographic challenges. Understanding how to manage innovation effectively is decisively substantial in a time when innovation is a practically obligatory survival system and strategy.

1.6. The context for the study

According to Carlborg *et al.* (2014), the dichotomy between the new product development framework and the new service development framework for measuring service innovation gives way to a synthesis perspective that finds service innovation a more comprehensive multidimensional process. Therefore, service innovation requires a broader acknowledgement of organisational activities (Gallouj & Savona, 2009; Edvardsson *et al.*, 2018). Various innovation frameworks have been developed, although they comprise two main elements: demand (market) pull and technology push, whose platform is to evaluate services and product innovation. Leaving a gap for contextualising it within a non-knowledge-intensive organisation of the present digital era. However, finding harmony among the characteristics of different organisations' global needs in this digital era is challenging. This thesis considers incorporating previous researchers' and stakeholders' perspectives to widen the review scope and to design a new innovative framework that is more relevant and valuable for the future digital shape.

1.7. Theoretical and Empirical gap

To best of the authors knowledge, limited research was found on the digital era implication on innovation management. Attempts to systematically draw on the perceptions, theories and empirical evidence accumulated over the last decades of innovation studies to inform this phenomenon debate. The study thus aims to fill in the gap of knowledge in this specific area of research. It attempts to develop an innovative integrated framework that can influence innovation outcomes in an organisation's service, product, process, and/or operating procedures. Moreover, the study equips both the private and public sector organisations with the knowledge required to systematise the processes of getting adapted to the macro-indicators of marketplace demand and technology pull in the era of demand digital economy within their competitive advantage. It is essential to view innovation as a comprehensive approach to organisational capabilities that facilitate firm operations to recognise, seek out, learn, organise, apply, and commercialise innovative new ideas, processes, products and services.

In the 21st century, future operations in organisations must increase their innovation capacity due to the increasing volatility of market conditions and the acceleration in technological development. Unlike organisations in previous decades, this will require the products and operating models facing this environment to innovate rapidly and be adaptive by design. Consequently, this research attempts to establish a framework of innovation management that enables future organisations to operate under these conditions and to sustain their competitive advantage within the digital economy/Industry 4.0. It is expected that it can increase competition between its competitors to dominate or even survive in the market; as an outcome, this thesis will discover criteria to meet organisations needs in the digital era.

1.8. Aim and Objectives of the thesis

1.8.1. Aim

In the 21st century, organisations need to be prepared for the unceasing changes in market conditions and technology development; therefore, enhancing the rate of innovation in products, services and processes becomes vital to survival in this competitive dynamic marketplace. This research aims to design a novel framework through which innovation can be managed in an integrated manner, presenting a solution for organisations to achieve and sustain their competitive advantages and meet their stakeholders' needs in the digital era.

1.8.2. Objectives

1. To carry out a comprehensive literature review of the current knowledge and to review of the existing practices in order to identify the gaps in the current innovation models, including the processes and tools, performance indicators, implementation techniques, capabilities, and systems used as a roadmap for innovation and supporting environment.
2. To propose an innovation framework that enhances innovation, copes more rapidly with the marketplace and becomes integrated with future digital demand.
3. To investigate the core aspects essential to elaborate a future digital innovation framework through decision-makers in seven prestigious countries: the "UK. UAE, U.S.A., Germany, Japan, China, Canada".
4. To validate the proposed new innovation management framework
5. To provide the necessary innovation processes in order to enable the organisation's dynamic and sustainable innovation system.

1.9. Outline of the thesis

The structure of the thesis: research offered in this thesis was conducted in five stages:

- Research Stage 1: ***Chapter 2*** evaluates the current state of knowledge embodied in the existing empirical literature on the relationship between innovation and the digital future pertinent to the research aim. It also details significant models and theoretical frameworks related to the topic.

- Research Stage 2: The research methodology used in the present study mainly involves data collection through online surveys administered to different professionals (academics, "private-government" organisations, and decision-makers) over seven countries. Data analysis is performed using a quantitative statistical approach along with analytical software known as Analytical Hierarchy Process (AHP.), discussed in ***Chapter 3***.

- Research Stage 3: Building a conceptual Innovation Framework, Data Collection & Analysis, finding and Summary, ***Chapters 4 to 5***.
- Research Stage 4: This stage indicates a stepwise approach. Innovation Process Model within the Proposed Framework, ***Chapter 6***.
- Research Stage 5: Conclusions, contribution to knowledge, limitations and future work, ***Chapter 7.***

Chapter 2
Literature Review

2.1. Introduction

This chapter presents the current innovation models, discusses their strengths and weaknesses, assesses the current state of knowledge on the relationship between innovation and the digital future and details the theoretical frameworks related to the topic under study. It highlights the different types of innovation and provides a historical perspective on innovation development concepts through the time epochs.

2.2. Schumpeter – First steps to conceptualising innovation

The Harvard economist and Austrian Joseph Schumpeter (1883-1950), who fell off the map only to re-emerge in the 1970s during the oil price shocks and stagflation in the West, presaged the decline of the Keynesian settlement (Śledzik, 2013). Newly industrialising East Asian economies were exercising his insistence that entrepreneurialism, access to credit, and trade were the pillars of economic growth. Innovation became a vital watchword for post-industrial economies (Cunningham, 2010). However, this researcher also describes that the core impulse of instant gratification is responsible for pressuring frequent new product designs, options, and solutions. The fundamental impulse that sets the industrial engine in motion comes from new goods customers, new methods of production or manufacture, new markets, and the new organisational methodologies that capitalism naturally self-selects (Schumpeter, 1934).

Furthermore, Schumpeter is considered the earliest social economist to highlight the importance of innovation as a driving force for improved goods and incentives that pressure resources to be managed more efficiently (Kurz, 2012). Building on this supply and demand paradigm, this researcher is considered the first to conceptualise innovation systematically. According to Schumpeter, studying the economy under the lens of managing finite resources was not enough; instead, economic development had to be viewed as a process of qualitative change, with innovation actively responding to a multitude of real-time variables (Fagerberg, 2003). The innovations in this work led to the emergence of entirely new industries. It is argued that they have furthered the momentum for economic development (Coombs, 1987).

Innovation models are frameworks or approaches that help organizations understand and manage the process of innovation. Many different innovation models have been developed. While these models can provide a structured approach to innovation, there are also potential gaps or limitations to consider. Some potential gaps or limitations of innovation models include Limited scope, Lack of flexibility, Insufficient consideration of context, and Lack of focus on outcomes.

Overall, it is important to be aware of the potential gaps or limitations of the innovation models and consider how to address them to effectively manage the innovation process within the new generation of innovation framework. Digital innovation transformation is the mean gap in the previous models. Digital innovation is a key driver of change and transformation in the modern economy and is increasingly becoming a key focus for organizations looking to stay competitive and meet customers' changing needs, following an in-depth overview of the seven generations of innovation models.

2.2.1. 1st Generation technology push

Generally, the first generation of innovation models emerged from the 1950s to the mid-1960s and was considered a primary innovation source. As a simple model with no feedback loops, this model was broadly used after the Second World War and was developed in three stages: *1)* idealisation of pure science, *2)* practical science and its connection to solid science, and *3)* progression and growth (Stefanovska, 2016). Consequently, meeting rapid industrial expansion and new technology opportunities lead to the conclusion that more research and development result in operative products (Taferner, 2017). To sum up, it can be said that the best practice for this form of innovation, termed the technology push, shaped itself into a linear progression from the primary scientific concept to design, engineering, manufacturing, and finally, commercialisation, as shown in Figure 2.1.

A host of authors have agreed with the terminology of the technology push, which was regarded as the best practice type in the industry (Tidd *et al.*, 2005; Berkhout *et al.,* 2006; Hekkert & Negro, 2009; Barbieri & *Álvares*, 2016; Taferner, 2017).

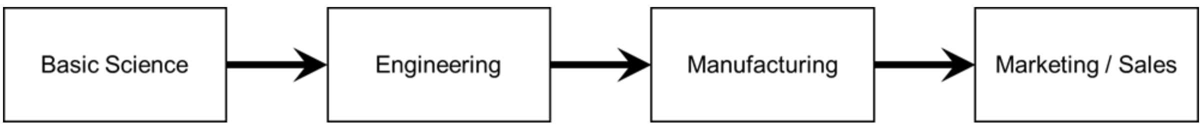


Figure 2-1. 1st generation technology push model, 1950s – Mid 1960s (Rothwell, 1994).

2.2.2. 2nd generation demand-pull model

The second generation continued from the mid-1960s to the early 1970s, as displayed in Figure 2.2. Most USA companies were highly competitive during that time, and the employment rate was static. However, productivity grew as products were subsequently advanced due to market demand for current technology. The 2nd generation is also called the market pull, demand pull, or need pull. (Rothwell, 1994; Stefanovska, 2016; Taferner, 2017).

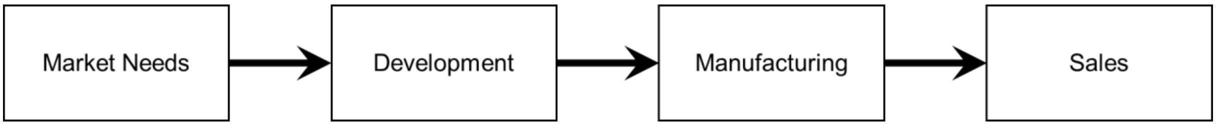


Figure 2-2. 2nd generation demand-pull model, Mid 1960s – Early 1970s (Rothwell, 1994).

Furthermore, one of the most popular models of the second generation in the USA is the stage-gate model used by NASA in the 1960s to generate creative, innovative ideas to send a man to the moon. Cooper (1990) discusses the five relevant stages, as shown in Figure 2.3. Quality control for the check gate between each work stage and the five gates ensures sufficient quality (Cooper, 1990; Guimarães, *et al.*, 2014; Stefanovska, 2016). As opposed to the first generation, due to the reliance on market demand for a source of innovative ideas, this progression has also been called reverse linear relative to the first generation (Barbieri and Álvares, 2016). Research and development, the primary activity leading the pathway in the first generation, became second fiddle and only played a supporting role in realising ideas from market demand. The same set of authors as mentioned previously agreed to the terms of the terminology and the time frame of the second-generation innovation (Tidd *et al.*, 2005; Berkhout *et al.*, 2006; Hekkert & Negro, 2009; Barbieri & Álvares, 2016; Taferner, 2017).

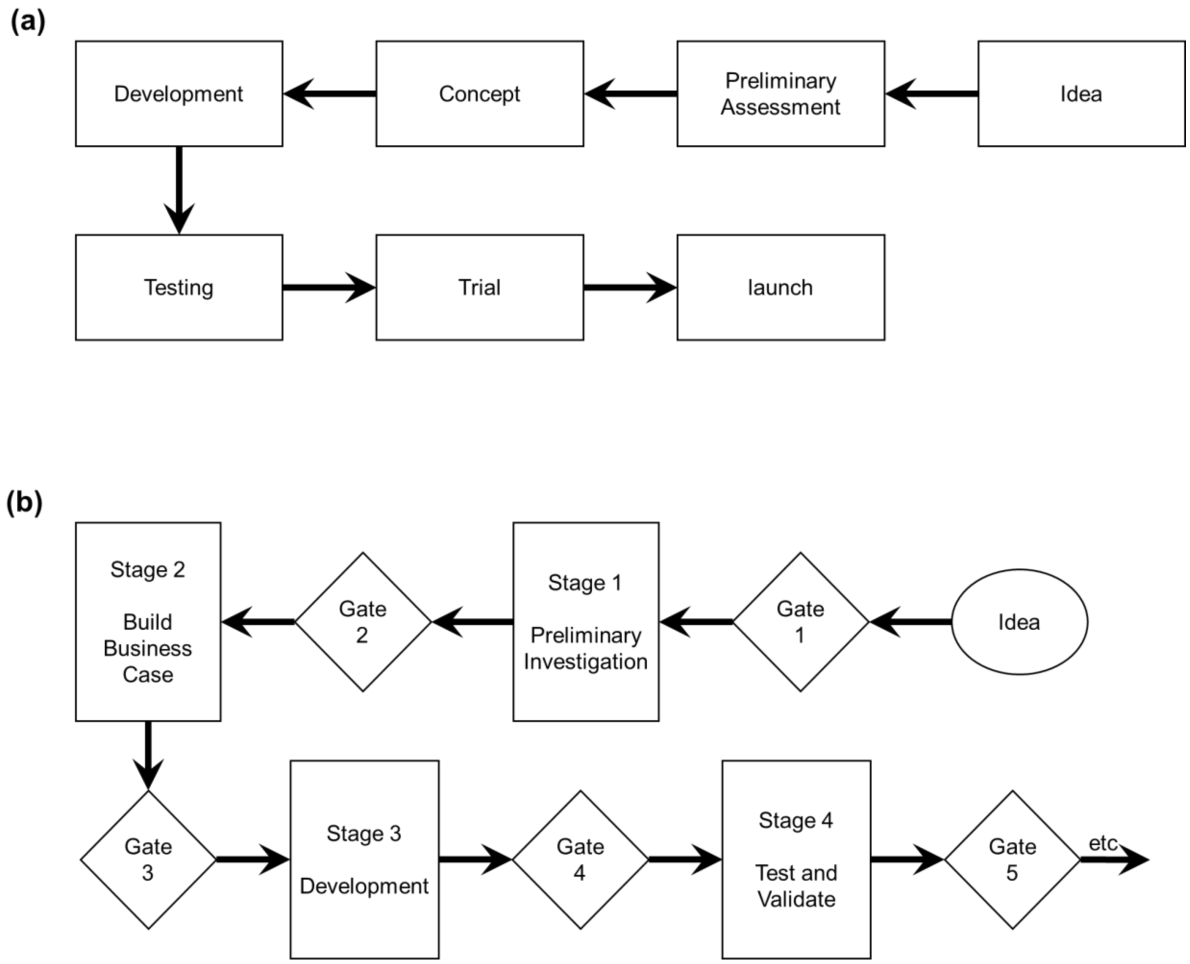


Figure 2-3. 2nd generation Cooper's stage gate model introduced in 1990 (Rothwell, 1994).

2.2.3. 3rd generation coupling or interactive model

Research and development identified the formation of the third generation from the mid-1970s to the mid-1980s. This era was met by significant industrial crises and high inflation rates in the economy (Rothwell, 1994) , R&D were no longer given free rein, and market demand was reduced; consequently, companies were forced to adapt and rationalise their activities with a focus on cost reduction. On the other hand, innovation projects were failures, e.g. projects were halted due to financial constraints, resource availability, and demand (Guimarães, *et al.*, 2014). Companies also incurred massive losses, which impacted business-as-usual operations. With this in mind, companies had to adopt a more cautious approach that essentially rationalised innovative activities to a certain extent with this in mind.

The third generation was considered a portfolio (Boehm & Fredericks, 2010). The interactive model is another name for the coupled model, which is still essentially a sequential process, as shown in Figure 2.4. Due to innovative work's value to companies, these activities started to gain direct attention and commitment from the corporate level.

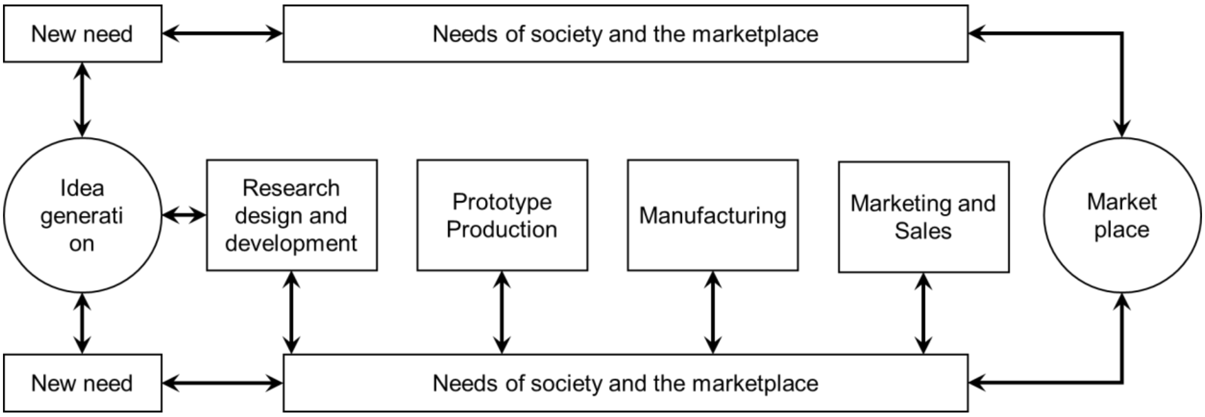


Figure 2-4. Third generation: Combined or Coupled Model (Early 1970s – Mid 1980s) (Rothwell, 1994).

2.2.4. 4th generation: Integration and Networking Models

The fourth-generation models surfaced from the early 1980s to the 1990s, when USA manufacturing was subjected to rigorous competition from the Japanese on the global market (Rothwell, 1994; Barbieri & Álvares, 2016). At that time, strategic development and league creation with other businesses developed in the USA were significant (Taferner, 2017). This generation exhibits the two most outstanding Japanese driving organisations in terms of innovation, integration and parallelism, driven by Simultaneous/Concurrent Engineering (S/CE) or New Product Simultaneous Engineering (NPSE) and the proficiency with which Japanese businesses used these processes to generate disruptive innovations. Thus, the Japanese automobile market introduced new ***Nissan*** cars within 30 months compared to the competitors 48-60 months (Boehm & Fredericks, 2010; Şimşit, *et al.*, 2014; Barbieri & Álvares, 2016; Taferner, 2017). The new product development process in Nissan is illustrated in Figure 2.5. Various authors have agreed with the general theme of the fourth generation; however, they have given the model different names: an integrated model (Rothwell, 1994), systems model, parallel lines model (Tidd, 2006), cyclic innovation model (Patrick, 2007), and integrated management model (Boehm & Fredericks, 2010). These scholars believe that supplier integration into the new product development process and the simultaneous nature of project activities, as opposed to the sequential approach in line with previous generations, became a central element in the best practices for innovation.

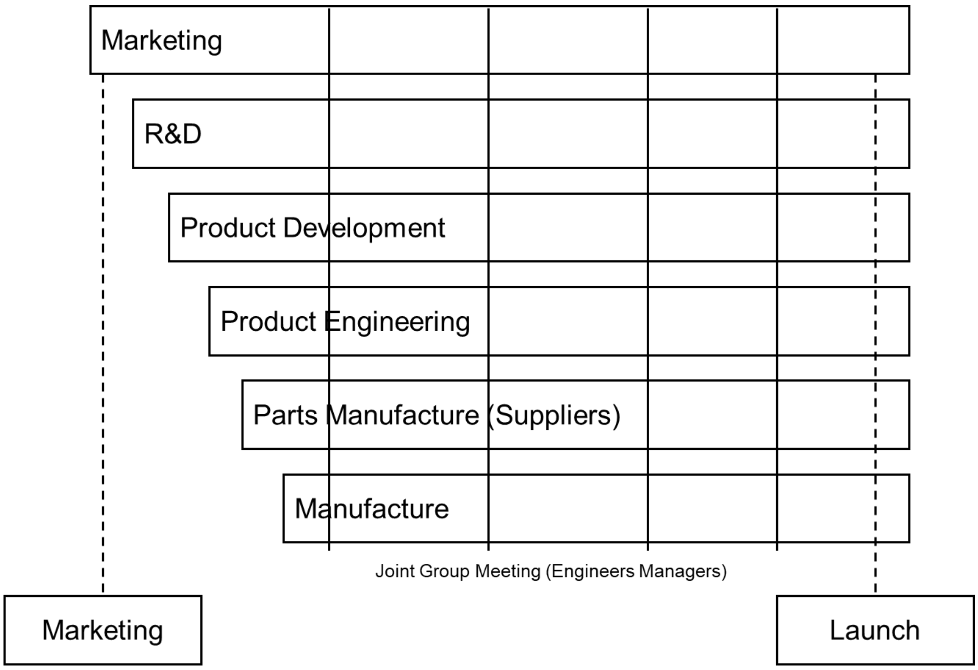


Figure 2-5. Fourth generation: Integrated model (Early 1980s - Early 1990s) (Rothwell, 1994).

2.2.5. 5th generation: Integration and Networking Model

Once the implementation of the fourth generation became commonplace, increased importance was placed on the company's technology strategy, time to market, and intelligent networking. From around the early 90s, companies were becoming smarter with time-cost trade-offs. A complete focus on the speed of product development might have provided more market share. However, it would have also strained resources and increased development costs and errors during design or manufacturing.

The fifth-generation model was recognised in the mid-1990s. The need for this kind of model began when a trend for reducing self-reliance dominated the R&D expenses of many leading industrial corporations for most of the 20th century. Therefore, companies had to network to find different methods to mobilise their innovative businesses (Stefanovska, 2016). According to Rothwell (1994), this phase developed from the fourth generation with its more sophisticated technology to improve production speed and efficiency. Galanakis proposed an innovation model using system thinking constructed by three major innovation processes (Du Preez, *et al.*, 2010; Taferner, 2017), as demonstrated in Figure 2.6.

- The knowledge creation process
- The new product development process
- The product's success in the marketplace

Consequently, information systems appeared to be the following main topic and standard in the workplace, particularly in process automation, acceleration of communications into an organisation's network itself, and external communications factors (Du Preez, *et al.*, 2010; Stefanovska, 2016). The authors agreed with Rothwell (1994) on calling this the generation that consisted mainly of system integration and networking (Tidd, 2006; Barbieri & Álvares, 2016). Kotsemir & Meissner (2013) opted to call this the evolutionary model, driven by the notion that it was a natural process of evolution and that the fittest would survive the highly competitive market environment.

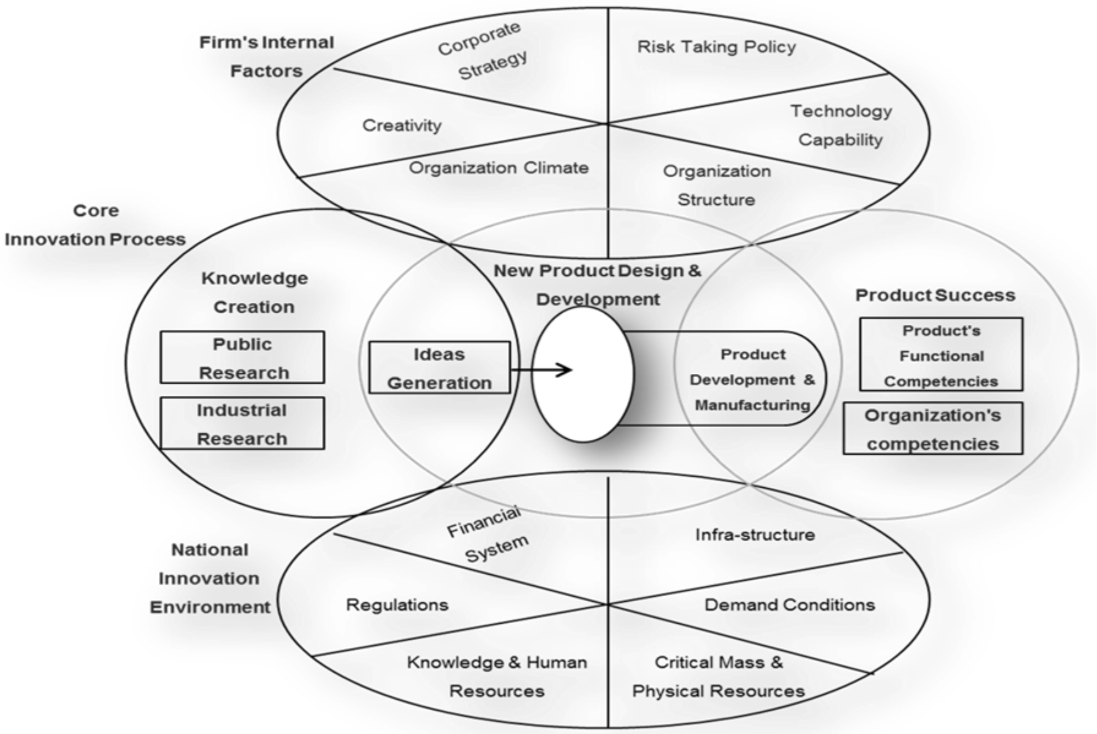


Figure 2-6. Fifth generation: Networking Model (Mid 1990s - Early 2000) (Galanakis, 2006).

2.2.6. 6th generation: The open/ networking innovation model

The sixth generation came into being when the third parties and customers became critical sources for innovative ideas. Companies began embracing open innovation and engaging in enhanced networking and system integration rather than formalising relationships through contracts and agreements. There were open and relaxed communications with external parties to create a constructive and productive environment filled with knowledge and expertise (Maier *et al.*, 2012; Todorov & Marinova, 2011). It is evident how technology and the market have influenced innovation over the decades. As a result, the framework has evolved from a simplistic sequential Technology Push and Market Pull to a combined model. The activities of project progression are consistent. Any innovation project begins with an idea, followed by scoping, research and development, realising the concept and commercialisation. The later generations have ensured that critical elements such as interactivity between different processes, multidisciplinary teams, systems and network integration become integral.

The open/networking innovation model, created and introduced by Chesbrough, underlines idea management within the organisations and with other external ones. It is also based on modelling simulation, virtual reality, data drawn from databases, artificial intelligence, and rapid prototyping. This model encourages outside knowledge, such as providers, rivalry, entrepreneurs or scientists (Nicolov & Badulescu, 2012; Stefanovska, 2016). Moreover, one of the most evident benefits of the open innovation model is the much superior base of ideas and technologies designed to lead internal development. The open innovation models, as presented in Figure 2.7, include four main stages (research, development, manufacturing, and marketing) where openness matters, instead of only two (research and development) in the closed innovation, as exhibited in Figure 2.8 (Gabison & Pesole, 2014; Şimşit, *et al.*, 2014; Barbieri & Álvares, 2016; Taferner, 2017).

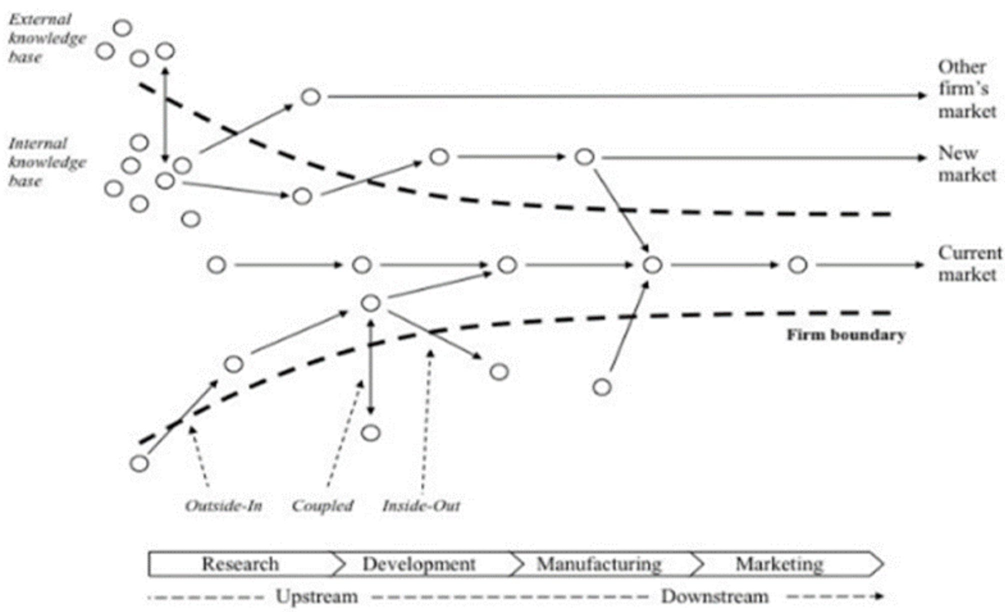


Figure 2-7. Sixth generation: Networking or sequential open innovation model (2003 -) (Chesbrough et al., 2014)

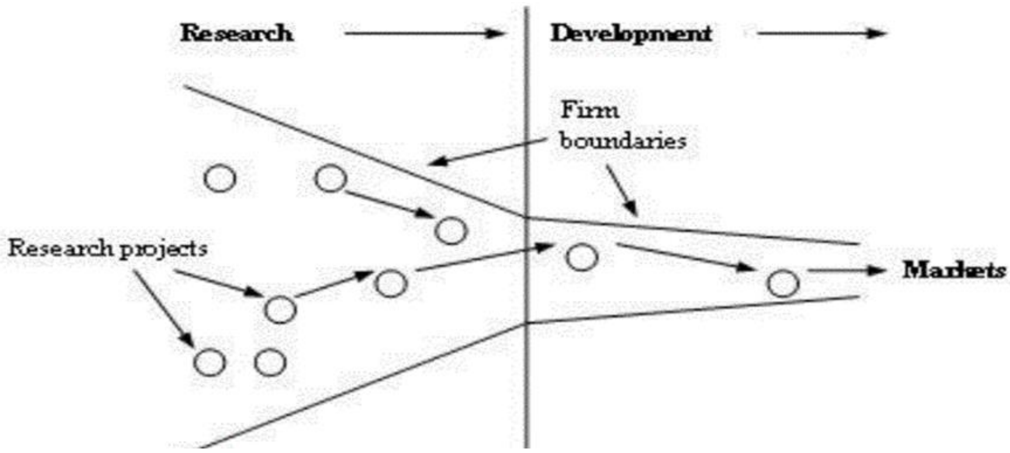


Figure 2-8. Sixth generation: Sequential closed innovation model (2003 -) (Chesbrough et al., 2014)

2.2.7. 7th generation: The Fugle innovation process model

Du Preez (2008) resented the fugal innovation model and introduced another view on the different elements required for innovation. The fugle model synthesises various process innovation models in the literature. The model aims to enable businesses to identify, evaluate, develop, implement and exploit novel products and services more resourcefully and efficiently (Du Preez *et al.*, 2010; Du Preez, 2008). Most innovation process models focus mainly on the funnel part of the innovation process (i.e., identifying and filtering new ideas and concepts). Moreover, they primarily address product innovation instead of service companies with fewer tangible products (Krause & Schutte, 2015).

The A.T. Kearney House of Innovation pointed out that the fugle model incorporates strategy, people and culture, information and knowledge, and organisational structures and processes into the innovation model (Krause & Schutte, 2015). Similarly, Pedrinho (2019) reiterated that the innovation process is guided and supported at the top by the same elements and strategies, human resources and culture, organisational structure and processes, and information and knowledge. Additionally, this model can be externally influenced by the innovation network and open innovation concept.

The model is placed in a generic innovation process that mixes the convergent innovation front-end (Identification & Evaluation) with the divergent deployment and exploitation of the identified opportunity (Innovation Bugle) as revealed in Figure 2.9. Nevertheless, the innovation process operates internally; however, all functions are connected to the external environment (Du Preez, *et al.*, 2010).

The author`s distinctly distinguished stages of the process model are described below:

- *The idea generation and identification stage:* Several sources identify new opportunities and filter to select the most practical ideas.
- *Concept:* The ideas are transformed into workable concepts with certain features during the concept definition stage.
- *Refinement:* The concepts should be further analysed, tested and prototyped to study their feasibility level.
- *Portfolio & Deployment:* The ideas are prioritised, and the resources are allocated and assigned responsibilities in the portfolio stage; the deployment stage comprises the design, implementation, and testing of the innovative solutions as identified, conceptualised, and decided upon in the previous steps.
- *Elaboration:* This phase is named the refining and formalisation stage, and it comprises monitoring, measuring, evaluating and refining the solution until it functions acceptably according to specifications.
- *Exploitation:* This step does not appear in all solutions, just in those that pass through the filter gates, which should be further exploited. This stage exploits the solution through new business models and demands to generate more value.

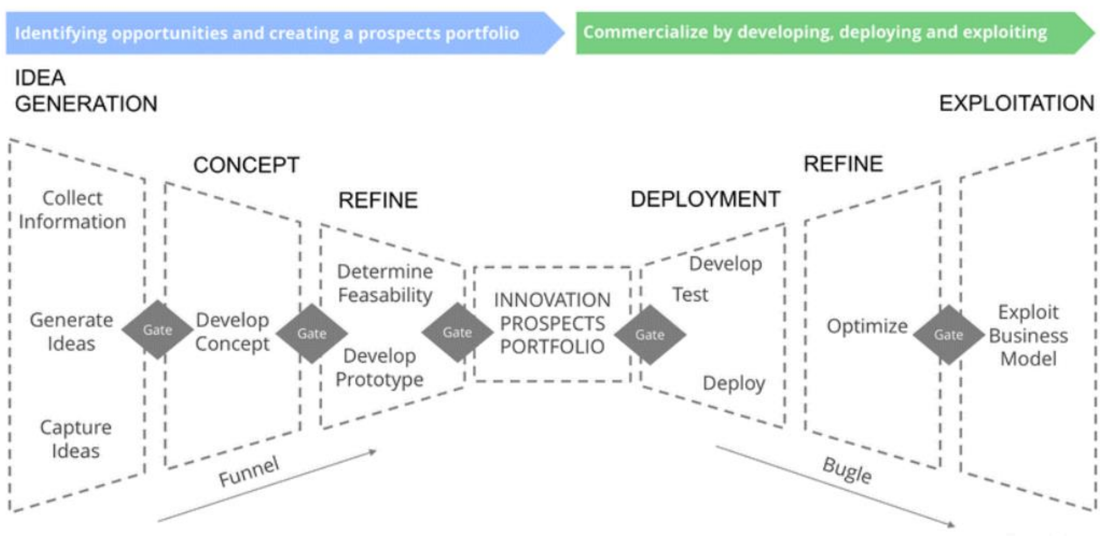


Figure 2-9. Seventh generation: The fugle (funnel-bugle) innovation process model (Du Preez, 2008).

The previous seven generations could meet the demands of businesses and society at the time when they were developed and applied. However, there is a high demand for innovation in many areas, including technology, business, and society. Innovation has proved to be vitally important innovation in the digital era; it attempts to fill in the gap in knowledge by a combination of push and pull factors. For example, the development of new technologies may create a stimulus for organizations to adopt these technologies to stay competitive. In contrast, the benefits of increased efficiency and cost savings may promote adoption. Shifting to Digital transformation is the main gap in the previous seven generations.

Moreover, Digital transformation has a significant impact on innovation in various ways:

- Increased efficiency and speed of innovation: Digital technologies such as cloud computing, artificial intelligence, and automation enable organizations to process and analyze data quickly, enabling them to identify new opportunities and innovations more efficiently.
- Improved collaboration and knowledge sharing: Digital tools and platforms facilitate collaboration and knowledge sharing among teams, departments, and even organizations. This can lead to faster, more effective innovation as teams can pool their resources and knowledge to develop new ideas.
- Creation of new markets and business models: Digital transformation has enabled the creation of new business models and markets, such as e-commerce, fintech, and the sharing economy.
- Access to new sources of data: The proliferation of digital devices and the internet has made it possible to collect vast amounts of data from a wide range of sources. This data can be analyzed and used to drive innovation in various industries, from healthcare to retail.

2.3. The journey of generations of innovation models

Seven different innovation models have been published over the last 70 years (1950-2019). Table 2.1 provides a brief overview of each model in terms of process characteristics and the elements of each model. (Nobelius, 2004; du Preez1, 2008; Acklin, 2010; Krause & Schutte, 2015; Taferner, 2017; Pedrinho, 2019)

Table 2-1 The Journey of Seven Generations of innovation models

		Generation Process Characters	Elements of seven models
1st	Black-hole demand 1950s - Mid-1960s	R&D is considered in its ‘ivory tower’, with a push of technology considered an overhead cost. This results in having little interaction with scientific practices and a focus on scientific breakthroughs.	A model of innovation driven by science It is a simple linear model whereby the organisation is driven by technological motives and a drive to solve functional dilemmas irrespective of current consumer demand.
2nd	Market shares battle (the Mid 1960s - Early 1970s)	The emphasis is placed on marketing and data as the source of new ideas for R&D and insights into business operations. This approach is driven by market demands and focuses heavily on business strategy to achieve this market fit. This views the needs and perceptions of the customer as the driving factor for both operational and marketing decisions.	Model of innovation driven by the market. This simple linear model is driven by indicators related to consumer preferences and inferred features based on present customer demand.
3rd	Rationalisation efforts (The Early 1970s - Mid 1980s)	Feedback loops are present between Product R&D and Marketing R&D. This approach avoids the individual project perspective and reveals links between business and corporate strategies. Additionally, the motives of risk-reward and similar incentives are the driving force behind all investments.	The model is named Technology Push and Market Pull. It is a hybrid model that encompasses the objective insights from science when engineering a solution to potentially unknown inefficiency within the customer experience – but then also calibrates this insight to decisions on feature design by following present customer demand.
4th	Time-based struggle (The Early 1980s - Early 1990s)	R&D is viewed as an integrative activity. This approach incorporates the Push and Pull model, integrates the organisation, and emphasises external associations. This category focuses on learning from the consumer and then backwards engineering such insights into product design, thus	The integrated model (a combination of linear models) It includes suppliers and primary users as part of the process.

		favouring a fully product-focused strategy. Activities are conducted similarly across multiple team functions.	
5th	System integration (The mid-1990s - Early 2000	In this category, R&D is considered a network. This approach emphasises expanding knowledge, developing external associations, adopting systems integration, and making an extensive effort to create networks that focus on collaborating in a system that acknowledges competitors and suppliers. Additionally, this strategy focuses on controlling the time provided for product development, where speed is considered essential; the R is separated from the D.	The network model involves a continuous accumulation of knowledge but simultaneously continuous integration of external and internal participants of the process, involves intense use of information technology, and innovation is treated as a constant process.
6th	Coupling process (2000-2008)	This category considers external and internal ideas and I&E paths to market in tandem and as a combined entity to advance technological development.	The external knowledge focus Under this model, a certain level of cooperation between organisations is expected and often encouraged for the mutual benefit of all parties involved.
7th	Open innovation Funnel–Bugle (2010 s)	A standard process combines an innovative convergent funnel and divergent innovative bugle processes. The result is the Fugle process, designed by Du Preez & Louw (2008), which serves as a reference architecture for innovation.	The goal of the Fugle process is to assist companies to recognise, assess, advance, apply and take advantage of new goods and services in a more resourceful and operational manner

2.4. Authors' identification of innovation models

As it is predicted, different views on the innovation models provide further explanations of generation models, so there is no consensus among academics regarding the number of generations and their names. Despite these distinctions, one can recognise that a specific gradation and particular titles are repeatedly explained by Rothwell (1994)**.** As a consequence, this has become a compulsory reference within this area.

The authors below identified the generations of innovation models. Table 2.2 summraises the differenecs between all the models and reflects how the concepts of economics certainly have evolved and how scientific thought on the economy and drivers such as supply and demand have developed (Kotsemir & Meissner, 2013; Karpińska, 2018; Şimşit, *et al.*, 2014; Avasilcai, 2015; Barbieri & Álvares, 2016; Bouwer, 2017).

Table 2-2 Innovation models evolution in historical prespective

Generation	Innovation model	Period	Authors of fundamental idea	Essence of the model
1	Technology Push	1950s – late 1960s	Usher (1955)	Linear process
2	Demand Pull	Late 1960s—first half of 1970s	Myers and Marquis (1969a, b)	R&D on customer wishes
3	Coupling model	Second half of 1970s— end of 1980s	Mowery and Rosenberg (1979)	Interaction of different functions
	Interatcive model		Rothwell and Zegveld (1995)	Interaction with research institutions and market.
4	Integrated model	End of 1980s—early 1990s	Kline and Rosenberg (1986)	Simultaneous process with feedback loops; 'Chain-linked model'
5	Networking-model	1990s	Rothwell (1992)	System integration and networks (SIN)
6	Open/networking innovation model	2000s	Chesbrough (2007)	Innovation collaboration and multiple exploitation paths
7	Open innovation	2010s		Focus on the individual and framework conditions under which to become innovative

2.5. Discussion

In this chapter, the researcher has discussed the innovation models pinpointing their strong points and shortcomings and illustrating the gaps in knowledge and the differences between the current state and the previous literature review of the seven generations of innovation models. The seven innovation models were designed at the beginning of technology development. Technology progresses rapidly these days. The models do not meet the recent development in the era of digital economy. As stated earlier, the aim of this research is to develop a modern comprehensive framework of future transition that enables organisations to maintain a competitive advantage. Innovative and future emerging technology could be viewed as generators of dynamic changes in all areas. Also, most businesses appreciate the significance of innovation in products, services, and processes. Thus, a new developing economy with new perspectives could realize success in the future. The proposed framework consists of seven most vital initiatives for a positive future development of an organisation within Industry 4.0 which include: Autonomous Robots, Cyber-security, the Internet of Things (IoT), Augmented Reality, Additive-Manufacturing, Big Data Analytics (BDA) and The Cloud.

On the other hand, in recent years, debates on sustainability perspectives have found their way into business models; companies with innovative business models are more likely to address sustainability. Thus, a new generation of innovation framework should include the latest perspectives and the sustainable development goals, in order to discover a positive and effective means to meet global customer satisfaction.

2.6. Conclusion

To summaries, there seems to be a general trend for the previous generations of innovation frameworks. The first few generations focused on growth innovation, using science and technology to increase productivity and market demand. However, the later generations (the 1980s) focused more on national systems of invention driven by intense competition and the prospect of launching products or services on the market. Those core elements of the first few generations were discarded altogether. There was more rationale behind their uses in the socio-economic environment of the later generations.

Similarly, the current atmosphere is undergoing a change, which could be termed the transformative change. It focuses on responsible innovation, i.e., promoting sustainable products and processes that negate climate change and greater customer involvement.

Nevertheless, it is vital to note that such framework could not replace the previous innovation framework's core elements, rather, it builds on it to rationalise its applications. In addition, this research focuses on transformative changes and their impact on current economic trends and competitive advantages, thus proposing an innovative framework for these factors. The literature review provides some perspectives and develops a thorough understanding of the evolution of innovation frameworks. The new framework proposed some of the core elements of previous generations that are still relevant. The following chapter describes the innovation framework in the digital era.

This study has shed light on the previous innovation models, which could be applied to different forms and sizes of companies; however, every organisation needs to locate and sort out what leads to their innovations and take the necessary action immediately. From the literature review, one can conclude that generating ideas is essential, alongside planning the implementation of these ideas. Therefore, several main components should be considered for any organisation, including new market needs, future demand, investigation of new tools of innovation in the era of the digital economy, and substantial development.

Chapter 3

Research Methodology & Proposed Innovation Framework

3.1. Introduction

This chapter describes the research methodology followed in this study and explains the methods used to achieve the research aim and objectives defined earlier in **Chapter 1.** Moreover, it provides an overview of the potential research methods and methodologies and describes the strategy applied to conduct the research. Furthermore, it can be argued that the selection of plans and procedures has a more significant impact on research outcomes; therefore, choosing suitable research methods to undertake the research is essential.

3.2. Research method

The literature research has proceeded according to the hierarchy of research evidence. The existing literature on this issue consists mainly of expert opinions, congress presentations and proof in the hierarch of methodical quality of evidence. Empirically researching, developing and testing innovative models applies to a specific innovation framework relevant from an exploratory perspective in the digital era. There is a considerable difference between research methods and research methodologies; Research methodology is a systematic way to conduct a practical research study and gather valuable information to support the research. According to Davy and Valecillos (2009), it is the systematic gathering and analysis of observations to generate novel knowledge that can enlighten actions and decisions.

While methods can be defined as research tools that assist in gathering data and information to explain research concerns, Saunders *et al*. (2009) underlined using the term 'methods' precisely; the difference is that the term methodology implies the theory of how research should be undertaken. According to Polit and Beck (2008), the primary objective of the research is to develop, expand and elaborate a corpus of knowledge; research is a systematic inquiry that utilizes well-organized methods to solve problems and answer questions. However, Lee & Lings (2008) argue that the definition of research may be distinct based on the authors' perspective. They further explain that research is about generating knowledge concerning how one views the world.

To sum up, research methods are primarily about collecting and analysing data; methodologies illustrate the limitations, strengths, and weaknesses. Researchers have also described research methods as logic when defining the research problem, the formulation of the hypothesis, the data collection technique, and the data analysis (Creswell, 2016)**.**

3.3. Research Design

This study implemented the theoretical framework in a longitudinal case study comprising two stages. The first stage study featured real cases covering innovation situations in seven prestigious countries. The second stage in 2018 featured an evaluation of the conceptual digital innovation framework concerning developing two main criteria, digitalisation-push and demand-pull

3.3.1. Country selection criteria

The innovation and technology transfer fields are often considered ”add-on” or “soft” areas of competency in the industry. To build an innovative framework, the researcher needs to analyse the country’s innovation case, especially during economic growth; thus, it is helpful to delve into previously prosperous innovative countries globally related to services, processes, and production stakeholder satisfaction. On the other hand, innovation effectiveness in the context of a nation can be measured by various metrics related to technology transformation and economic development.

Global Innovation Index (GII) has been chosen as a guide to finding out the aim of the case study; GII highlights that governments are putting innovation at the centre of their growth strategies. In that light, measuring innovation and providing a rigorous statistical benchmark that captures national innovation ecosystems is at the core of the ***World intellectual property indicators*** (WIPO) Global Innovation Index team and mandate.

The GII describes the innovation ecosystem performance of 132 economics and tracks the most recent global innovations trends. GII indicated that the geography of innovation is changing unevenly. Despite some innovation “catch-up,” divides still exist concerning national innovation performance in the world regions: which regions perform best in innovation. Northern America and Europe continue to lead, followed by South-East Asia, East Asia, and Oceania (SEAO). More specifically, Northern Africa and Western Asia, Latin America and the Caribbean, and Central and Southern Asia sub-Saharan Africa, respectively.

The GII presents various criteria, making it more difficult for the researcher to select based on what can make an appropriate country case. Thus, the needs to consider: a time carefully chosen from (2015 – 2021), and then pick random criteria from both main-sub criteria recorded in (Hempen, 2002) as presented in Figures (3.1 to 3.6).

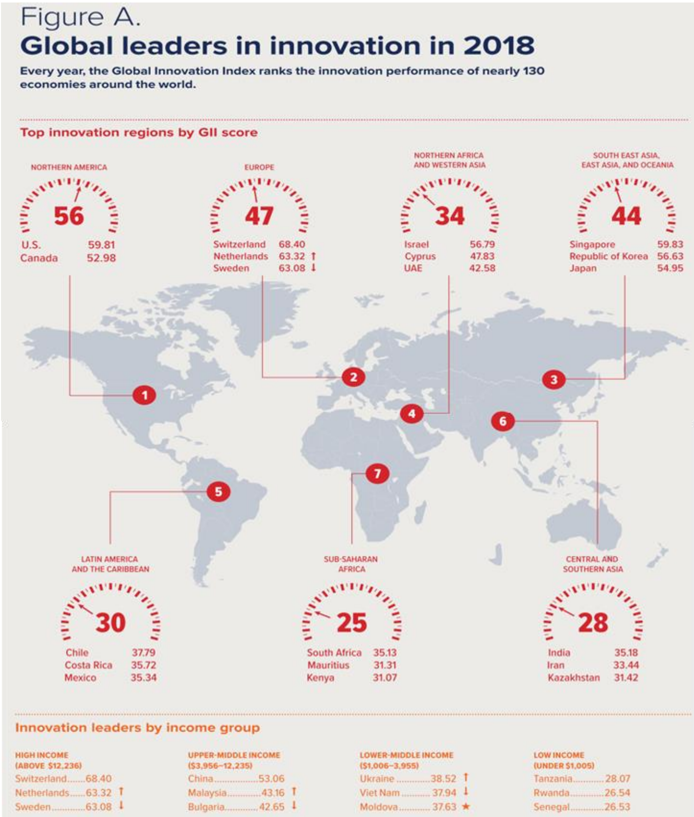


Figure 3-1. Global leaders in innovation 2018 (WIPO, 2018)

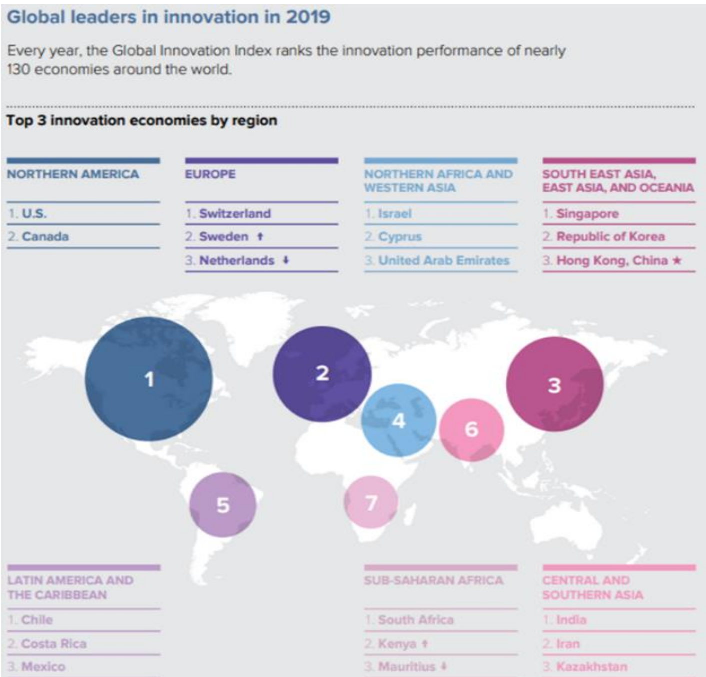


Figure 3-2. Global leaders in innovation 2019 (WIPO, 2019)

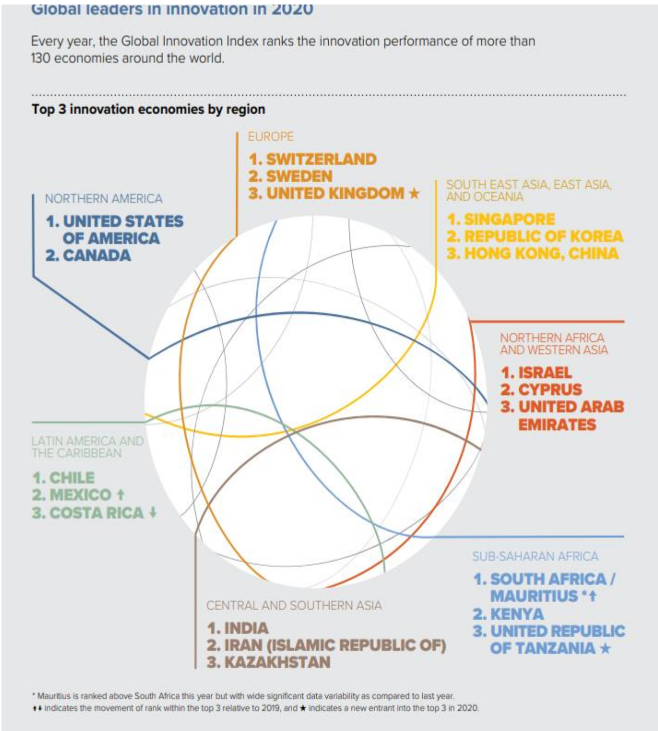


Figure 3-3. Global leaders in innovation 2020 (WIPO, 2020)

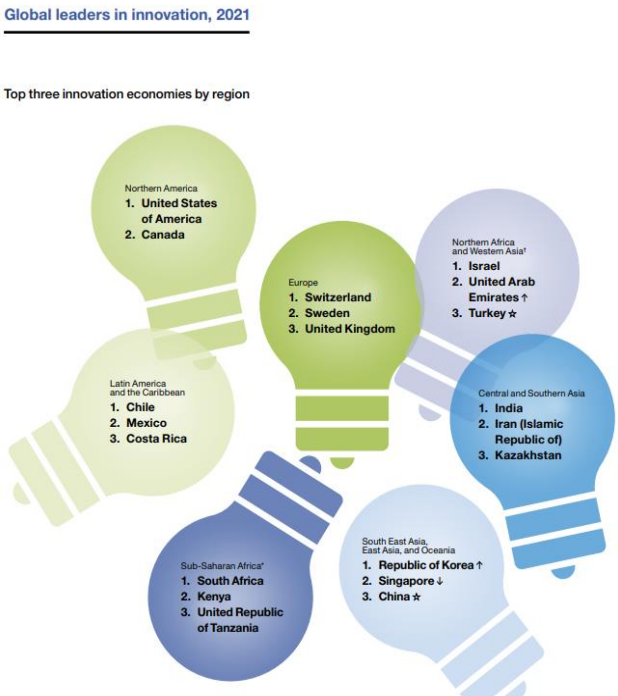


Figure 3-4. Global leaders in innovation 2021 (WIPO, 2021)

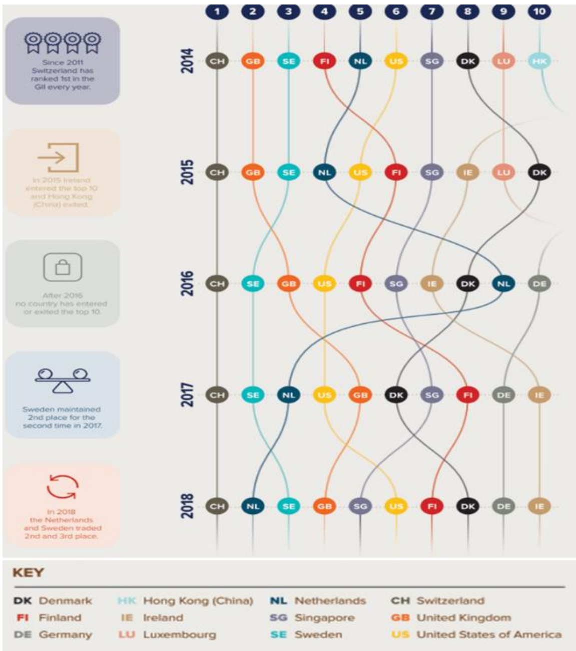


Figure 3-5. Movement in the GII top 10 from 2014 to 2018 (WIPO, 2019)

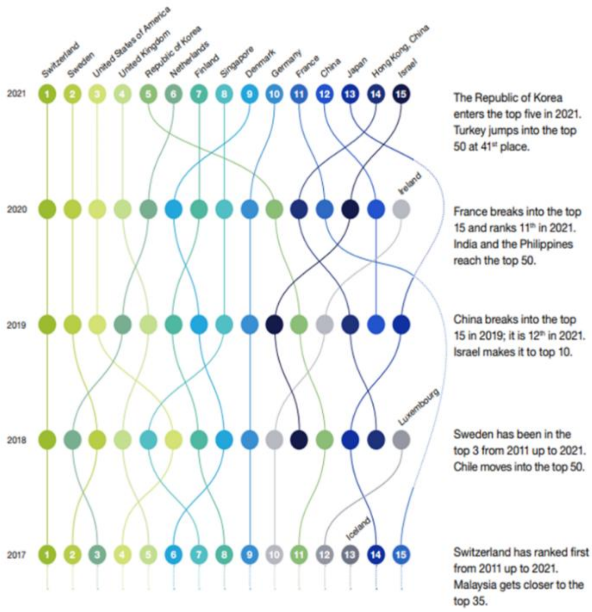


Figure 3-6. Movement in the GII top 15 from 2017 to 2021 (WIPO, 2021)

3.3.2. Sample Size

Estimating sample size is critical in conducting industrial management. Consequently, the sample size must be planned carefully to ensure that the research time, personnel effort and costs are not wasted. Furthermore, the appropriate sample size depends on the specified statistical hypotheses and study design parameters, including the minimal meaningful detectable difference (effect size), estimated measurement variability, desired statistical power and significance level. Moreover, such a sampling arrangement is part of an ongoing comprehensive study (J. Creswell et al., 2006). However, selecting the sampling method depends on the nature of the research study, including theoretical and practical issues (Taherdoost, 2018). Sampling techniques can be classified into two categories (Figure 3.7).

- Probability or random sampling
- Non-probability or non-random sampling

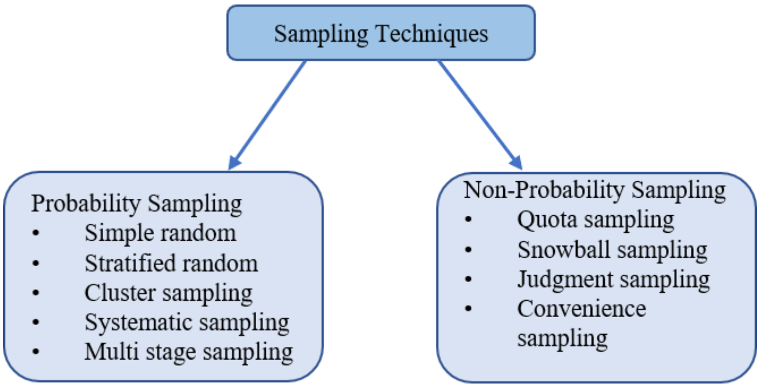


Figure 3-7. Classification of Sampling Size (Taherdoost, 2018)

The non-probability sampling technique is one of the most cost-effective sampling methods. Researchers choose this method because it is regularly related to case study research design, focusing on fewer samples and examining real-life phenomena (Taherdoost, 2018). Additionally, the non-probability model requires some knowledge of the cases, and the population from which the points are selected, as shown in Figure 3.8 (Uprichard, 2013). Perceptibly, the only viable choice for sampling the survey was non-probability sampling, on the understanding that population generalisation has its limitations because of the unknown quantity of the population and the study's exploratory nature. Even so, in the non-probability sampling, a purposive sampling technique was used to enhance representativeness, with advice from academic experts in the manufacturing field (Saunders, *et al.*, 2009).

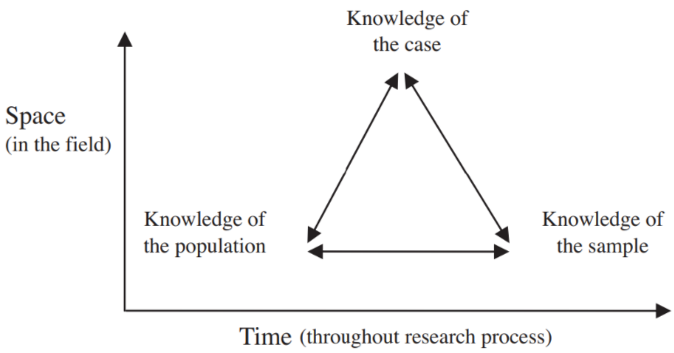


Figure 3-8. Non-probability Sample (Uprichard, 2013).

Interestingly, the digital era has spread worldwide. Little research has been carried out on the innovation management of actual spheres; thus, to fill this gap, one needs to explore the research questions, requirements, and numerous views to test the innovation framework criteria. The author believes that the management employees selected belong to a trustable target population who can provide reliable survey questionnaires. In total, 364 questionnaires as shown in Table 3.1 were completed and returned within a given time frame, a percentage considered relatively high above the median (Saunders, *et al.*, 2009).

Table 3-1 Number of Sample Size

Country	UAE	China	UK	Germany	USA	Japan	Canada	Total
Response numbers	60	50	50	50	50	54	50	364

Nevertheless, selecting different countries was not easy once again; therefore, the author attempted to decide based on accessible communication and quick response to the second stage of the survey. Consequently, the researcher demonstrates that the appropriation of the above criteria by GII is subordination to the future global vision.

3.3.3. Quistioner

In market research, the term “questionnaire” refers to “a questionnaire intended for self-completion by survey participants and survey instruments to be administered by interview, either face-to-face or telephone”. Bradburn *et al.*, (1979) and Jones, et al, (2013) described questionnaires as handy survey tools that allow a large population to be assessed with relative ease. Despite a widespread perception that surveys are easy to conduct, a survey needs extensive planning, time, and effort. Thus, a structured questionnaire is created to gather appropriate data to perform the intended investigation and achieve the research aims. However, researchers clarified that each method for collecting data has advantages and disadvantages that should be evaluated before deciding which methods are most suitable for a particular research topic (Nardi, 2018).

A questionnaire is developed and administered. It contains questions and other items designed to solicit information appropriate for analysis. Exploratory survey research is conducted during the early stages of research into a phenomenon. The objective is to gain preliminary insight on a topic and to provide the basis for a more in-depth survey. The quantitative analysis comprises two distinct yet, methodologically interconnected research approaches: experimental and survey research (Coughlan, *et al.*, 2009).

An online monkey survey is designed for the study. A critical advantage of online qualitative surveys is openness and elasticity to declaim a wide range of research questions of interest to management stakeholders. The authors emphasised that online qualitative surveys facilitate easy access to a sizeable geographically dispersed population (Braun et al., 2021).

The online surveys were conducted in seven countries from June 2019 to November 2020. It targeted decision-makers in various organisation types: federal, private, academic, and government. Respondents were contacted through e-mail, LinkedIn, social media platforms, and official websites for senior firms. Thus, the total number of collected surveys captured many future demand category indicators. From a deep perspective, several comprehensive surveys were distributed on various features to seven countries, including:

- Both languages, "English & Japanese."
- Full hierarchy innovation framework description
  Comprehensive brief for sub-criteria

Table 3.2 illustrates the percentage of different levels of expertise participated in this survey from each country.

Table 3-2 Partcipents Profiles

Country	Characteristics Job area	Percetage %
The United Kingdom	Manufacturers	30
	Academics	40
	Private Sectors	15
	Public/Government Sectors	15
The United Arab Emirates	Manufacturers	20
	Academics	10
	Private Sectors	15
	Public/Government Sectors	55
The United States	Manufacturers	25
	Academics	38
	Private Sectors	22
	Public/Government Sectors	15
Germany	Manufacturers	33
	Academics	17
	Private Sectors	22
	Public/Government Sectors	23
China	Manufacturers	45
	Academics	25
	Private Sectors	10
	Public/Government Sectors	20

Japan	Manufacturers	30
	Academics	40
	Private Sectors	17
	Public/Government Sectors	53
Canada	Manufacturers	20
	Academics	40
	Private Sectors	30
	Public/Government Sectors	10

3.4. Conceptual modelling "Innovation Framework."

The author believes that identifying the relevant individual framework components, interpreting their interrelations and setting the appropriate boundaries of an innovation framework are determined by the methodology choice of the researcher. Furthermore, researchers argue that besides their economic importance, innovation in services affects sectors beyond the actual service sector and additionally, some services play pivotal roles in innovation processes throughout the economy as agents of transfer, innovation support, and sources of innovation for other sectors (Evan & Damanpour, 2019).

Therefore, the innovation framework largely depends on the research objective and analytical inquiry. This way, the proposed innovation framework can be understood based on an actual model designed for analytical purposes. Bergek *et al.* (2015) noted that concept boundaries could be perceived as mutually excluding conceptual magnifying glasses, bringing essential items to the forefront, and giving a real portrait of an empirical study. Moreover, conceptual modelling is developed to understand the 'evaluations and revolutions' in innovation management and to gain specific benefits realised by manufacturers, academics, and organisations, facing the challenges that remain (Calabrese, *et al.* 2020). The researcher agrees with Greenwood *et al.* (2013), on considering a critical part of the conceptual model to be a visual representation of a diagram that depicts the system's essential elements. The system needs to be respected, and the relationships between structure and behaviour must be clarified. A diagram is an effective means to describe a technique to various stakeholders. It also serves as an operational means to facilitate validation with concerned people; in other words, it effectively conveys the scope and clarifies what will and will not be included in the model.

Conceptual modelling is the first stage toward formal modelling, analysis and decision-making of identified problems in the framework configuration (Horn & Brem, 2013). It provides modelling for measuring and optimising logistics capabilities in the innovation framework as the main task of this methodology. Moreover, a universal understanding of innovation is necessary to conceptualise a system for innovation and to decide what needs to be measured (Zizlavsky, 2016). This study suggests a conceptual framework for future direction in innovation management in the digital era. It helps to put the different streams of innovation management research into categories and to give an overview for managerial practice highlighting which areas of innovation management can be applied to exceed future demand.

Additionally, building a conceptual framework to name fields and categories into new branches and streams of research gives an outlook on aspects such as Demand-pull and Digitalisation-push, which is reflected in the marketing doctrine and digital transformation for every aspect of production; and consumption that can increase organizational efficiency. Hence, the conceptual framework and discussion of future examination areas will help other researchers identify future paths of innovation management that are worth focusing on. Finally, a conceptual innovation framework is introduced based on the synopsis of the literature and its theories.

3.5. Decision Making

Decision-making (DM) problems are crucial in economics, yet, success in economics and business is a specific concern focusing on all life issues; thus, decision analysis is widely recognised as a sound perspective theory (Zavadskas & Turskis, 2011). DM is the primary task of all humans, and the output of all activities depends on the reliability of the decision (Mahmoudi et al., 2020). However, DM is not constantly simple, mainly when the problem and associated information contain uncertainty, vagueness or complexity (Liao, *et al.* 2018). There is an extensive range of methodologies in the literature for decision-making (P. H. Dos Santos et al., 2019). Multiple Criteria Decision Making (MCDM) methods received little attention despite their ample potential as decision-support tools (Jankowski, 1995). MCDM combines information from several criteria to form a single evaluation index (Chen, *et al.,* 2010).

Moreover, MCDM refers to decision-making with other and sometimes contradictory multiple criteria (Liao, *et al.*, 2018), which helps the decision-maker identify, describe, evaluate, rank, and select the alternatives (Montis et al., 2000). In general, the MCDM method employed presents a refined and improved way of dealing with the complex evaluation and selection problem comprising four main components: *i)* alternatives, *ii)* attributes/ criteria, (*iii*) relative importance (weight) of each attribute, and (*iv*) performance measures of options according to different features (Ardil, 2021). From another perspective, the nature of the challenge of choice in decision-making is explained in two ways (Jankowski, 1995):

- How to identify the choice of alternatives that satisfy the objective;
- How to reduce/order the practical choice of alternatives to sympathise with the ideal alternative.

However, researchers observed that MCDM could be categorised into two subfields, as shown in Figure 3.9:

- *Multiple attributes decision-making (MADM)* is based on analytical decision-making procedures that specify how to attribute information to arrive at a choice, intended with ranking or selection by evaluating predetermined alternatives.
- *Multiple Objective decision-making (MODM)*: aimed at identifying the optimal outcome by searching for the efficient frontier within a solution space under the given constraints, involving Simple Additive Weighting (SAW) methods, Weighted Product Method (WPM), analytic hierarchy process (AHP), Multiplicative AHP method, Promethee, Vickor method, and Topsis. Zavadskas & Turskis (2011) stated that there are four different families of MCDM methods:

    - The outranking;
    - The value and utility programming;
    - The multiple objective programming
    - Group decision and negotiation theory-based methods

In the current research, the researcher opted for the analytic hierarchy process (AHP) for decision-making as related to the future demand for innovation, making it possible to detect gaps and future research pathways.

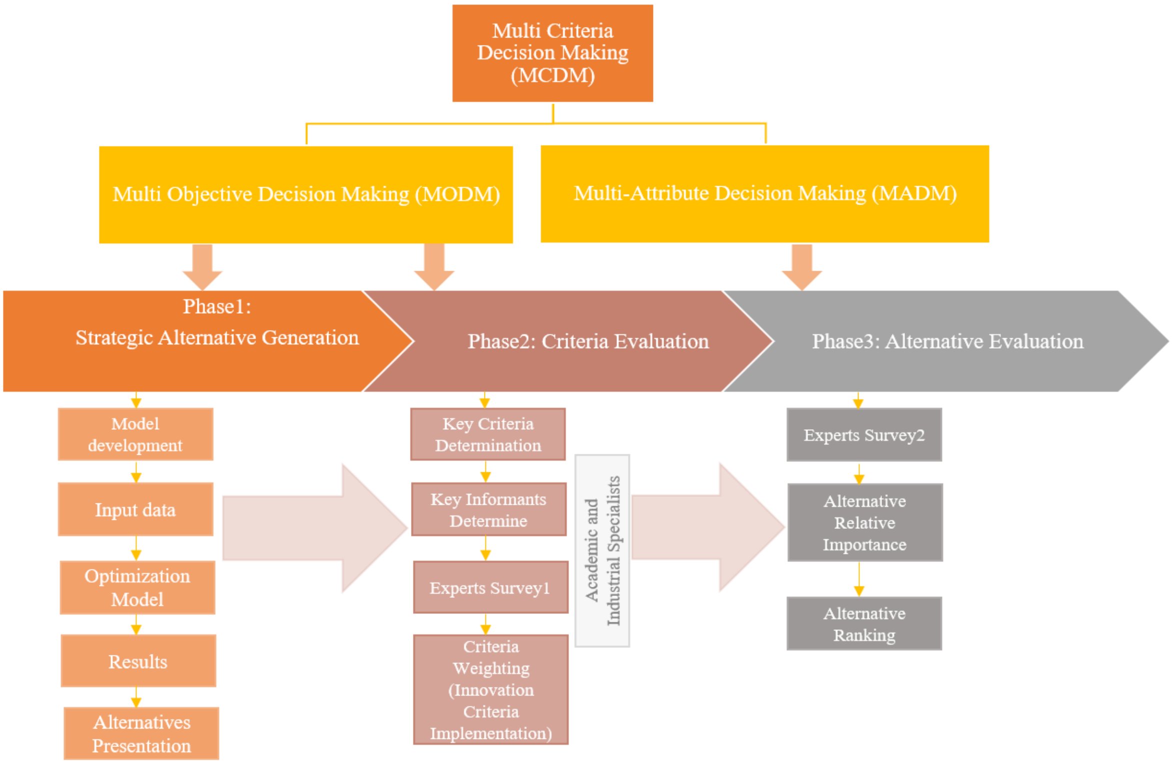


Figure 3-9. Strategic alternatives of Multi-Criteria Decision Making (MCDM) adopted from Chaitanya & Kolla, (2019) and Keyghobadi *et al.* (2020).

3.6. Analytic Hierarchy Process (AHP)

Wind and Saaty (1980) introduced the Analytic Hierarchy Process (AHP) methodology in the 1970s. Harker and Vargas (1987) defend AHP admirably and attribute its lack of complete acceptance to "a reluctance to move away from traditional analysis methods." Furthermore, AHP should be viewed as a lively area for intellectual progress (Meade & Sarkis, 1999). AHP involves pair-wise comparisons and uses the experts' decisions to obtain a priority scale (Meade & Presley, 2002). In other words, the AHP decision-making depends on the theory of relative measure based on comparing pairs used for standardised proposed natural numbers that elements are then used as priorities (P. H. Dos Santos et al., 2019). Popularity amongst the decision-makers facing sophisticated decision challenges whereby none of the alternative pillars is the best alternative (Meesapawong, 2013).

Thus, the AHP method enables decision-makers to model a problem into a hierarchal structure illustrating the relationship among its factors (Bayazit, 2005). That supports decision-makers to deal with equally rational and intuitive judgment to first-rate the best from several alternatives concerning the number of conflicting factors (Meade & Sarkis, 1999). However, the pair-wise comparison, the mean employed to compare the elements in the hierarchy, can supply the numerical consequences for operative decision-making (Feng *et al.*, 2020, Bayazit, 2005). The technique demonstrates the consistency and inconsistency of decisions characteristic of this technique, which will be discussed briefly. In short, since its release, AHP has been helping people in numerous fields and industries to make sensible decisions when decision criteria are considered based on the following four principles (Saaty, 1995, Forman & Gass, 2001):

1) ***Decomposition***: A complex problem is decomposed into *A hierarchy,* with each level consisting of a few practicable criteria/elements or clusters, sub-cluster, or sub-sub-cluster. Each is, in turn, decomposed and so on.

2) ***Prioritisation***: The hierarchy's impact (criteria/elements) is measured through paired comparisons related to each of the criteria/features of the level instantly above. In other words, the dependence on comparative judgments enables one to carry out pair-wise comparisons to drive "local" priorities (weights) of the elements in a cluster concerning their ancestry.

3) ***Synthesis***: The priorities are pulled together; the *Hierarchic Composition* principle provides the overall assessment of available alternatives, multiplying the main priorities of the criteria/elements in a cluster by the "global" importance of the root element.

4) ***Sensitivity***: the stability of consequence to changes in the significance of criteria is defined by testing the top choice against the "what-if" sort of the change in priorities of the criteria/elements.

3.6.1. Data Collection and Analysis Tool

The questionnaire is one of the most popular methods for collecting data in this study. Thus, judgments involving criteria in the hierarchy can be elicited by questionnaire. The AHP questionnaire comprises sets of pair-wise comparisons requesting the respondents to compare the rank of the components in the hierarchy model and then to evaluate the alternative orientations' impacts on the criteria. Utilising ratio scales is one of the pillars of the AHP. The multidimensional scaling of the elements and their alternatives is converted to the identical scale using integer "1 to 9" to signify the intensity of importance or impact. The odd numbers (1, 3, 5, 7, 9) represent five attributes: equal, moderate, vigorous, very strong and extreme respectively, whereas the even numbers are designed for intermediate values between the two adjacent judgements. The intermediate values remedy uncertainty in making a decision. The standard AHP software 2020 package is ExpertChoice®, used to determine the relative weight of functional measures, an online database of references and models that have been used to build an "innovation framework" found at the "hierarchy".

3.6.2. Validation of the proposed framework contents

Criteria and sub-criteria proposed for the framework were extracted from thematic literature and previous experience. Both subdivisions increase the representativeness of the final decision. Moreover, the pilot questionnaire was appropriately matched with the absorptive capacity of the innovation framework criteria, as presented in the index sample of the questionnaire.

3.6.3. Reliability

Since the present questionnaire is in the form of pair-wise matrices, its reliability could be measured utilizing a consistency ratio. Sun *et al.* (2008) suggested the use of the consistency index to measure the extent of consistency. The applied mechanism demonstrates the degree to which the judgements and priorities can be reliable. Generally, a consistency ratio with equal or less than ten percent can be considered adequately consistent.

The AHP can maintain the consistency of the group when individual DMs are consistent, utilising the weighted geometric mean method (Sun et al., 2008), where the biggest eigenvalue is denoted by λmax. Matrix rank is denoted by n, *CI* indicates the consistency index, RI means the random index, and the satisfactory extreme value of CR is <0.1. It would help achive a better level of consistency; therefore, one can compute the *CI* values with the help of the equation below

$$CI = \frac{\lambda\text{max} - \text{n}}{\text{n} - 1}$$

$$CR = \frac{\text{CI}}{\text{RI}} \tag{3.1}$$

Furthermore, the coherence ratio *CR* is calculated by the equation: *CR=CI/CA*; it is impossible to satisfy many equations when constructing a pair comparison matrix. Thus, the paired comparison matrix is essential to present consistency; a certain degree of inconsistency in the paired comparison matrix can be accepted. In addition, the consistency ratio CR for each matrix is measured. If the *CR* is more extensive than 0.10, it implies a 10% chance that the elements have not been compared well, and the decision-maker should re-evaluate the comparison (Zuo *et al.*, 2021; Nimawat & Gidwani, 2021; Belloula *et al.*, 2020; Process, 2001). The value of the random consistency index is shown in table 3.3 (Taherdoost, 2017)

Table 3-3 The value of the random consistency index

(n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

3.6.4. Sensitivity analysis (SA) in building performance analysis

Sensitivity analysis is a methodology used to validate the stability of the implemented MADM methods. It validates many mechanical applications in static and dynamic analysis (Chaitanya & Kolla, 2019). Applying SA compels the decision-maker to identify influential variables in prophecy, indicating the critical variables for which different processes could be achieved (Sohani, *et al.*, 2021, Asheghi *et al.*, 2020). From another perspective, all SA use a one-factor-at-a-time approach to assess the relative importance of input factories in the presence of factors uncertainty. This approach is only justified for linear models; however, SA is identified as a mathematical definition, with output differentiation concerning the input (Saltelli et al., 2006).

In addition, SA on the effects of fluctuations in the criteria rankings provides valuable insight into the performance of the options; the first level is compared to the second (alternatives), respectively (Mahmoudi et al., 2020). Also, it indicates how the possibilities are prioritised over others concerning the goal. Nevertheless, the framework allows conducting threshold proximity of decision trees, including alternative approaches to maximality alone (Machina, 1987).

A series of sensitivity analyses were conducted to investigate the changing impact of the priority criteria on the alternatives. Dynamic sensitivity of Expert-choice® was performed to determine the accuracy of the last outcome, yet, it was used to dynamically change the priorities of the criteria to indicate how these variations affect the importance of choice (Bayazit, 2005, Saaty, 1995). In particular, SA is a crucial and appropriate step that can boost confidence in ranking and focus on the probability order obtained through the innovation framework, as shown in Figures 3.10. and 3.11. A different scenario is indicated briefly and more thoroughly in chapter 5.

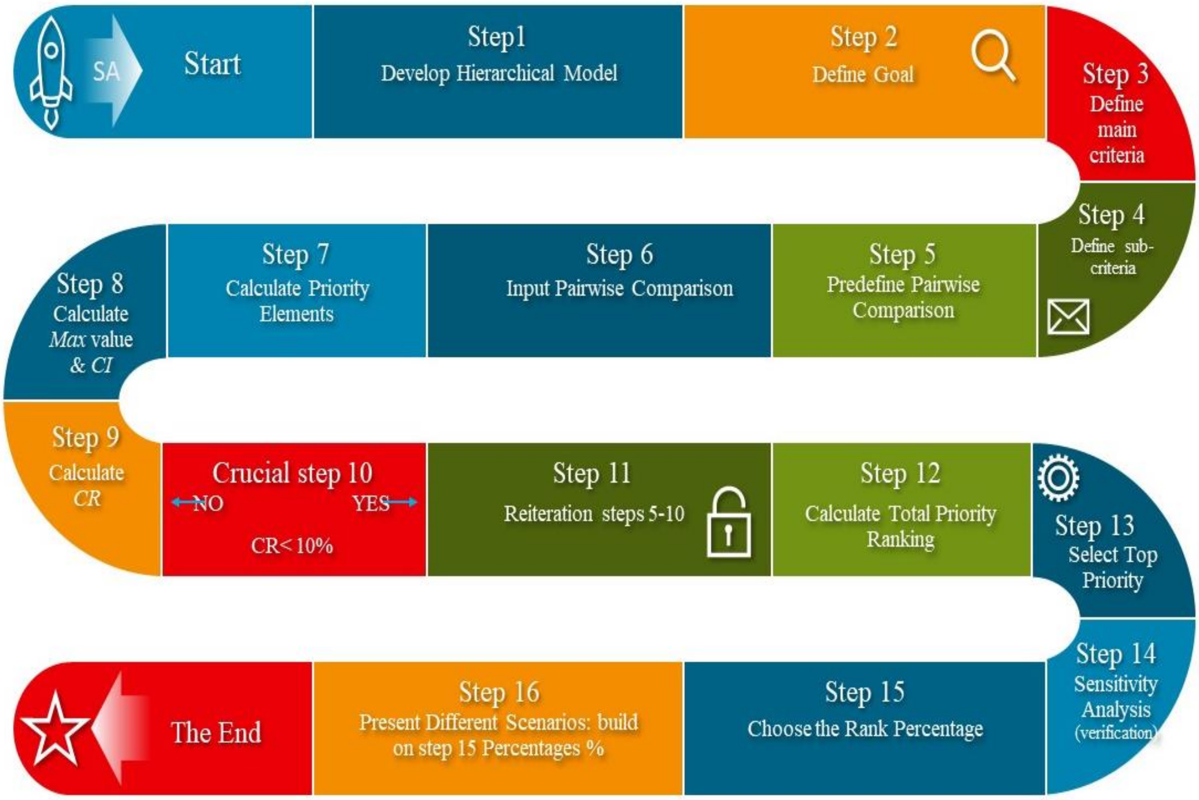


Figure 3-10. Systematic info-graph for AHP sensitivity analysis (SA)

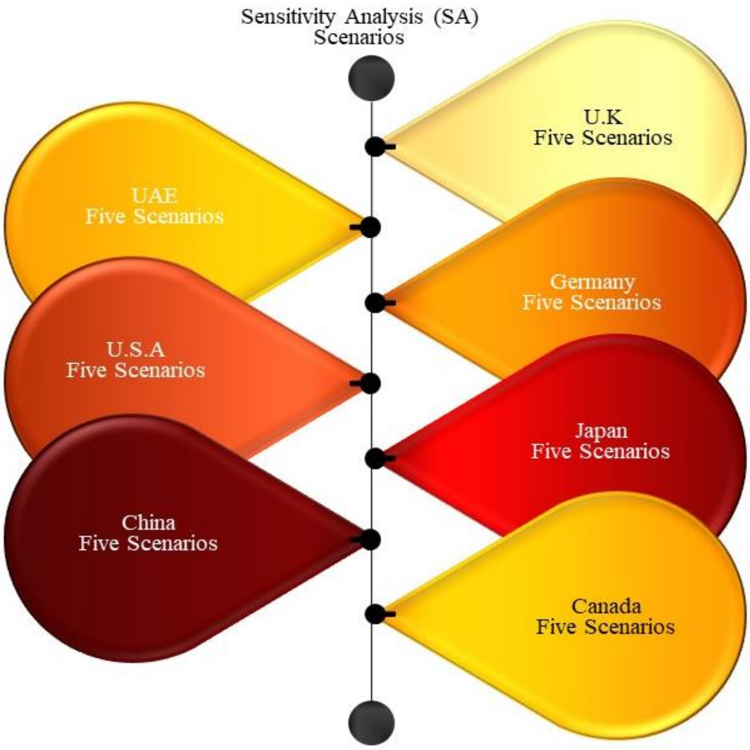


Figure 3-11. Info-graph for the number of scenarios for the seven countries included in this steady

3.7. Conclusion

This chapter has provided a review of methodology illustrating the decision-making processes and using the AHP method to build a hierarchy innovation framework together with the widely proposed embedded techniques of AHP. Furthermore, the research process used methods of ***Ontology*** philosophy, a logical approach to time-space, comparative analysis and an elaborate researcher's view of the nature of reality to explore research philosophy further through the social science paradigms such as "pragmatism". The research has come up with generalised conclusions and recommendations on the state of digital technologies in the seven countries, the achievements in the area, and the issues that need to be addressed. The methods of analysis and synthesis, economic and statistical analysis, and graphical comparison were used to study framework criteria.

In other words, the advantage tool used in this study is the analytic hierarchy process (AHP). A tool helped build the proposed innovation framework and study the criteria impact on the future era. Moreover, a practical application of AHP in assessing the effects of Demand-pull and Digitalisation-push is discussed. The most crucial aspect is the sensitivity analysis (SA) which explores the relationships between the output and inputs of the modelling application. Consequently, it is essential to validate and calibrate the numerical model, which checks the robustness of the outcomes against slight changes in the input data; it can clarify the measures of importance to sensitivity indices, from retrogression or correlation methods to variance-based techniques. Accordingly, the SA techniques can reduce uncertainty in MCDM and the stability of its outputs by illustrating the effect of minor changes to specific input parameters on outcomes estimation.

It can be concluded that AHP captures stakeholders'/decision-maker's perceptions of the relative seriousness of different innovation aspects and impacts, which will help different types of organisations mature and upgrade organisation plans. In the current study, the researcher incorporated the AHP method with a survey distributed in seven prestigious countries to analyse the reasonable criteria for an optimal innovation framework for the future digital era.

Chapter 4

Developing the new proposed conceptual innovation management framework

4.1. Introduction

This chapter builds on the research instruments chosen in the Methodology Chapter and proposes a conceptual framework for innovation management. The proposed framework attempts to create performance indicators for innovation that can be adapted to each sector's characteristics, indicating a model timeline of future modifications that a given organisation must make use of to maintain a competitive advantage. In contrast to previous innovation frameworks, this study is an attempt to observe innovation as an organisational phenomenon, it is anticipated that the new framework presents unique aspects for future demand.

4.2. The conceptual new generation framework of innovation management

Innovation management theory cannot be purchased as a tangible product. Academic theory is a practical construction that attempts to explain phenomena observed in the real world. Therefore, industry and economics transform theory into an influential aspect in the organisation, specifically the "innovation process". Additionally, some authors present the innovation process as a knowledge transformation process using three significant activities (Penidea et al., 2013).

A. Knowledge management sourcing
B. Knowledge transformation into a physical innovation (new product or process)
C. Exploitation of Innovation

The continuously rapid and underlying driver for this push-up innovation lies in the increasing need for companies to develop the ability to adapt to rapidly changing environments quickly. Time-to-market remains essential for quick market and technology adaption, enabled by a disciplined new product development process (Van der Panne, *et al.*, 2003; Sandmeier *et al.*, 2004). Thus, practitioners and innovation researchers agree upon the relevance of this early innovation stage, which consists of prospect identification, idea generation and evaluation/assessment, business-plan growth and product perception (Acklin, 2010; Press, 2019), as presented briefly in Chapter 2. As global development has increasingly built a competitive presence on the global stage, the conceptual innovation framework will exhibit the industrial demand to exceed organisational innovation and substantially meet global competitiveness. The empirical innovation framework is divided into three main criteria *1*) Demand-Pull for Future Shape, *2*) Digitalisation Push, and *3*) Dynamic Innovation System, which fulfils organisations' and industrials' global future needs; it is explored in-depth below.

4.3. Demand-pull for the future shape

According to Rothwell (1994), empirical and practical studies of innovation in the latter half of the 1960s emphasised innovation as a product of 'pull' or market-led influences in need or demand (Rothwell, 1994). The results of numerous studies published since the 1960s emphasised the role of the marketplace in innovation. These developments resulted in speedy employment creation, intensifying prosperity and serving as an associated consumer boom, leading to the quick growth of the consumer goods, electronics and automobile industries, even though demand during the earlier years exceeded production capacity (Rothwell, 1994). This is generally favourable resulting in scientific advancement and industrial innovation, as innovation adoption is reflected in the marketing doctrine. Therefore, the framework section will present the most significant transformation aspects where prosperity remained high, having striven to model innovation in their practice to exceed market demand.

The most significant aspects of demand-pull that drive innovation are categorised according to the seven influences illustrated in Figure 4.1 to meet the global market.

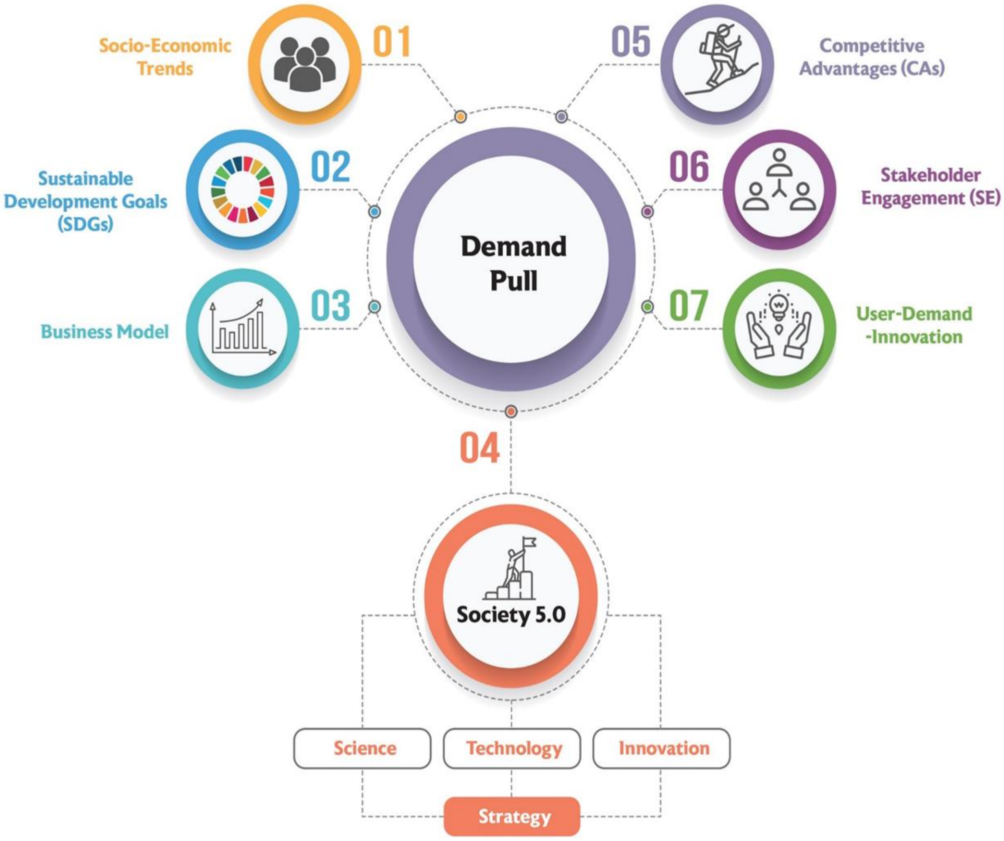


Figure 4-1. Demand-pull

4.3.1. Socio-Economic trends

Socio-economics, known as Economic-sociology, is the study of various economic phenomena' social cause and effect; it can be broadly divided into a classical period and a contemporary one (Swedberg, 2003). It is also identified as Social Economics, the social science that studies how economic activities (production, distribution, and consumption of goods and services) affect and shape social processes. It analyses how modern societies progress through technological advancements, science and social organisation, and the economy stagnates. Societies are split into three groups: social, cultural, and economical. It also affects how social and economic aspects influence the economy (Hellmich, 2017; Levina et al., 2015).

One of the most influential and possibly complex systems is the social and economic (socio-economic) system. Systems of this sort represent complex structures consisting of social and economic elements. Such systems subsume a complex mix of individuals, groups, institutions, and organisations interlinked in the economy and society (Javanmardi & Liu, 2019). Moreover, the systems are made up of humans, especially the relationships between them and their roles. Socio-economic systems do not pay full attention to humans, but they consider the character of humans in the systems surrounding them (Boulding, 2017). However, the prolonged period of slow economic growth (traditionally measured in terms of GDP growth) is usually accompanied by high unemployment, as estimated by macroeconomists, even though the growth rate may be nominally more elevated than that in countries that do not experience economic stagnation (Kofanov & Zozul` 2018). On the other hand, there is a common belief among many scholars that the world we live in is a world of socio-economic systems; thus, the experiential world in such practices is associated with human life and society in all their complexity and enrichment. The term "socio-economics" can generally point to the application of economics in the scrutiny of society (Kapliński, & Peldschus, 2011).

Global trends in creating strategic management systems focus on developing forecasting methods and models (socio-economic and technological ones) that form the foundation of socio-economic planning. They also design economics, its household; mechanisms of intergenerational mobility and transmission, accumulation processes of resources, short- and long-term effects of institutional change and policy reforms and the speed of convergence between East and West (Kofanov & Zozul`ov, 2018; Goebel *et al.*, 2019). It is a component of political, climatic, temporal, and other characteristics (Kosov *et al.*, 2016; Fedulova & Komirna, 2017). However, experts address various social and economic development issues through specific planning, design, and management methods, many of which have long proven effective. According to Kovács, & Kot (2017), industrial transformation, which focuses on mineral resources, has several implications for socio-economic growth.

Additionally, as Patrick, *et al.* (2007) pointed out, transitions observed in the market are considered the dynamic socio-economic processes in whereby dynamics determine changing demand and product-service combinations in the needs and concerns of society. Moreover, as these socio-economic conditions are continually changing, this is thought to modify incentives and consumer behaviours, thus placing the onus on modern organisations to predict how such pathways for consumer solutions may evolve (Zafirovski, 1999). This association led authors to suggest that characteristics defining a product or solution as innovative would be found repeatedly within these socio-economic zones (Baregheh *et al.*, 2009).

Scientific and business society's acknowledgement of the character of innovations and most effective economic development defined the swiftness of different processes in this area, the support for which became one of the national priorities several years ago (Esmailzadeh *et al.*, 2020). Experts often pay attention to specific examples of dynamic development of territories and substantial expenses for innovative development, as innovation is gaining traction globally in emerging economies and the industrialised world (Tiwari, *et al.*, 2017). Nevertheless, experts regard innovation as a critical topic in today's global competition. A recurring issue was the need to localise products, which was considered an essential element in innovation (Fedulova & Komirna, 2017; Tiwari, *et al.*, 2017). According to past researchers, the socio-economic approach to economic exchange, including its market modes, recognises and analyses its social conditions. It defines market-economic exchange as a particular form of social action (Zafirovski, 1999). As explained, the concept of sustainable development was proposed to make positive socio-economic transformations, and it can be implemented through innovation (Kofanov & Zozul`ov, 2018). So, socio-economics is the most crucial aspect of demand-pull to meet the global competition; as a result, building an innovation framework is especially important for understanding and often modelling social and economic behaviour toward social needs (Zavadskas & Turskis, 2011). Baregheh, *et al.*, (2009) noted that characteristics defining a product or solution as innovative would be found repeatedly within these socio-economic zones; hence, the inclusion of the Socio-economic in the proposed framework is vital.

4.3.2. Sustainable Development Goals (SDGs)

Due to economic and technological climate changes, attention is placed on Sustainable Development (SD) (Tomás, *et al.*, 2016). The primary three-pillar paradigm of SD introduced by the United Nations (UN) includes economic, social and environmental indicators (Dos Santos et al., 2019). It is believed that sustainable development "can meet the requirements of the current generation and that it does not have to consume the capability of the future generations. People must find meaningful ways to turn it from a general concept into reality (Wu et al., 2018). According to Baboshkina, *et al.*, (2018), managing SD in long-term programmes demands the growth of the region's strategic management goals. Previous research has shown that innovation can implement sustainable development. Seyfang & Smith (2007) state that the contemporary start-up phenomenon is shared among the modern innovation drivers. The term "start-up" refers to the newly created projects and companies that develop innovative products or services while looking for a cost-effective, reproducible and scalable business model to become a viable and successful organisation. Nevertheless, the Federal Government of Germany underlined that sustainable development creates innovation from a position of responsibility for the present and future generations (Germany F. Government, 2014).

This section aims to contribute to developing relevant Sustainable Development Goals as the current format of SDGs is to be implemented as one of the main aspects of the innovation framework's Demand-Pull. Griggs, *et al.* (2013) remarked that the definition of SDGs entails the development that meets the needs of the present while safeguarding the underlying life-support system Earth that sustains it". Seventeen goals within this adapted framework are conceived with the active participation of UNESCO, building on the Millennium Development Goals (MDGs) achievements. In September 2001, building upon the Millennium Declaration, the United Nations (UN) presented the Millennium Development Goals (MDGs) as a list of common goals for the global community to be achieved by 2015 (Fehling, *et al.*, 2013). These introduced "macro-economic and social issues, including climate change, economic inequality; managing innovation; sustainable consumption; and military peace" (UNISCO, 2019).

Moreover, the MDGs have remained a focus of global policy debates and national policy planning for more than a decade. They have become incorporated into the work of non-governmental organisations and civil society more generally and are taught to students at all levels of education (Lowe, 2012). Moreover, this focus on climate change and the ability of an organisation to comply with changing environmental regulations is increasingly impacting decisions made by organisations, with environmental sustainability becoming, in some cases, a criterion for modifying an innovative new product for the market (Alola, 2019). Consequently, although they only begin to influence innovation management in private sector organisations, governments already use environmental regulations (ERs) to streamline firms for sustainable growth and development (Ramakrishnan, *et al.*, 2018; Zhou, *et al.*, 2019). In September 2015, sustainable development by 2030 agenda was approved by the United Nations (UN.) in its Summit in New York. The summit proposed a new indicator framework, associated with the universal indicators, for international corporations to achieve sustainable development between 2015 and 2030, including seventeen new Sustainable Development Goals (SDGs) (Shen, *et al.*, 2015; Wu *et al.*, 2018; Endl *et al.*, 2021), as shown in Table 4. 1 and Figure 4. 2.

Table 4-1 Sustainable development goals (SDG)

	17 Sustainable Development Goals
Goal.1	End poverty in all its forms everywhere
Goal.2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal.3	Ensure healthy lives and promote well-being for all at all ages
Goal.4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal.5	Achieve gender equality and empower all women and girls
Goal.6	Ensure availability and sustainable management of water and sanitation for all
Goal.7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal.8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal.9	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
Goal.10	Reduce inequality within and among countries
Goal.11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal.12	Ensure sustainable consumption and production patterns
Goal.13	Take urgent action to combat climate change and its impacts
Goal.14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal.15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal.16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal.17	Strengthen the means of implementation and revitalise the global partnership for sustainable development

Figure 4-2. Sustainable Development Goals (Wu et al., 2018)

SDGs need to be included in the Demand-Pull as one of the significant aspects of economic growth and innovation. The inclusion is explained in more detail in the 2030 (SDGs) plan, and associated targets form a practical framework for determining real-world research impact (United, 2015), as shown in Table 4.2.

Table 4-2 SDGs (8-9) including sub-targets by 2030

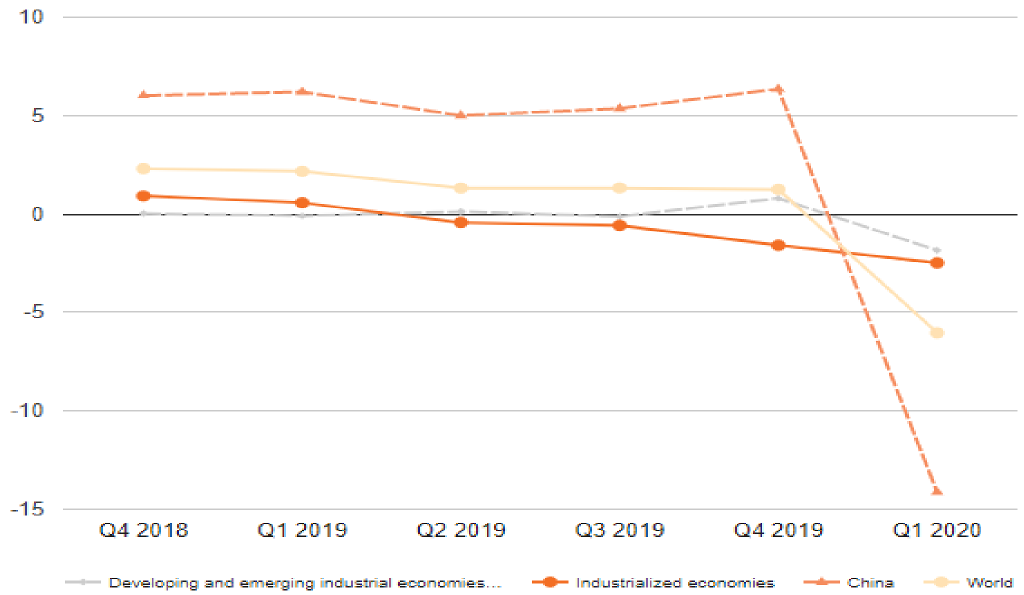
Goal.8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all
8.1	Sustain per capita economic growth following national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries
8.2	Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including a focus on high value-added and labour-intensive sectors
8.3	Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including access to financial services
8.4	Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead
8.5	By 2030, achieve full and productive employment and decent work for all women and men, including young people and persons with disabilities, and equal pay for work of equal value
8.6	By 2020, substantially reduce the proportion of youth not in employment, education, or training
8.7	Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms
8.8	Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular, women migrants, and those in precarious employment
8.9	By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products
8.10	Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all
8. a	Increase Aid for Trade support for developing countries, in particular, least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries
8. b	By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization
Goal. 9	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
9.1	Develop quality, reliable, sustainable, and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
9.2	Promote inclusive and sustainable industrialization and, by 2030, significantly raise the industry's share of employment and gross domestic product, in line with national circumstances, doubling its share in the least developed countries

9.3	Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets
9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action by their respective capabilities
9.5	Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending
9.a	Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States
9.b	Support domestic technology development, research and innovation in developing countries, by ensuring a conducive policy environment, industrial diversification and value addition to commodities
9.c	Significantly promote access to information and communications technology and strive to provide universal and affordable access to the internet in the least developed countries by 2020.

Therefore, we stress the other main concept: SDGs can also be used as a reference or address research impact on management. Moreover, management research can contribute to the SDGs (Nilsson, *et al.*, 2016; Biggeri *et al.*, 2019; Chapman *et al.*, 2020; Nations, 2020; Hourneaux, 2021; Jeffrey & Sachs, 2021) as indicated below:

- Firstly, on how to deal with them from a management perspective. Besides its importance, the SDGs are extensive and complex, comprising the already mentioned 17 goals and 169 targets and more than 300 indicators. Several authors highlight the need to deal with the SDGs from an integrated perspective to combat this complication.
- Secondly, SDGs assessments were previously more directly related to their original purpose, or to how to evaluate the countries' performance regarding their presumed SD targets. Nevertheless, the SDGs have also been used as a parameter for introducing or evaluating SD in different areas or levels of analysis. For instance, the SDGs have been considered to implement sustainable organisational strategies and to assess their performance. Moreover, Management research can address how these assessments occur and analyse the degree of efficacy in implementing SDGs in diverse institutions.

Innovation and research are vital to long-term economic development; investment in research and development (R&D) has undoubtedly increased. As a real global example, Figure 4.3 below presents the role of (R&D) in management analysis as having a real global impact. In Goal 9: industry, innovation, and infrastructure are described as factors that “build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”, it is clear that "global manufacturing output growth witnessed a sharp decline of 6.0 per cent in the first quarter of 2020 due to economic lockdown measures. China, the world's largest manufacturer, was battered by COVID-19 in the first quarter of the year, registering an unprecedented drop of 14.1 per cent in manufacturing output. Since manufacturing is considered an engine of overall economic growth, the global slump in manufacturing production has severely impacted the economy" (United Nations, 2020).



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Period	Developing and emerging industrial economies (excluding China)	Industrialized economies	China	World
Q4 2018	0.027	0.912	6.019	2.303
Q1 2019	-0.092	0.571	6.199	2.167
Q2 2019	0.119	-0.432	4.998	1.313
Q3 2019	-0.124	-0.577	5.354	1.32
Q4 2019	0.791	-1.593	6.35	1.24
Q1 2020	-1.844	-2.481	-14.121	-6.04

Figure 4-3. The quarterly growth rate of manufacturing output compared to the same quarter the previous year, the fourth quarter of 2018 (United Nations, 2020)

Furthermore, according to various human needs perspectives, the 17 SDGs can be roughly classified into three significant dimensions: social, economic, and environmentally sustainable development (Chams & García-Blandón, 2019). Within each element, there are also several SDG categorised related to each other falling into smaller groups according to different perspectives of people's needs, such as self-fulfilment, psychological, and basic needs (Wu *et al.*, 2018). The classification is shown in Figure 4. 4 below.

SDGs attainment requires a strategic process involving several actors: the private and public sectors, governments, multi-national enterprises, non-governmental and philanthropic organisations, and individuals (Chams & García-Blandón, 2019). Thus, the UK Government links with sustainability in the DTI 2003 Innovation Report, stating that innovation is essential for meeting the environmental challenge. In this vein, 'sustainable innovation', 'ecopreneurship', and 'eco-efficiency' are key terms used to describe the greener business activity espoused by bodies such as the World Business Council for Sustainable Development. Alongside greener business innovation, the government aims to promote sustainable consumption through 'market transformation' and develop more sustainable market choices for products and services (Seyfang & Smith, 2007; Schumacker, 2008). From the business standpoint, the essential objective of the SDGs is to establish "sustainable, innovative, and people-oriented" economies that enhance employment opportunities (Chams & García-Blandón, 2019).

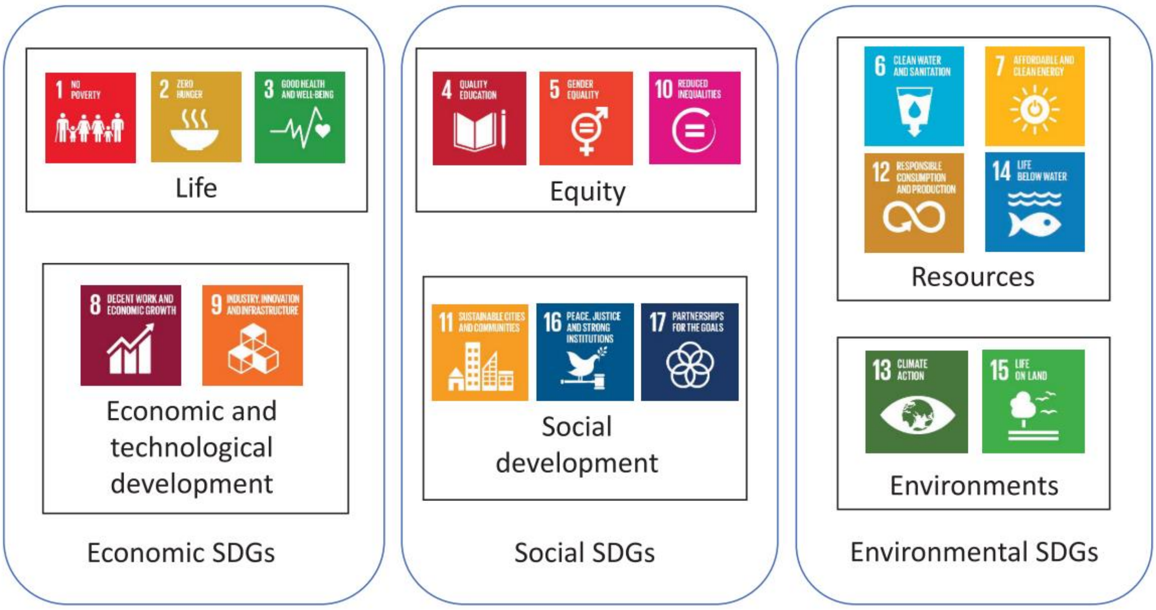

Figure 4-4. SDGs are classified into three dimensions according to human needs (Wu *et al.*, 2018).

Although innovation is a valuable tool for developing countries, sustainable industrialisation is still in its early stages. Scholars explored the dynamic mechanisms that affect the evolution of industrial products when they adapt to changing environments. The authors also discussed the impact of evolutionary theory on environmental innovation (Acuti, *et al.*, 2020); an incremental innovation-based strategy called Eco-evolution has been proposed; it aims to understand the procedures, functionalities, and roles in end-to-end Innovation (Jofre, *et al.*, 2008).

Economic growth is sustainability based on two main aspects, firstly: innovation, mainly touched upon in SDG 8 ("Sustainable Economic Growth and Productive Employment and Decent Work") and SDG 9 ("Sustainable Industrialisation and Foster Innovation"). Secondly: society 5.0 which has multidimensional significance as a perception of a technology-driven society that purports to be super-smart and people-centric. Consequently, Society 5.0 does not just provide a vision to guide Japan's science and technology strategy but it will serve other purposes which be highlighted in detail in the next section; its relevance extends to the political and economic spheres (Holroyd, 2020). It offers excellent hints on how to forge a future sustainable economic growth through societal relationships (Deguchi, 2016). In other words, Society 5.0 aligns actions and objectives with the SDGs from the UN development programme; it is defined as a "universal call for ending poverty, protecting the planet, and ensuring the enjoyment of peace and prosperity by all people 2030".

The SDGs were planned to achieve collective progress between governments and citizens, thus avoiding the consequences of social inequality. Therefore, the Japanese government defines the following actions to be implemented and carried out within Society 5.0 to achieve the objectives of the SDGs in the year 2030, as illustrated in Figure 4.5. (Narvaez Rojas et al., 2021). Furthermore, the researcher defined Society 5.0 as the next principal aspect of Demand-Pull.

Figure 4-5. Society 5.0 for SDGs (Rojas et al., 2021)

4.3.3. Society 5.0 (Science, technology & innovation strategy)

The government of Japan has introduced the vision known as "Super-Smart Society", alternatively, the "Society 5.0" science and technology basic plan. Moreover, the preliminary plan proposes the idea of Society 5.0 (Fukuda, 2020), a vision of a future society guided by scientific and technological innovation. This new society is created by transformations led by "scientific and technological innovation, after hunter-gatherer society, agricultural society, industrial society, an information society." (Deguchi, 2016), as shown in Figure 4.6.

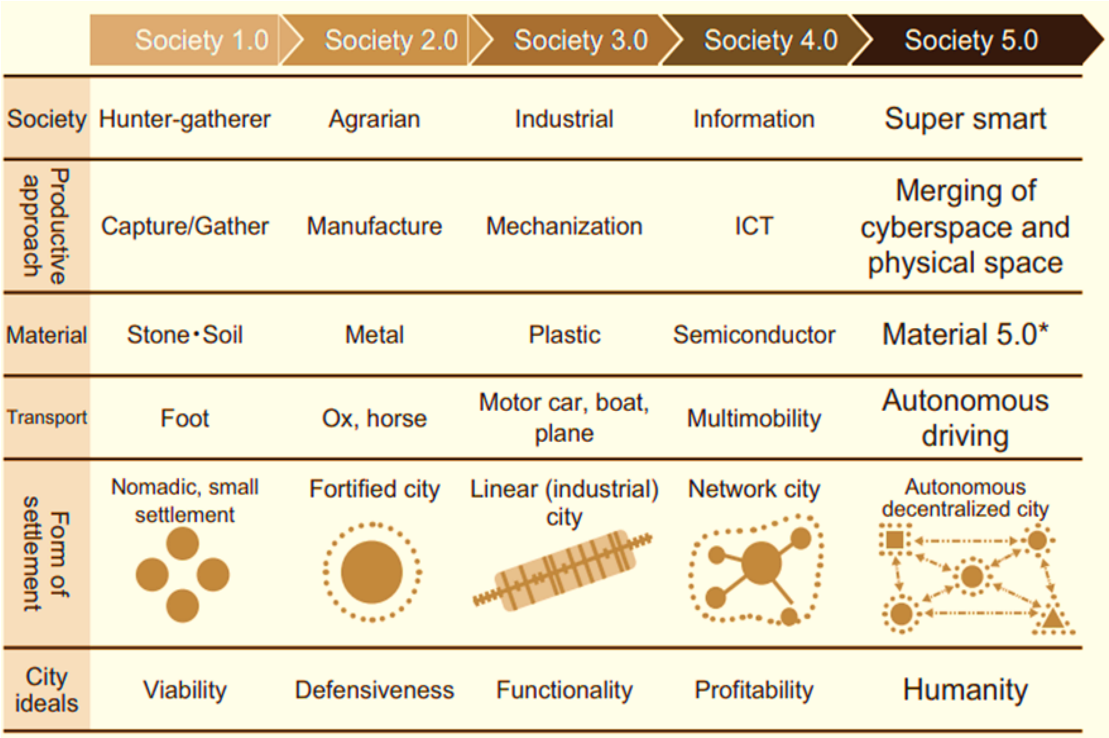

Figure 4-6. Contextualising society 5.0 categories (Deguchi, 2016)

In 2017 the Japanese government addressed the comprehensive strategy on science, technology, and innovation for the 2017 vision states of Society 5.0. Furthermore, to thrust capitalism and gain high-quality lives of comfort and vitality, a human-centred society will be able to balance economic advancement with the resolution of social problems by providing goods and services (Holroyd, 2020). Nevertheless, Science, technology, and innovation (STI) policies have created the world as it is today. In medieval Europe, kings and princes were engaged in the competitive support of science and art (Fukuda, 2020). This competition was considered to be crucial for the relative success of Europe as compared to, for instance, China, where the centralised control slowed scientific progress (Chaminade, & Lundvall, 2019). The competition mode fostered a culture, still with us today, of open science, where the individual scientist has positive incentives to share knowledge and to contribute to the common growing foundation of scientific information (Mayumi, 2018).

Any new scientific theory, working technology, or service innovation requires implementation through human resources. However, in December 2017, the "New Economic Policy Package" was adopted to implement measures in the "Investment for the Future Strategy 2017", including a human resource development revolution and supply system innovation as key policies (Mayumi, 2018) . As the competition and complexity of modern markets increase, this will ultimately impact how human resources are transferred and allocated to innovations

(Rojas *et al.*, 2021). This transition to a knowledge-based economy will pressure governments to shift displaced employees into research and R&D development positions. Moreover, this dynamic shift of human resources to research-focused functions will require three prominent roles for every future organisation to maintain its competitive advantage: *1)* scientific research, *2)* technological development, and *3)* innovation capacity management for the organisation as a commercial entity (Chaturvedi, *et al.*, 2019).

Keidanren (Japan Business Federation) is Japan's most crucial federation. It is well-aligned with Corporate Behaviour, including a section on the "Realisation of a Sustainable Society". The primary aim of proactively delivering on SDGs through the creation of Society 5.0; Strategy is the direction and scope of an organisation over the long term to benefit the organisation through its configuration of resources within a challenging environment, meeting the needs of markets, and fulfilling stakeholder expectations. There is a correlation between innovations based on science, technologies, and societal changes; sustainability is a crucial concept for innovation processes presented by Society 5.0 due to its thoughtful relevance in economic, social, and environmental dimensions. However, sustainable innovation integrates sustainable environmental, social, and financial considerations into organisational systems. Consequently, that integration generates ideas for R&D to improve and to generate economic growth as desired in Demand-Pull, Figure 4.7 (Fukuda, 2020; Narvaez Rojas et al., 2021).

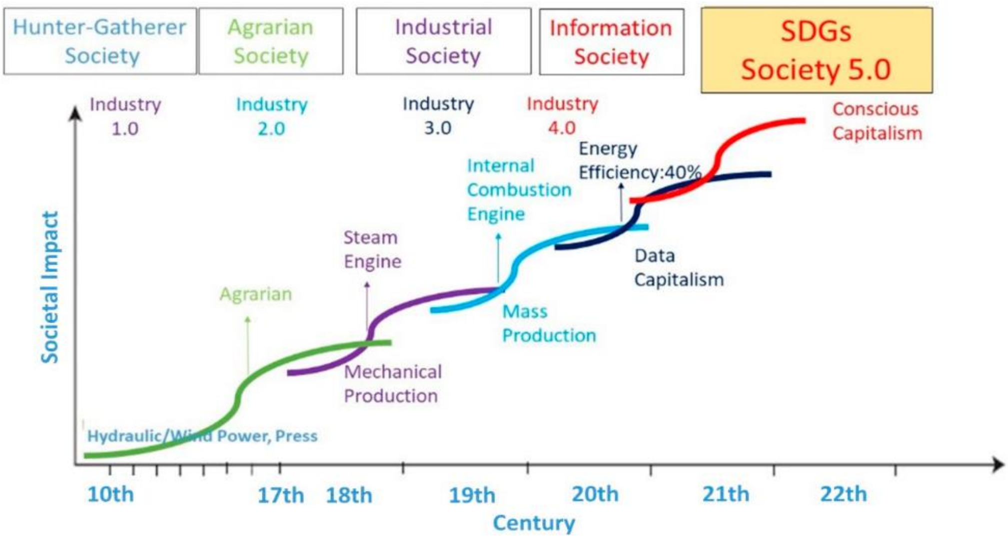

Figure 4-7. The relationship between innovations based on science, technology and changes in society (Fukuda, 2020; Rojas et al., 2021)

4.3.4. Competitive Advantages (CA)

The extant literature in management illustrates the increasing need for enterprises to achieve sustainable competitive advantage in the increasingly turbulent and unpredictable business landscapes of the 21st century. The pressure of attaining and maintaining a competitive advantage increases in today's market environment. Consistent with this, globalisation has created a mindset of the world as a single market, creating substantial uncertainty in the competitive situation by bringing about fundamental changes in the traditional boundaries of nations, industries, and companies. In addition, such changes continue to challenge the conventional rules of competition (Voelpel, *et al.*, 2004) .

According to Baltzan (2010), competitive advantages (CAs) can be defined as "possessing a product or service that customers value more highly than functionally-similar offerings from its competitors". From another perspective, Comparative Advantage, Cost advantage, and Differentiation Advantage refer to the firm ability to generate goods or services at a lower cost compared to other competitors, allowing the organisation to minimise price to enable the competition to develop a more significant margin on sales and services (Baporikar, 2014). Companies are experiencing substantial pressures from increased levels of competition, speedily changing market needs, higher levels of technical obsolescence, shorter product lifecycles and the heightened importance of meeting the needs of progressively sophisticated customers (Shepherd & Ahmed, 2000). Therefore, organisations have to build new competitive advantages for future growth. Consequently, organisations must be able to research and develop innovative processes, considered among the factors causing competition and change (Fongsuwan et al., 2017).

Tidd *et al.* (2005) and Meesapawong (2013) considered innovation as a top priority to sustain competitive advantages in many countries. Innovation is recognised as a process that includes embodying a novel idea into a usable product or service to gain a competitive advantage in the global market (Nagano, *et al.*, 2014). Additionally, introducing and maintaining continuous change can signify competitive advantages in terms of cost reduction, increment in products' life cycles, increase in sales and a global market perspective (Alfaro-García, *et al.*, 2017).

Further, scholars argue that to meet rapid transformations, one needs to ensure that one's products or services remain functionally superior to the competition; defining a functionality-focused and perceptions-focused competitive advantage also requires innovation within the organisation. This more conscious innovation management model could incorporate Porter's Five Forces, three generic strategies, and systems capable of anticipating value chains. However, despite several researchers' views that conscious processes of innovation management will be required to innovate for the market systematically, researchers such as O'Brien and Marakas (2011) suggest that innovation remains wholly dictated by market forces. Furthermore, organisations can follow one of five basic competitive strategies specified by Porter (2008): "cost, leadership, differentiation, innovation, growth, and alliance".

Besides, within this paradigm, an organisation must follow five basic competitive strategies: cost leadership, differentiation; innovative systems for growth; and alliance formation (Bakhshinejad, 2014; William., 2016; Diran, 2017). Teece (2010) further elaborates that strategy formulation "coping with competition" In contrast, the dynamic capabilities are about "shaping competition itself" - through "selecting and developing technologies and business models that build competitive advantage through assembling and orchestrating difficult-to-replicate assets." Furthermore, BM is the relationship between top management and their customers (Holm & Andersson, 2017).

Similarly, Urabe (2018) observes that it is frequent in the early stages of a new industry that radical product innovation is the most widespread form of Innovation. In contrast, the cumulative effect of incremental innovation through minor changes in established products seems to have a more critical economic impact on protecting competitive advantage; hence, innovation is a significant driver of growth and sustainable competitive advantage for organisations (Shepherd & Ahmed, 2000). The Global Competitiveness Report was presented in a special edition of 2020 at the World Economic Forum. The Global Competitiveness Index (GCI) contained in the report has continued to evolve along with the latest economic thinking, society's needs, and technological developments. However, there are priorities for economies across three timeframes: those of the last decade as revealed by time-series data on competitiveness factors, presented in section 4: "Reviving and transforming the innovation ecosystem." (Klaus & Saadia, 2020) ,Table 4.3.

Table 4-3 Reviving and transforming the innovation ecosystem

	Trends and Crisis Impact From the financial crisis to the pandemic crisis	Revival Priorities for the next 1-2 years	Transformation Priorities for the next 3-5 years
Reviving and transforming the innovation ecosystem	Entrepreneurial culture was strengthened in the past decade but has not resulted entirely in creating new firms. There is a lack of sustained creation of breakthrough technologies. Where there has been innovation, it has not been widely successful at delivering solutions to increasing energy consumption, managing emissions and meeting the demand for inclusive social services.	Expand public R&D investments; incentivise venture capital, R&D in the private sector, and the diffusion of existing technologies that support the creation of new firms and employment in "markets of tomorrow".	Incentivise and expand patient investments in research, innovation and invention that can create new "markets of tomorrow". Incentivise firms to embrace diversity, equity and inclusion to enhance creativity

To conclude, it can be noted that the competitive advantage built through the innovation process is a consequence of business growth, which generates speed and produces efficiency gains through sharing resources and services. Business model innovation is a source of value creation and competitive advantage; managers can thus target emerging markets more efficiently. In a way, the experts or future entrepreneurs can guarantee the competitive advantage of their schemes by promoting the appropriate knowledge, enhancing performance, and following-up business model innovation.

4.3.5. Business Model (BM)

Business model (BM) has flourished since the end of the 90s in managerial studies, specifically with the beginning of the internet and its massive adoption of e-commerce. BM is crucial to any organisation; it furnishes a powerful approach to understanding, analysing, communicating, and managing strategically oriented choices (Hamrouni, *et al.*, 2018).

Generally, the concept (BM) refers to two different uses that can be identified. The first defines what we might call a static approach; the expression is 'model', establishing coherence between its core components. The second use represents a transformational approach, considered a concept or tool to address change, focusing on innovation (Demil & Lecocq, 2010). In contrast, there are mainly two core components of a business model. The first is the basic unit of business, which is the building block of any strategy because it refers to what customers pay for. The second is an organisation's process or operational advantage, which yields performance benefits to enjoy superior efficiency or effectiveness on the key variables influencing its profitability (Mc Grath, 2010). Nevertheless, a business model definition consists of four interlocking elements that create and deliver value (Porter, 2008).

According to Joan (2002); Chesbrough, (2007); Fehling, *et al.*, (2013) the functions of the business model are as follows:

a) Articulating the value proposition, the value created for users by the offering.
b) Characterising a market segment: the users to whom the offering is valuable and for what purpose.
c) Identifying the value chain structure required by the company to create and circulate the offering and to determine the complementary assets needed to support the organisation's position in this chain.
d) Specifying the revenue generation processes for the business and approximating the cost structure and profit potential of producing the offering, provided the value scheme and value chain structure are selected.
e) Describing the company's position within the value network (an ecosystem) linking suppliers and customers, including identifying potential competitors.
f) Formulating the competitive strategy that the innovating firm will gain an advantage over.

A business model articulates the customer value proposition, the means to create that four values, the network of partners needed and the approach to capture some of the value for the firm (Smart, *et al.*, 2016), Figure 4.8.

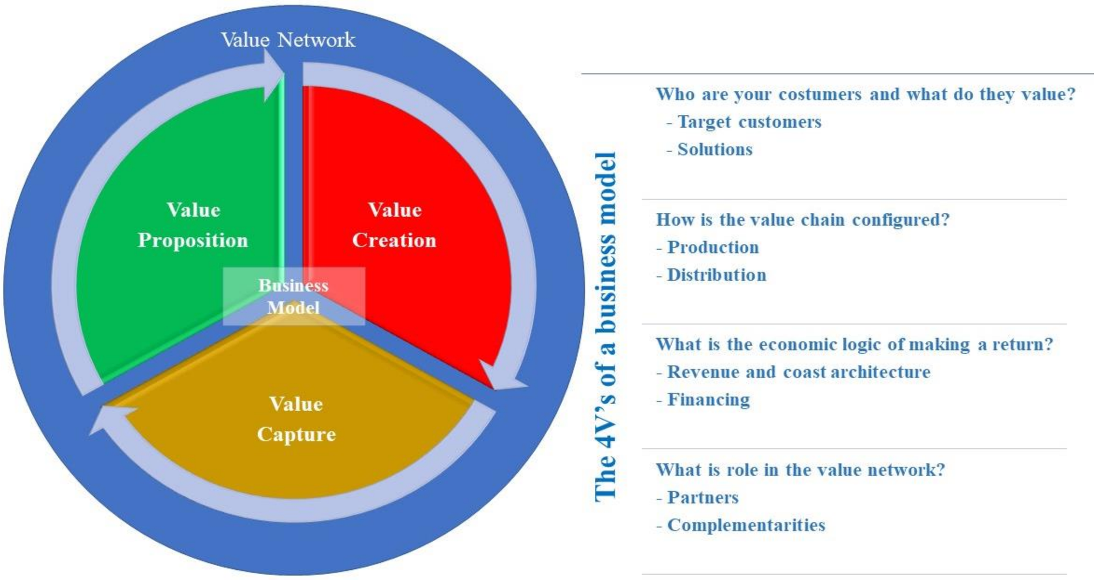

Figure 4-8. The 4V's of Business Model: Cambridge Business Model Innovation Research Group (CBiG) (Smart et al., 2016)

Most of the existing literature has accepted a static view, forgetting that business models may be topics to change; they must be thus treated as dynamic concepts (Frankenberger et al., 2013). The unique perspectives are that a continuum between minor, incremental improvements to existing business models led to more radical advances that fundamentally challenged predominant business models within the industry (Schaltegger, *et al.*, 2012; Pedersen, *et al.*, 2018). At this point, a Business Model Innovation (BMI) can be defined as a novel approach to creating, changing, and capturing value in a time of high environmental unpredictability (Spieith, 2013). At the same time, BMI is a central issue in management practice (Abdelkafi & Pero, 2018); thus, it has a high priority in the future agendas of managers (Zott, *et al.*, 2011).

BMI is a new approach for a company to do business and gain money (Frank, *et al.*, 2019a). Moreover, academics regularly classify BMI by giving illustrations of fundamentally new techniques of doing business from successful companies such as Apple, Hilti, and Southwest Airlines (Abdelkafi & Pero, 2018). The most outstanding scholars argue that BMI should be a function of corporate strategic entrepreneurship (Cucculelli & Bettinelli, 2015) intended to establish a direct link between customer intimacy, operational excellence, and product leadership (Dahan et al., 2010). SMEs are considered the driving force in most economies, responsible for employment, innovation, and growth, as often argued by the Organization for Economic Co-Operation and Development (OECD), the European Union, and national governments (EASME, 2015).

A host of leading universities operating in "Cambridge, Exeter, and IFM management technology policy" has identified essential attributes and configurations that reinforce competition with the dominant model (and new entrant alternatives). Three apparent propositions are inferred: (Smart, *et al.*, 2016):

1. A business model is a holistic, contextualised design of attributes (and activities) representing value proposition, value creation, and value capture.

2. Business model innovation seeks to identify unique configurations of business model attributes to compete with the dominant and new entrant models.

3. Disruption is how a new business model acquires the customers and beneficiaries of the dominant model or creates new markets.

From the sustainability point of view, the viable business model in terms of innovation is a complex and multifaceted phenomenon; thus, it's essential to understand its various manifestations (Pieroni, *et al.*, 2019); sustainable business models generally aim to integrate economic, social and environmental aspects in their value creation and value capture processes (Geissdoerfer et al., 2020). Sinkovics *et al.*, (2021) identified eight types of business model innovation Table 4.4.

Table 4-4 Different business models are related to the sustainable business model innovation concept adapted.

Sustainable Business Model Manifestations	**Definition**
Sustainable business model	A business model that aims to increase positive effects (and/or) significantly reduce adverse effects on the environment and society by indicating how an organisation and its networks create, deliver and capture value (Lüdeke-Freund et al., 2018)
Base (bottom) of the pyramid business model	A business model aims to simultaneously alleviate poverty and increase profitability by developing radical innovations to cater to the needs of the poor and other vulnerable communities (Prahalad, *et al.* 2012)
Circular business model	A business model built on a circular economy aiming to achieve circularity across the business model, a vertical view (value proposition, value creation & delivery, and value capture) and a horizontal view (cycling, extending, intensifying, and dematerialising) (Geissdoerfer et al., 2018) and (Geissdoerfer et al., 2020)

Lean and green business model	A business model inspired by the lean philosophy, aiming to maximise customer value by minimising waste (Balocco et al., 2019)
Product–service system	A business model with tangible products and intangible services jointly aimed at maximising customer satisfaction and fostering sustainability (Arnold, 2004)
Sharing economy business model	A business model facilitating temporary access to an underutilised product by mediating between resource owners and resource users via a sharing platform (Curtis & Mont, 2020)
Social business model	A business model that aims to achieve social goals by generating tangible and intangible social value and increasing the relational and mutual interactions among market participants (Jabłoński & Jabłoński, 2019)
Integrative business model	An integrative business model that balances all three aspects of sustainability (Kleine & von Hauff, 2009)

4.3.6. Stakeholder Engagement (SE):

Stakeholder engagement research has typically focused on the conceptual and theoretical development. Scholars have defined stakeholder engagements (SE) in the different connections in the business field. Greenwood (2007) defines stakeholder engagements as "practices that the organisation undertakes to involve stakeholders positively in organisational activities." He separates stakeholders from corporate responsibility, a purely moral attitude and considers engagement practices as strategic efforts through which "an organisation responds to the needs of stakeholders to further the organisation's goals" (Greenwood, 2007). Notwithstanding, many academics define stakeholders as "a group or individual who can affect, or is affected by achieving a corporation's purpose" (Freeman, 2010; Ghassim & Bogers, 2019). Moreover, the research has provided insight into stakeholder engagement in organisational activities, such as value creation, strategic planning and decision-making, innovation, learning and knowledge creation, reporting, corporate social responsibility (CSR) and sustainability (Kujala et al., 2022).

4.3.6.1. Stakeholders within Corporate Social Responsibility

From a Corporate Social Responsibility (CRS) perspective, the Stakeholder concept is one of the ubiquitous scientific and practical instruments related to CSR issues. Moreover, SE has also been considered a powerful method to facilitate interactive shared learning processes capable of promoting transformative actions and social change to build and maintain a robust reputation in the market (Cosma et al., 2021) . Manetti (2011) stresses the importance of organisations respecting stakeholders' opinions in preparing sustainability reports; CSR activities must consider all the stakeholders of an organisation; also, the best means for organisations to obtain stakeholders' views is to engage them in sustainability reporting (Manetti, 2011). Thus, organisations have realised that their business's success depends on their level of accountability to a broad group of stakeholders by providing commercial, social and environmental information (Tegofack, 2021). Moreover, scholars emphasised the need for transition to a new management thinking based on the idea of the stakeholders (Antonova et al., 2018).

4.3.6.2. Stakeholders within the sustainability of Economics

Sustainability is one of the most critical challenges of our time. The augmentation in size and significance of social and environmental challenges has made it inevitable for organisations to integrate aspects of sustainability. The primary strategic focus is on either profit-seeking or services; as a result, that led to the emergence of a corporate sustainability perspective, which proposed economic, environmental and social sustainability as pathways to gain a competitive advantage (Ghassim & Bogers, 2019; Cosma *et al.*, 2021; Tegofack, 2021). Sustainability ultimately improves the competitive organisation's position in the market (Pedersen et al., 2021). Enhancing competitive advantage requires input from different stakeholders with various backgrounds. They must work simultaneously with the other skills and knowledge they possess. As such, they contribute to improving the levels of exploitation which involves understanding the essential stakeholders (Frankenberger & Sauer, 2018).

The relationship between innovation and sustainability has received significant attention from private and government research organisations. On the one hand, it is argued that true environmental sustainability is incompatible with the process and value chain behind consumer-focused products; consumers' incentives would need to change for such organisations to achieve sustainability and competitive advantage simultaneously (Nidumolu & Rangaswami, 2005). Nevertheless, strengthened stakeholder relationships can become a significant competitive advantage in trust, reputation, responsibility, and innovation (Ayuso et al., 2011). Additionally, some researchers have reported that engaging in proactive relationships with their stakeholders will also help integrate the obtained stakeholder perceptions into their organisational innovation process from a sustainable development perspective (Kujala et al., 2022).

4.3.6.3. Stakeholders within Innovation

In ‘the real world,’ each stakeholder can impact size and scope differently. Today, there are many more new stakeholders. In our digital society, new stakeholders in social media such as "Face-book, Twitter, and LinkedIn" can substantially impact corporations. In the context of rising social and environmental push, innovation is one primary means for companies to achieve sustainable development. However, pursuing additional sustainable products, processes, and business models will demand fundamental changes in traditional innovation approaches (Ayuso et al., 2011; Song et al., 2015).

Furthermore, innovation can be a critical business activity to stimulate economic growth (Wu, 2013). The intrapreneurial and entrepreneurial ecosystem makes it a perfect haven to launch innovations in products and services to create value for all associated stakeholders, including companies, collaborators, and customers (Blok *et al.*, 2015). Provasnek *et al.* (2017) among other academics suggest that learning how to create shared value for companies and stakeholders presents the best opportunity for businesses to ensure operations and success in the long term. Shared value aligns companies' and stakeholders' concerns by merging social, eco-friendly, and economic processes. Likewise, achieving consensus among stakeholders about the purpose of innovation can be seen as a challenge because of multiple stakeholders' diverging visions, goals, motives, and values (Baporikar, 2014; Blok *et al.*, 2015).

Typically, stakeholders are more needed, as stakeholders' expertise and experience act as sources for new ideas; they establish a coordinative and drawing platform that gathers all relevant opinions from stakeholders and ensures that they are appropriately used in the innovation process (Song et al., 2015). In this context, there is growing belief that stakeholders can be essential sources of innovation for businesses, and research on innovation investigates how organizations can take advantage of that (Rogers, 2010); thus, stakeholder engagement in innovation management is a chore of developing a significant outcome. Hence, organisations comprehend planning and implementing the innovation processes necessary to achieve sustainable competitive advantages through stakeholder engagement (Leonidou et al., 2020). It can be asserted that innovation is the direction and scope of an organisation over the long term, which achieves advantage for the organisation through its configuration of resources within a future challenge to meet the needs of markets, fulfilling stakeholder expectations and sustaining competitiveness.

4.3.6.4. Stakeholder standard process (AA1000)

The Institute of Social and Ethical Accountability has developed a process standard AccounAbility1000 (AA1000), and defined stakeholder engagement as "the process used by an organisation to engage relevant stakeholders for a clear purpose to achieve agreed outcomes" (Ferrero-Ferrero et al., 2018). This standard involves stakeholders in identifying, understanding and responding to sustainability issues and concerns and reporting, explaining and answering to stakeholders for decisions, actions and performance (Greenwood, 2007; Ayuso *et al.*, 2011; Provasnek, *et al.*, 2017). In addition to this fundamental standard for an effective SE process, the AA1000SES (AccountAbility 1000 Stakeholder Engagement Standard), most lately published in 2015 (Albornoz & Diego, 2017) (AccountAbility, 2015), identifies four stages of this process: planning, preparation, implementation, and activation as well as reviewing and improving engagement. This standard is based on the following three main principles (Slabbert, 2016; Albornoz & Diego, 2017; Antonova *et al.*, 2018; Venturelli, *et al.*, 2018; Liu, *et al.*, 2022) , Figure 4.9:

1. Inclusivity/ completeness: completeness stipulates that organisations should understand stakeholder concerns related to their material issues, including understanding and managing relevant impacts and relevant opinions and needs of stakeholders and their perceptions and expectations, and facilitating broad involvement leading to balanced and determined results in strategies, plans, and actions.
2. Materiality: it emphasises that the organisation and stakeholders' material concerns should be known; it refers to the relevance of organisation issues and their stakeholders that could affect an organisation's decisions, actions, and performance.
3. Responsiveness: it stresses that there should be coherent responses to the identified stakeholder and organisational concerns, the organisation's response to stakeholder issues through decisions, actions, and results, as well as communication with stakeholders. As a result, it is expected to establish new policies, objectives, and achievements; governance structures, processes, and systems; action plans, measurement, and performance monitoring (Albornoz & Diego, 2017).

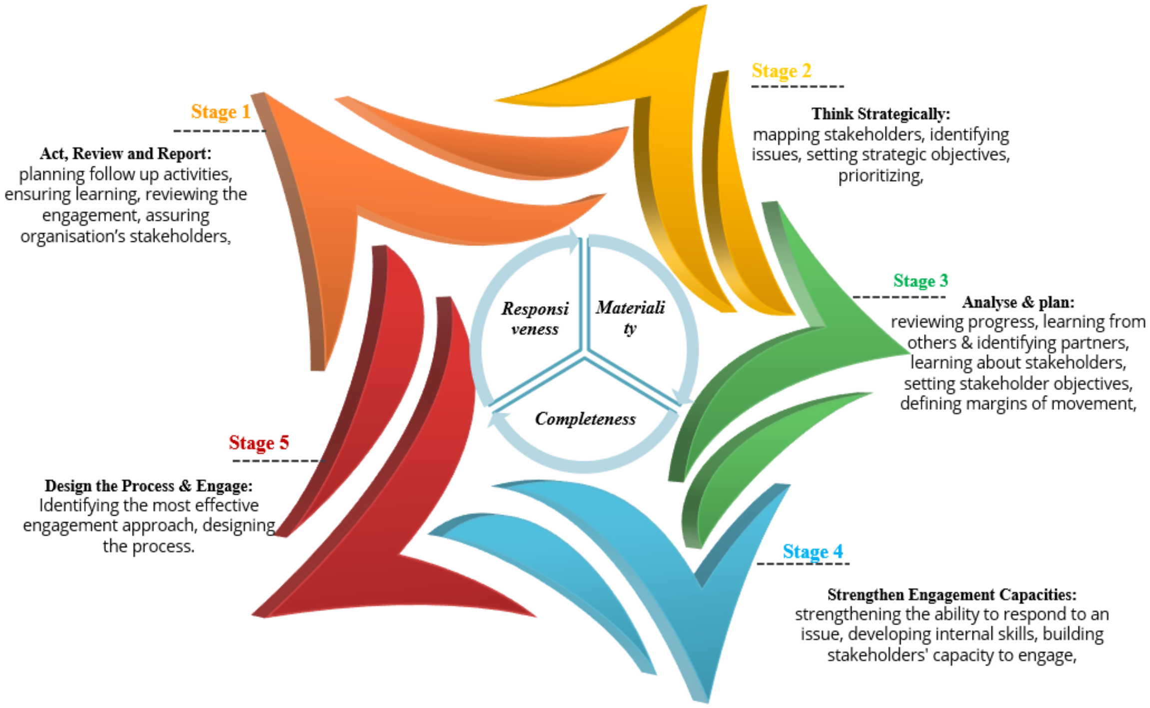

Figure 4-9. The five stages of effective stakeholder engagement. This figure is adapted from Albornoz & Diego (2017),

4.3.7. User Demands-Innovation

Existing research has indicated that user innovations can become significant and even lead the market. Several users create innovations from scratch, while others, known as creative consumers, adapt and modify current product offerings (Pongtanalert & Ogawa, 2015). The user demand diversity gain builds on the users' diverse throughput demand (Jin *et al.*, 2018; Wouters, *et al.*, 2018). Baldwin & Hippel (2011) have developed the zones of viability for single users, collaborating users, and product innovation users. Users and producers vary in their benefits from innovating, design, communication, production, and transaction in terms of costs.

Therefore, users and producers have overlapping sets of viable innovation opportunities (Baldwin & Hippel, 2011). Innovation users and producers are thus two general "practical" relationships between innovator and innovation; therefore, researchers consider user innovators as individuals in households that expect to benefit from pursuing innovations via their use of innovation (Bengtsson & Edquist, 2020). To distinguish between business and government sectors, households are regularly viewed as consumers in the economy: "A household is defined as a person who shares the same living accommodation, which pools some, or all, of their income and wealth and who consumes certain types of goods and services collectively" (Young, 1993).

Furthermore, much R&D shows that collaboration with user-innovators yields commercial success for companies. Thus, certain user-innovators established their own companies as their innovation grew widely and gained popularity; this is evidence of users' innovation capabilities and contribution to society (Pongtanalert & Ogawa, 2015). In contrast, users often voluntarily share information or reveal their innovations to colleagues, manufacturers, and competitors in the user-centred paradigm (Baldwin & Hippel, 2011). Classic examples of user innovation by shoppers include innovative products, in which the proprietary offerings of firms are adapted and improved upon by consumers, who then freely contribute to these innovations with other users (Bogers, *et al.*, 2015). The participation of the community in the R&D process offers other advantages for practitioners because the community's reaction to innovation can help firms predict the commercial attractiveness of user innovations (Pongtanalert & Ogawa, 2015). Present research has indicated that user-innovators, especially those belonging to communities, have a high potential to adapt their innovations widely and to collaborate with firms looking for new product ideas because these users often disclose their innovations (Van Der Boor, *et al.*, 2014). However, national surveys in Japan and the US reveal that those ideal figures are challenging to find. Merely 18% and 11% of user-innovators in the US and Japan revealed their innovations.

Additionally, approximately 10% of user-innovators in both countries belonged to communities, and less than half disclosed their innovations (Ogawa & Pongtanalert, 2012). From a practical viewpoint, Europe has focused on public and private linkages by placing citizens at the heart of the innovation process (European Commission, 2013). To achieve their target, the European Commission (EC) has, since 2006, been promoting Living Labs (LLs). LLs are innovative instruments that offer opportunities for testing, validation, development, and co-creation at all stages of a design and commercialisation progression by synchronizing the innovation processes among the actors of the QHM. In other words, LLs have been proposed as a possible platform for quadruple helix innovation (Leminen et al., 2016).

Furthermore, LLs became a part of a transformative institutional change that draws on top-down and bottom-up strategies to pursue innovation sustainability (Compagnucci et al., 2021). Consequently, they are a practical methodology for improving sustainability in cities by facilitating collaborative learning and innovation, responding directly to the users' needs (Van

Geenhuizen, 2019). User innovation has to meet two conditions of the innovation definition ‘new or significantly improved’ and ‘introduced on the market (Gault, 2019). The importance of user innovation has primarily been demonstrated through the efficiency of product development and benefits for national economies.

Moreover, a particular aspect of the user-innovation studies is the diffusion channels that user innovators choose to share and to commercialize their findings (Fursov, *et al.* 2017). From the perspective of Boor *et al.* (2014), user innovations in developing countries have successfully diffused to industrialized countries (Boor, *et al.*, 2014). The presence of official statistics gives an entry point for the development of innovation policy which is now focused on promoting innovation in the business sector. User innovation a decade ago considered the impact of two significant changes: digitalisation and the introduction of a general definition of innovation (Escobar et al., 2021). Digitalisation goes beyond the use of computers and the internet to include ways in which computer services are provided and the impact of artificial intelligence and the internet of things (Compagnucci et al., 2021). Subsequently, reviews of user innovation a decade or longer ago and a discussion on user innovation in the digital economy, where it is going in the future, and the policy effects of user innovation are encouraged (Füller, *et al.*, 2013). From another point of view, the character of digital technologies link various types of user innovation and entrepreneurship and the inter-firm collaboration between user-generated ventures and executive businesses (Escobar et al., 2021).

4.4. Digitalisation-push

Digitalisation is the most phenomenon topic in the 21st century; digital technologies have significantly influenced talent management and human resource systems. Moreover, according to Coroam & Matten (2019), digital technologies are predicted to overshadow the past century's industrial revolutions and are projected to disrupt social practices and employment formats (Coroam & Mattern, 2019). Furthermore, digital transformation is becoming a topic of academic and business concern worldwide; it is essential to distinguish between the terms” digitalization”, which denotes the conversion of analogue products to digital ones and the resulting changes, and “ digital engagement”, which covers topics extending from social media to more specific issues such as using digital data and technologies by individuals or organisations to systematise data management and rationalize processes, and “digital transformation” ; it is a new concept used by researchers, consulting firm professionals and directors; so it can be understood as changes the digital technology causes or influences in all aspects of human life from different means (technology tools, organisational processes, social aspects) (de Bem Machado et al., 2022).

Digitalisation can be understood as converting analogue into digital information processing in a technical sense. However, this may be too short as this view mainly encompasses a technological perspective. Furthermore, digitalisation is understood as digital technologies that create measurable added value (Laudien & Pesch, 2019). Digitalisation goes beyond the use of the computers and the internet to include ways in which computer services are provided considering the impact of artificial intelligence and the internet of things (Gault, 2019). With the specular user interface of the ongoing digital revolution, the holy grail of the efficiency revolution gets yet another new finish. By digitalising, almost every aspect of production and consumption, one can boost the organisation efficiency even more (Zuo, *et al.*, 2021), optimising entire industry sectors, public and government organisations, transport, and agriculture. Furthermore, digitalization can further enable more environmentally desirable solutions, which would be too complex to achieve or manage, such as the smart electrical grid (Coroam & Mattern, 2019).

Indeed, digital innovation-led organisations progressively utilise different disciplinary teams to address the multidisciplinary problems associated with highly integrated technologies (Tiwari, *et al.*, 2017). Moreover, digitalisation makes businesses act rapidly in a short time frame where there is a need to modify entire strategies and cultures, creating key performance indicators to measure digital marketing, personalising and encouraging innovation in digital marketing. Technologies and innovation go hand and hand; they present a positive focus for digital transformation and innovation in line with the aims of the current study (Ullah et al., 2021). However, within the organisational Context, a global survey of automotive decision-makers conducted by Friedemann (as cited in Sundermeier, 2019) suggests that the ability of an organisation to remain agile within the modern market now also requires actively leveraging the latest Information and Communication Technology (ICT) systems to enhance existing ‘analogue’ processes that contribute to the organisation’s competitive advantage.

However, the essential digitalisation push elements in the new generation framework have linkages and interdependencies, as illustrated in Figure 4.10 which is followed by detailed explanation of its contents.

Figure 4-10. Digitalisation-push

4.4.1. Industry 4.0

Industry 4.0 was introduced by a German initiative of the federal government during the Hannover Fair event of 2011, which symbolised the beginning of the fourth industrial revolution (Qin, *et al.*, 2016); Industry 4.0 is recognized as a modern industrial platform whereby there is an integration between manufacturing operations systems and information and communication technologies (Dalenogare et al., 2018). This integration results add value to the whole product lifecycle in the development of factories that are "Smart"; therefore, researchers introduced I4.0-related keywords known as ***Smart manufacturing***, ***Smart production***, ***Smart factory***, ***Cyber-physical system***, ***Cloud manufacturing***, and ***Internet of Things*** (Kamble, *et al.*, 2018). From another perspective, intelligent manufacturing technologies work as the central pillar of internal operations activities, while innovative products consider the external value-added of the product as the core of the I4.0 concepts; both scopes have their roots firstly in the progressive manufacturing systems and their connections with other processes and procedures of the company (Frank, *et al.*, 2019).

Additionally, Empirical evidence reveals that operational architecture, barriers, procedures and abilities must be compatible with innovative technologies to have a meaningful effect on external information development and its eventual use for innovation (Yoon *et al.*, 2019, Salge *et al.*, 2012 and Foss, *et al.*, 2011), Yoon *et al.* (2019) introduced a study of business model innovation in industry 4.0, using ANP method. At the same time, Stentoft *et al.*, (2019) observed that empirical facts regarding the adoption of industry 4.0 are still scarce and present limited aspects towards the judgments of the position of industry 4.0 implementation. On the one hand, despite the new technologies that characterize industry 4.0 – including the robotic automation of workers, driverless vehicles and artificial intelligence – the risks and threats from these technologies can distract many observers from the radical boost in productivity they represent. Moreover, such technologies are crucial for tackling the challenges that will threaten humanity within the next century (BCG Worldwide, 2019). Figure 4.11 provides the time line of industry 4.0.

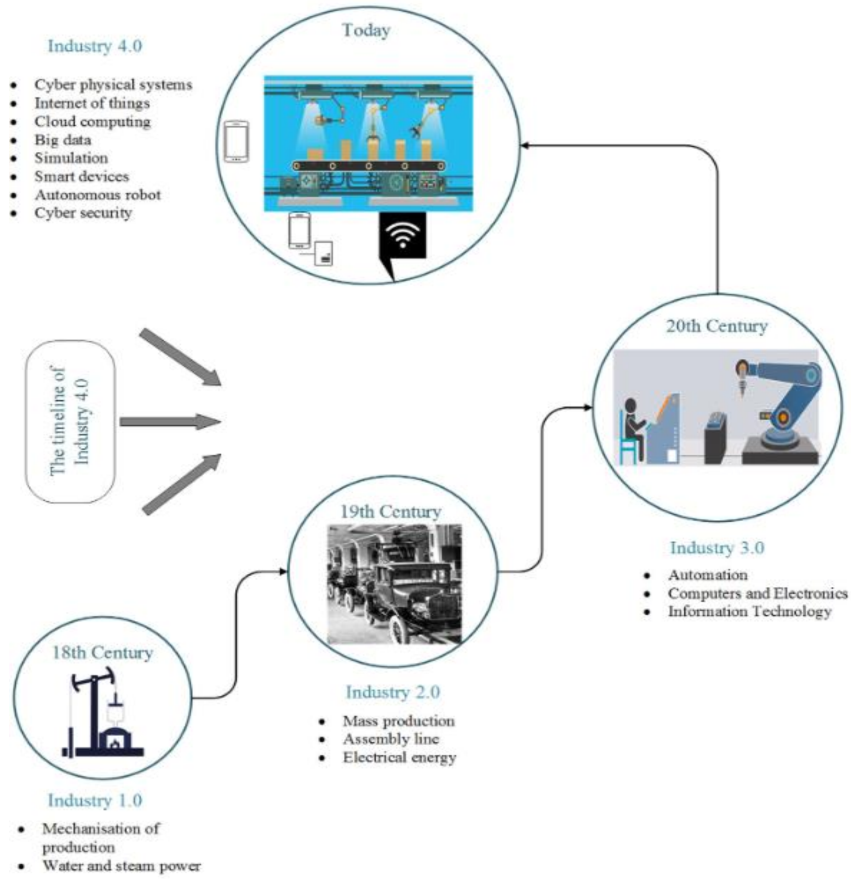

Figure 4-11. The timeline of industry 4.0 (Karatas et al., 2022)

The nine widely reported and leading technologies that are currently being developed to transform industrial production could be incorporated into a new digital innovation framework; they are summarised in the following sub-sections:

4.4.1.1. Autonomous Robots

Worldwide, companies consider robots as systems and technologies efficient for improving the industrial process making it more competitive in the market. Innovative robots are exemplified as systems offering autonomy, flexibility, versatility, and collaboratively by completing a given task precisely and intelligently within the given time limit; in particular, they will interact with one another and perform the interaction with humans safely, supporting the workers' activities (Vaidya, *et al.*, 2018). For example, during the global pandemic *Covid-19*, advanced countries included collaborative robots as a technology of the intelligent working dimension. Consequently, the artificial intelligence technology strategy was released to transform society's future needs (Czimmermann et al., 2021). Automated manufacturing solutions should be a core feature in many operations intended for optimum performance, protection, and competitive advantage; moreover, production robotics automate routine jobs and decrease error margin to nominal rates (Javaid et al., 2021).

4.4.1.2. Big data analytics

Big data analytics indicates organisations' systemic and computational analysis ability of big sets, popularly characterised by 5Vs (volume, velocity, variety, veracity and value-adding) (Shukla, *et al.*, 2019). Big data analytics (BDI) has the potential to transform and advance industrial and service systems in future. Moreover, BDI can support industries in making informed decisions such as better predictions for products, performance management across various manufacturing and service units (Moktadir et al., 2019); besides, improving the quality of products and services, providing greater visibility onto operations and insight into the customer predilection and buying patterns (Haseeb, *et al.*, 2020) in order to analyse real-time data across different manufacturing process phases and product design, collecting a detailed design, procuring, selecting suppliers and outsourcing policies, product warehousing, maintenance, recycling, and identifying labour errors (Fahmideh & Beydoun, 2019).

Although it has been widely recognized that applications of I4.0 technologies can bring many benefits, SMEs have been cautious about using big data; research reveals that, while 78% of SMEs have adopted I4.0 technologies, only 2% use big data (Sari & Santoso, 2020). From another point of view, consultants consider that big data analytics can help SEMs become more agile and flexible in providing customised solutions (products or services) by acquiring strategic information from the production process or segmented customer engagement. Figure 4.12 presented a data science platform for data capturing, pre-processing, mining and using the analytics results to decide on collaboration (Han & Trimi, 2022)

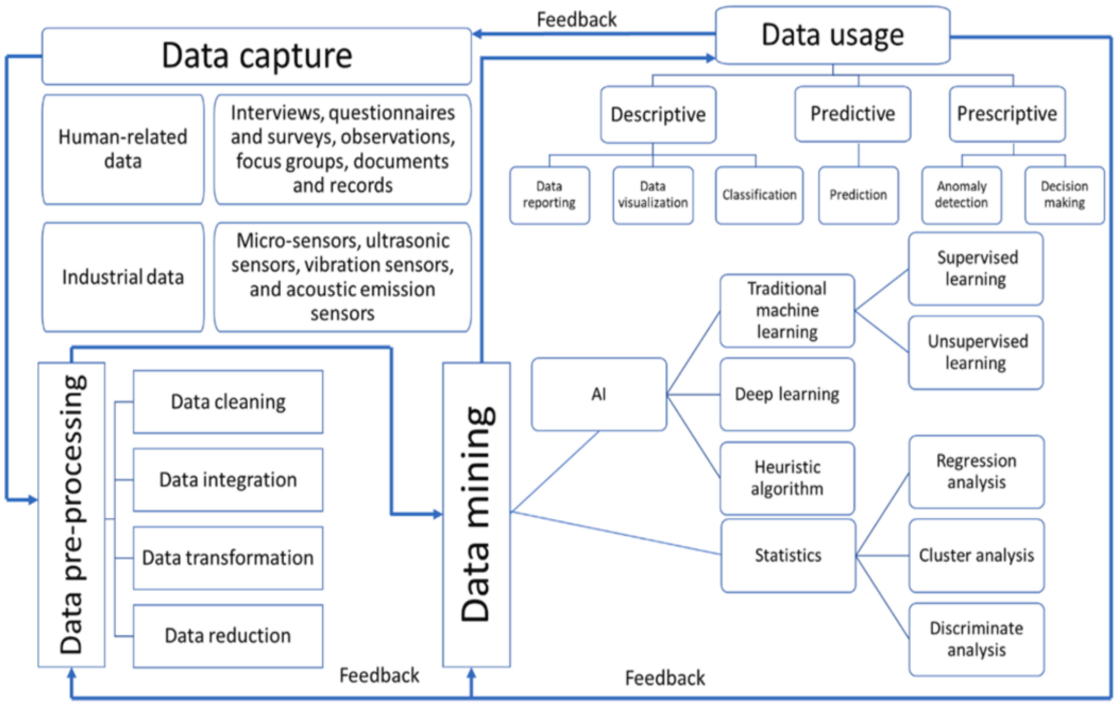

Figure 4-12. Overview of big data platform (Han & Trimi 2022)

4.4.1.3. Additive Manufacturing (AM)

Additive manufacturing is another phase apart from instant prototyping reinforcing rapid manufacturing. It quickly manufactures any complex shape part, which other traditional manufacturing processes could not. It supports more significant designs, manufacturing easy to create innovation in industry 4.0 (Gürdür & Asplund, 2018, Haleem & Javaid, 2018). AM "is the capability to create a physical object from a digital encoded design through material deposition via a 3D printing process"(Gartner, 2022). More specifically, based on Standard terminology for additive manufacturing technologies, AM is "a process of joining materials to make objects from 3D model data, usually layer upon layer, instead of subtractive manufacturing methodologies" (ASTM, 2012).

Hence, AM is extensively used to produce small collections of customized products that offer construction advantages, such as complex, lightweight designs. The high-performance, decentralized additive manufacturing systems will also reduce transport distances and stock on hand and promote sustainable production (Vaidya, *et al.*, 2018, Frank, *et al.*, 2019a). There are a variety of techniques used in additive manufacturing technologies: Stereolithography (SLA), Selective laser sintering (SLS), Fused deposition modelling (FDM), Direct metal laser sintering (DMLS), Polyjet 3D printing (PJP), Inkjet 3D printing (IJP), Laminated Object Manufacturing (LOM), Colour-Jet-Printing (CJP), Multi-Jet-Printing (MJP) and Electron Beam Melting (EBM) (Haleem & Javaid, 2018).

4.4.1.4. Augmented Reality (AR)

Augmented reality (AR) can be characterized as a facet that enriches the real world with virtual objects generated on a computer which look as if they exist in a similar location to the real world (Karnik et al., 2021). AR supports workers with interactive and real-time guidance for the critical actions of the tasks (Frank, *et al.*, 2019a). Moreover, AR content may require a redesign of infrastructures by using unique knowledge of interface design, modelling in 3D, spatial tracking and programming (Mourtzis et al., 2018). In order to remain competitive, engineers and researchers have been attempting solutions toward intelligent manufacturing by utilizing technologies such as Virtual Reality (VR), Augmented Reality (AR) technologies, Artificial Intelligence (AI), Internet of Things (IoT) and Industrial Digital twins (Lai et al., 2020). Moreover, in recent years, smart glasses emerged that use embedded transparent displays to overlay computer graphics onto the actual environment, creating a realistic super-reality (Ras et al., 2017).

4.4.1.5. The cloud computing

Cloud-based IT platform is a technical backbone for connecting and communicating various aspects of the application centre industry 4.0 (Vaidya, *et al.*, 2018). Cloud computing is broadly recognised as the fifth efficiency after water, electricity, gas, and telephony; it has been proposed as the latest computing parading (Buyya et al., 2009). Cloud technology with adaptable solutions is aligned with the most advantages of digital manufacturing to meet customer demand (Haghnegahdar, *et al.*, 2022); The intelligent factories of the future will rely upon modern computer models, such as mobile and interactive systems interlinked. Moreover, artificial intelligence, cloud computing, and data processing can also enhance the reliability of industrial robotics (Javaid et al., 2021). Consequently, manufacturers focus on resource optimization and cloud-driven facilities adaptation by looking for a more agile approach for system innovation to process support via the cloud (Rodriguez, *et al.*, 2022). A third-party organisation offers a cloud computing service that makes virtual resources available via the internet, which leads to superior security and performance and also generates economies of scale and the accessibility of more significant resources (Han & Trimi, 2022).

4.4.1.6. Internet of Things (IoT)

The IoT is a new industrial ecosystem that combines intelligent and autonomous machines, advanced productive analytics, and machine-human collaboration to improve productivity, efficiency, and reliability (Wong, & Kim, 2017). Moreover, it is also a concept in which the virtual world of information technology integrates flawlessly with the real world of things, which is more available across computers and network devices in business and common human scenarios (Liu, 2018). Context, Omnipresence and Optimization are the three key features of IoT. *Context* refers to the possibility of advanced object interaction with immediate response to any changes, and *Omnipresence* provides information on an object's location and physical or atmospheric conditions. *Optimization* demonstrates that today's objects are more than just linked to a network of human operators at a human-machine interface (Vaidya, *et al.*, 2018, Xu, *et al.*, 2018).

4.4.1.7. Cyber Security system

With increased connectivity and standard communication protocols with industry 4.0, protecting critical industrial systems and manufacturing lines from cyber security threats increases considerably (Dalenogare et al., 2018). Cyber-security highly depends on ethical practices followed by individuals and companies; there are precisely six strategic principles of cyber-security (*confidentiality, integrity, availability, authenticity, nonrepudiation, and privacy*) (Karnik et al., 2021).

Consequently, secure, reliable communications, sophisticated character, and access management of machines and users are essential (Vaidya, *et al.*, 2018). Thus, Cyber security refers to the processes and availability of technologists with the needed skills that protect information and computer technology systems, such as networks, systems, programs, devices and data (Hassoun et al., 2022).

4.4.2. Knowledge Management (KM)

Knowledge management is related to organisation success since Nonaka and Takeuchi's (1995) SECI model on knowledge management introduced a set of four core processes (socialization, externalization, combination, and internalisation) (Siu Loon Hoe, 2006). Nonaka promoted the difference between "*tacit*" and "*explicit*" knowledge and developed the well-known spiral of organisational knowledge creation, illustrating conversations between these knowledge forms (Walsham, 2001). That showed its importance to the success of Japanese organisations in terms of the creation of organisational knowledge (Emiliano *et al.*, 2022). Organisational knowledge is defined as the ability of a company to generate new knowledge, making it comprehensive and to integrate it into products, services, and systems (Xin et al., 2021). Additionally, knowledge significantly impacted organisational performance, followed by knowledge utilisation and acquisition (Phayaphrom, *et al.*, 2022).

Knowledge management involves obtaining and communicating ideas and information that underlie innovation competencies (Adams, *et al.*, 2006). Further, KM assists in building competencies required in the innovation process; thus, organisations must use sufficient information to verify the level of business activities and to make educated business decisions. This information comes from various internal and external sources, and their credibility is crucial to providing sufficient knowledge (Horn & Brem, 2013). KM researchers have investigated the relationship between knowledge and innovation (Migdadi, 2022); knowledge plays a significant role in innovation, enabling the sharing and codification of tacit knowledge; on the other hand, knowledge sharing is critical for organisations' innovation capability (Carneiro, 2000, Tamer *et al.*, 2003). The role of KM in innovation is that knowledge is a resource used to reduce complexity in the innovation process (Obeso et al., 2020); consequently, innovation is highly dependent on the availability of knowledge (du Plessis, 2007). According to Saunila (2014), organizational innovation enhances the organisation's value, and it involves changes in the routines of firms planning to improve the efficiency, productivity, profitability, flexibility and creativity of the firm using intangible knowledge.

Many companies and institutions accept the importance of knowledge management and knowledge for the forthcoming movements of business and society. For instance, the Europe 2020 report sets out a vision of the social market economy of Europe in the 21st century. One of the main concerns is to promote moderate growth, which consists of developing an economy based on knowledge and innovation. Such reasonable development requires, among other things, the advancement of innovation and the transfer of knowledge, the full use of information and communication technologies and the provision of the transformation of innovative ideas into new products and services (European Commission, 2010).

Moreover, using knowledge analysis, organisations can predict future events to make more precise decisions and compete with other organisations (Giménez-figueroa et al., 2018). KM is illustrated as one of the most critical aspects of digital transformation (de Bem Machado et al., 2022). According to Wang (2018), digital transformation can drive the establishment of a knowledge-based economy; this covers the way for industry 4.0, referred to in the first sub-criteria in digitalisation-push.

4.4.3. Artificial Intelligence & Decision Support System (AI & DSS)

Artificial intelligence (AI) has been gaining significant attention in various fields to reduce costs, increase revenue, and improve customer satisfaction. AI is the "*bio-psychological potential to process information. to solve problems or create products that are of value in culture*" (Fithian, 2001). It is also described as" *a set of techniques for modelling and simulation of environmental systems, which includes artificial neural networks, fuzzy models, reinforcement learning, cellular automata, and meta-heuristics*"(Chen, *et al.*, 2008). It has been recently identified as" *a domain of computer science relating to the simulation of intelligent behaviour in computers*"(Carvajal *et al.*, 2019). " *a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation*"(Kaplan & Haenlein, 2019). According to the European Commission's High-level Expert Group on AI (AI HLEG), transparency is one of the essential requirements for trustworthy AI (Amann *et al.*, 2022).

AI is a family of powerful technologies that are incredibly well capable of providing innovative structures for business process re-engineering (Dirican, 2015 , Giménez-figueroa *et al.*, 2018); it is also embedded into business processes to support humans by intelligent agents or to drive them out of the process and replace them with fully automated solutions. From another perspective, AI can be interpreted as the ability of the computer or robot to reduce human intelligence in the form of software and algorithms (Rojek & Studzinski, 2019).

On the other hand, the term Decision Support System (DSS) was coined by Keen and Scott Morton (1978) to signify the other features of information processing, namely the provision of information for supporting management decision making; it was defined as " *the* *application of available and suitable computer-based technology to help improve the effectiveness of managerial decision making in semi-structured tasks*" (Er, 1988). Earlier researchers emphasised that AI accelerates automated decision-making through various technologies, such as intelligent agents and planning. Furthermore, on the opposite side, builders of expert systems must choose the most applicable artificial intelligence techniques; and developers must focus on the organizational and operational attributes of the decision support system (Kahn, 1994). Based on that approach, DSS is characterized as an intelligent information system that facilitates the time in which decisions can be made and the consistency and the quality of decisions (Kose et al., 2021).

Besides, AI techniques are increasingly applied in various fields; the most crucial area are the clinical decision support systems that assist healthcare professionals in predicting outcomes (Amann *et al.*, 2022). Thus, from that perspective, researchers emphasized that AI helps process varied information such as (threats involved, anatomical information, histories of disease, the economics of patients, and could make better forecasts of surgeries) (Manickam et al., 2022). That example of the transformative impact of AI as a vector of innovation is the subject of the extreme theoretical and analytical production process with the capability to generate value by applying analytical or decision-making techniques and tools (Miguel, *et al.*, 2022). Therefore, AI proposes opportunities to improve operational efficiency and to speed up innovation by driving perceptions from enormous data sets and predicting unexpected outcomes; it is a development of considerable importance across many industries (Lee *et al.*, 2019 and Åström, *et al.*, 2022).

Moreover, the Manufacturing Execution Solution Association (MESA) defines groups of functions which require adequate decision support for production management: (1) detailed planning, (2) resource management, (3) registration and display of the current status of resources, (4) document management, (5) material management, (6) performance analysis, (7) order management, (8) maintenance management, (9) process management, (10) quality management, (11) data collection and acquisition and (12) product tracking and genealogy (Ehrlich et al., 2018).

4.4.4. Open Networking

The network has been conceptualised from different perspectives. In previous years, Thorelli (1986) described a business network as a long-term relationship between two or more organisations. According to Powell (1987), the network is an intermediate transactional form that combines market and hierarchy and requires cooperative behaviour. In contrast, nowadays, researchers consider network management in data-centre telecommunication and cloud computing domains, evaluating its suitability for future-proof industrial network management systems (Ehrlich et al., 2018).

Networking and innovation are crucial aspects of the digital era; networks are considered one of the most promising contexts for Industrial Symbiosis (SI). It also could be channelled whereby new ideas towards sustainability might be developed; the identity as an IS network needs to be established first as a precondition for any further sustainability-oriented IS networks. Innovation is also believed as a vital aspect of IS development for providing new supporting technologies [(Bell & Giuliani, 2007, Posch, *et al.*, 2011 , Taddeo *et al.*, 2017). In addition, firms could accelerate innovation within a business network by increasing and expanding network contact, considering network density; variety are prospective combined with better innovative capabilities (Xu, *et al.*, 2008). Moreover, the authors described networking, cooperation, social capital and spatial proximity that are the key components of group learning processes and the innovativeness of organizations, regions and nations (Fitjar & Rodríguez-Pose, 2014). The Responsible Research in Business and Management (RRBM) network developed a 2030 vision, in which business schools and international scholars will have converted their research, focusing on responsible science and the production of reliable knowledge that contributes to addressing the real-world problems important to business and society (Paper & Knowledge, 2020**;** Chapman *et al.*, 2020).

Nevertheless, the fifth innovation model, namely the *Network Model* (1990-2000), emphasises knowledge collection and external linkages, systems integration and extensive networking. In addition, this model offers innovation as a distributed networking process based on corporate alliances, partnerships, joint enterprises and government support (Şimşit, *et al.*, 2014). In parallel, researchers predicted that business model innovation under networking in the internet of things IoT will be an important area in the future (Jin & Ji, 2018), and that will be linked to how open networking is a crucial aspect of digitalisation-push.

4.4.5. System Integration (SI)

Over the world, organisations are employing different standardised Management Systems (MSs). Researchers have attempted to find approaches to light up the new requirements executed by economic globalisation, so they developed and implemented several management systems such as quality management systems, information management systems, environmental management systems, and occupational health and safety management systems. According to the International Standardization for Organisation (ISO), the global number of organisations that are executing and verifying their organisations with the MSs has been developed to meet the requirements of their different involved parties to improve their efficiency (Rebelo, *et al.*, 2016). Moreover, ISO seizes the opportunity to suggest system integration as a route to sustainability. A further proposal is that public policies for industry development consider integration to promote sustainability (Martí-Ballester & Simon, 2017, Poltronieri, *et al.*, 2019). Many studies on the integration of management systems focus on integrating quality, health, safety, environmental, and information security management systems (Asif et al., 2009). Integrating management systems is the best practice when an organization has multiple MSs (Mežinska, *et al.*, 2015)**.**

Moreover, integration can be defined as "putting different function-specific management systems into a single and more effective integrated management system (Beckmerhagen et al., 2003). From a top-management perspective, integration has to be significantly committed to all MSs and their integration (Bernardo et al., 2017). Furthermore, integrating multiple management systems brings the most diverse advantages to the organization, which can convert into a more efficient organisational activity, enhancing business performance (D. Maier et al., 2017). Therefore, many researchers categorize the integration of MSs as a type of innovation as it is the case with other quality management practices and performance (Bernardo, 2014).

The proposed experimental framework for 5G wireless system integration into industrial applications, aimed at providing service to industries; it is motivated by the lack of digitalization reference models considering in-depth wireless performance integration and performance; further, looped runs of the operational flow which focus on the robots overall 5g control which reflects industry 4.0 and digital transformation (Rodriguez et al., 2021). I4.0 is considered a socio-technical paradigm that depends on further development, access, and integration of information and communication technologies with automation technologies to promote end-to-end systems integration across the entire value chain; it is a collective term for technologies and concepts of value chain organisation (Oztemel & Gursev, 2020).

4.4.6. Simulation Modelling (SM)

A model is a system used as a substitute for another system. Models can enable researchers to study how a prospective system will work before the natural system has even been built to mitigate risks. Machine modelling and simulation emerged from the construction of electrical computers in the 1940s when computational tools for creating models for system simulation became available (Fang, *et al.*, 2012 , Rojek *et al.*, 2021). Simulation is a tool applied to create a system model on the computer that allows for experimentation without negatively impacting the natural system (Pawlewski, 2018). From an organizational structure perspective, simulation of structure, performance and functions is enhanced to be realistic, thus promoting the product's model quality and success rate for one-time development (J. Zhou, 2013). Simulation modelling is conducted to gain insight into complex systems, assessing new operating or resource policies and new concepts or systems before implementing them (Chryssolouris, *et al.*, 2004). With the advent of Industry 4.0, digitalisation has played a crucial role in future creation. Further research on cutting-edge digital technologies reflects its actual impact on simulation; likewise, augmented and virtual reality simulations have arisen to simulate product designs before production (Nee et al., 2012). Simulation techniques play significant roles because they offer the possibility to evaluate multiple I4.0 scenarios through planning and examining models of complex systems, which can support addressing partly problems (de Paula Ferreira, *et al.*, 2020).

There are many helpful simulation tools for manufacturing system development. Thus, simulation tools are more dynamic regarding interactions between service levels and potential revenue generation (Trebuna, *et al.*, 2019). In addition, studies showed that simulation enabled fast prototyping and easily implemented autonomous components; another information exchange is facilitated by integrating systems with manufacturing equipment through different communication methods (Oztemel & Gursev, 2020). Simulation optimization runs an intelligent brain to improve the productivity of manufacturing systems; depending on the variety of difficulties to be analysed. There are various optimization techniques in combination with simulations that can be exercised in the I4.0 paradigm, which are considered the main sub-criteria of digitalisation push (Karnik et al., 2021).

4.4.7. Information Technology (IT)

Information technology is "a process that uses a set of means and methods of processing and transmission of primary information to obtain information of a new quality about an object, process, or phenomenon", which ranges from the form of information presented to the formation of its content (Nepsha, 2003). Based on the literature review, the fifth generation of the innovation model, namely the network model, attempts to demonstrate the benefits of computerizing the innovation process through complex information technology systems (İzadi, *et al.*, 2013). Innovations through IT are referred to as IT innovations; thus, innovations are needed to reach a higher organisational maturity towards a specific IT type and to locate new value creation opportunities, (Fukas & Thomas, 2021).

Moreover, IT includes vital components of modern infrastructure, with extensive applications throughout global economies, which play a crucial role in productivity, organisational infrastructure, and international cooperation in finance employment (Kurniawati, 2020). However, companies pursue innovation from their existing partners in their value chains. Recently, companies must expand their partnerships from existing ones to various sources such as universities, think tanks, consultants, crowd-sourcing platforms, start-ups, and innovation labs (Yuana et al., 2021). Many researchers have examined how IT affects various aspects of the economy, including the market, firm productivity, and social networks (Lee & Sasaki, 2018). Further, while considering the relationship between economic growth and innovation, the role of information communication technology (ICT) cannot be disregarded; some researchers revealed that there are three ways that ICT can positively affect growth by: (1) developing the diffusion of innovation, (2) enhancing the quality of decision – making by organisations and stakeholders, and (3) reducing production costs thereby increasing output levels; thus, economics might also influence innovation (Pradhan *et al.*, 2017, Olalekan & Grobler, 2020). Furthermore, ICT is a set of actions and rules related to the preparation, processing, and delivery of information for personal, mass and industrial communication, as well as all technologies and industries that integrally support the listed processes; this is based on the cluster of five ICT indicators: telephone landlines (TEL), mobile phones (MOB), internet users (INU), internet servers (INS), and fixed broadband (FIB) derived through principal component analysis (Pradhan et al., 2017). Recently, researchers asserted that managers must pay attention to designing and deploying appropriate operational alignment of the open innovation search approach with IT use to achieve their specific organisational innovation (Cui, *et al.*, 2022).

Japan's government was bringing changes to society and industry; it intended to leverage ICT to its fullest to gain new knowledge and to create values by connecting “people and things” and “ real & cyber.” to be an effective and efficient means of resolving issues in society through Society 5.0, identified in the part A (*Demand-Pull*) (Mayumi, 2018). Digital transformation is about investment in information communication technology (ICT) for operational changes to become more efficient. European countries have announced their I4.0 strategy of developing technology roadmaps and research agendas. Consequently, Industry 4.0 intends to intensify the digitalization of manufacturing processes and to supply chains, facilitating communication between humans, machines and products, thus enabling real-time access to product and production information for joining entities and the performance of autonomous work processes beside value chains (Santos et al., 2017). ICT facilitates the networked manufacturing systems, implying interoperable systems, information interchange and decentralized control and decision-making (Lee, *et al.*, 2021).

4.5. Conclusion

This chapter introduces the new proposed conceptual innovation framework; its construction comprises theories, methods and techniques and even working applications to analyse and improve organisational innovation management; it presents two parts of an innovation framework significantly enhanced by two main criteria: *Demand-Pull* and *Digitalisation-Push.* It is also an illustration that depicts the sub-criteria regarded as relevant to this framework. Part (A) considers seven sub-criteria for *Demand-Pull,* which illustrates the causality between economic growth, organisations' demands, and faster product development with various accesses to the market and innovation in the presence of other future variables. It enhances success indicated by sustainable industry and firms growth; it contains Socio-Economic Trends, Sustainable Development Goals, Society 5.0: (*Science, Technology & Innovation Strategy*), Competitive Advantages, Business Model, Stakeholder Engagement, User Demands-Innovation. Simultaneously, Part (B) provides a systematic and significant integration of seven essential digital perspectives, explaining the positive digital transformation, which plays a crucial role in production, process, procedure, and fresh global stimulus.

The performance of this part is primarily based on the intensive industry's digital era. It displays a significant positive relationship between digital aspects and organisational innovation, which includes Industry 4.0 “Autonomous Robots, Big Data Analytics, Additive Manufacturing, System integration “Horizontal & vertical system integration, Simulation, The Cloud Computing, Internet of Things (IoT), Cyber Security system”, Knowledge management, Artificial Intelligence & Decision Support System, Open Networking, System Integration, Simulation modelling and Information Technology. Digitalisation is the main innovation path which inspires new ideas and approaches developed to boost the performance of industries and organisations.

Chapter 5

Data Analysis, Results and Discussion

5.1. Introduction

This chapter presents the analysis of data obtained from seven international countries: the UK, UAE, USA, Canada, Germany, China and Japan. As pointed out earlier, the proposed framework is validated via a comprehensive questionnaire administered by practitioners from each of the specified seven countries using the Analytical Hierarchy Process (AHP), which could flexibly combine quantitative and qualitative methods. The impact of digitalisation-push and the demand-pull as main criteria, with many sub-criteria associated with each main criterion are also considered.

The global online survey was distributed to achieve the aim of this study which is to support organisations in managing change, improving and competing. This research also aims to set the innovation management programme for most industries to realize a long-term and sustainable future disregarding the size of the organisation or whether it is public/ government or quasi-government /third sector. These outcomes shape the new structure of the Innovation Framework in the following pages.

5.2. Data collection and Analysis

5.2.1. Data Collection

In April 2020, the author commenced collecting data despite the spread of the global Covid-19 pandemic, which affected everyday life: borders were closed, and international students returned to their home countries. Despite the unforeseen wide-ranging consequences of the pandemic, the researcher pursued her research non-stop to achieve her study goals. Replacing the data collection system and analysis was challenging. Nevertheless, she succeeded by using Expert Choice Software. The data collected was reviewed for completeness and accuracy. It underwent several stages of pre-analysis, such as error checking and data screening. The data was coded and fed into AHP software to measure the importance of competing objectives. A dedicated tool and proven mathematical techniques enable the researcher to obtain the best decision to reach a goal. Hence, using comparison AHP to develop an innovation framework will be explained further in the following sections.

5.2.2. Development of the proposed AHP innovation framework

As discussed in Chapter Four, AHP is one of the most popular multi-criteria decision-making methods to assess the AHP method and structuring, analysing a series of simple hierarchies pair-wise comparison matrices (Wind & Saaty, 1980). It also uses judgments of decision-makers to form the decomposition of problem complexity into an order (Kahraman, 2020), appraise and support the decision, considering various criteria by prioritising all available decision alternatives (Mahmoudi et al., 2020). Besides, the process of structuring a hierarchy involves: (*a*) stating a goal, (*b*) arranging criteria, and (*c*) adding sub-criteria. A problem's hierarchy structure could enable researchers to understand the interactions amongst elements and their impacts on the entire system. As can be seen in Figure 5.1, the IFW has been developed using the Expert Choice Software.

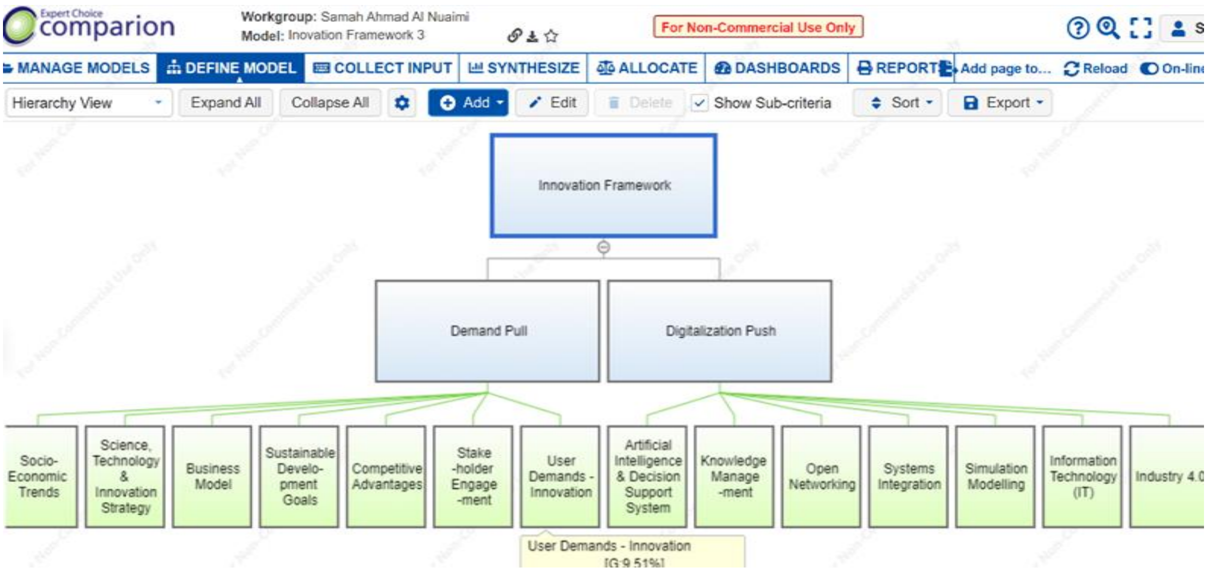

Figure 5-1. Developing innovation framework

Chapter Four presented a comprehensive review of the IFW, containing two main criteria (*Demand-Pull* and *Digitalisation-Push*). The *first* scheme presents seven comparison criteria along with those that advantage organisation demand and market effects. Additionally, the *second* scheme equalises the first with different orders most recommended in the digital era.

5.2.3. Results analysis of the data collected from the seven countries (Global)

As can be seen in Figure 5.2, the global exploratory questionnaire result shows, predictably, that the overwhelming majority (76.92%) of Digitalisation-Push (DI-P) is the most effective area of innovation criteria, followed by 23.08% of Demand-Pull (DE-P). The DI-P is the main criterion for an essential factor Industry 4.0 noticeably as the significant sub-criteria with 20.08%, whereas Artificial Intelligence and Decision Support Systems (A.I. and D.S.S) steeply went down by 14.47%; however, it still can be confirmed that A.I. and D.S.S became crucial to maintain life throughout the globe.

On the other hand, Information Technology (IT) is predicted as key to preserving life with 11.46%. Although Knowledge Management (KM) can be considered a crucial factor in any organisation, it falls dramatically to about 9.75%. Systems Integration (SI) is necessary to function successfully. Hence, the factor of 9.27%, which is lower than Knowledge Management (KM) by only 0.48%, indicates that it is a dynamic aspect for the organisations. Simulation Modelling (SM) has a factor of 9.02%, which is an essential function for all world industries; it falls just 0.25% below Systems Integration (SI).

However, while the last sub-criterion for Digitalisation-Push (DI-P), Open Networking (ON), was recorded at 8.13%, the sub-criteria of Demand-Pull (DE-P)'s main criteria appeared to reveal the User Demands-Innovation (U.D-I) with verified 4.88%. Nevertheless, the upcoming sub-criterion steadily decreased, as demonstrated by Sustainable Development Goals (SDGs) measuring 3.66%, Socio-Economic Trends (S-E.Ts) at 3.19%, while Competitive Advantages (CAs) measured 2.44%, respectively. Compared to the last three sub-criteria: Science, Technology and Innovation Strategy (S.T&I.S), the Business Model (BM) and Stakeholder Engagement (S-h E) shared a factor of 1.22% equally.

The global demand for Industry 4.0 is driven by a number of factors, including the need to increase efficiency and productivity, reduce costs, and improve product quality. The increasing use of IoT and data analytics in manufacturing, as well as the development of new technologies such as 5G networks and edge computing, is also driving demand. Additionally, the ongoing COVID-19 pandemic has accelerated the shift towards Industry 4.0 and digitalization across many sectors.

Another factor that drives the demand for Industry 4.0 is the shift of the global economy towards Industry 4.0 driven by the increasing global competition. Most of the companies are investing in the technology to stay competitive in the market and to be on the edge of innovation. This has also increased the demand for Industry 4.0 professionals across different sectors to implement and manage these advanced technologies.

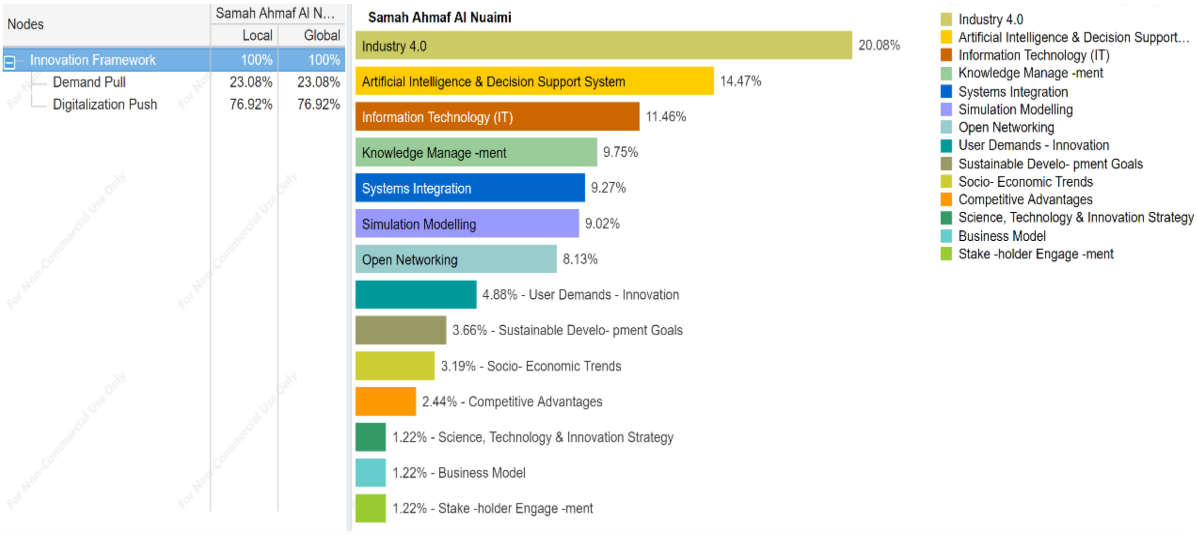

Figure 5-2. The priority weights of sub-criteria to global result

5.2.4. Results analysis of United Kingdom (UK) data

Figure 5.3 reveals that there has been a marked increase in the percentage of Demand-Pull (DE-P), which measures 56.00%, as opposed to Digitalisation-Push (DI-P), quantifying 44.00%, (DE-P) leads by some 12.00% more than (DI-P).

The most imperative factor that reached a peak regarding the sub-criteria is User Demands-Innovation (U.D-I), which deliberated 10.76%. In contrast, these measures are 1.7% more than the second most vital factor, Competitive Advantages (CA), ranked at 9.06%. Likewise, the third essential factor lies just 0.16% behind Competitive Advantages (CA), specifically Industry 4.0, quantifying 8.90%. Subsequently, determining 7.93% each is the three Socio-Economic Trends (S-E.Ts); Science, Technology, and Innovation Strategy (S.T&I.S); and Stakeholder Engagement (S-h. E).

These three factors lie in fourth place after User Demands-Innovation (U.D-I), Competitive Advantages (CA) and Industry 4.0. Following, at a percentage of 7.36%, is the Business Model (BM), which is slightly less by 0.57%, than the three equal scoring factors of Socio-Economic Trends (S-E.Ts); Science, Technology, and Innovation Strategy (S.T&I.S) and Stakeholder Engagement (S-h.E). The movement decreased gradually by 6.79% for Sustainable Development Goals. Similarly, just 0.12% below for Artificial Intelligence & Decision Support Systems (A.I. and D.S.S), which measures 6.67%. These two factors scored 0.57% and 0.69% less than BM. Following on from Artificial Intelligence & Decision Support Systems (A.I. and D.S.S), Knowledge Management (KM) has an element of 6.23%, just 0.44% smaller. Knowledge Management (KM) is followed by the two aspects of Simulation

Modelling (SM) and Information Technology (IT), measuring 5.78%. These two factors are just 0.45% less than Knowledge Management (KM).

Finally, with both quantifying and 4.45%, Open Networking (ON) and Systems Integration (SI) elements are 1.33% smaller than Simulation Modelling (SM) and Information Technology (IT). These criteria score some 6.31% less than the leading factor of User Demands-Innovation (U.D-I).

In the United Kingdom, user innovation has become increasingly important as small businesses and entrepreneurs have played an increasingly important role in driving innovation and economic growth. This is partly driven by the accessibility of technology and the growing availability of open-source software, which has made it easier for individuals and small groups to develop new products and services. Additionally, the UK government has been promoting innovation by investing in research and development and providing funding for startups and small businesses. This has helped to create a supportive environment for user innovation.

The increasing adoption of Industry 4.0 technologies such as IoT, artificial intelligence, and big data, has also been driving user innovation in the UK. For example, many small businesses and entrepreneurs are using these technologies to develop new products and services, such as smart home devices, and connected agriculture. However, one of the challenges that UK faces is the lack of trained professionals to implement and manage these technologies which creates a bottleneck for many innovative ideas.

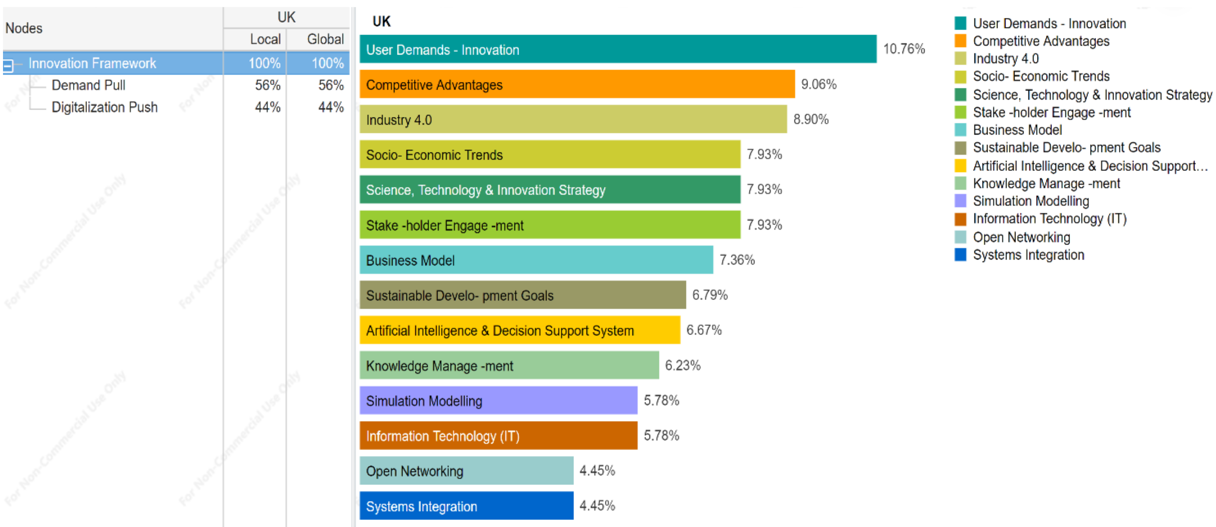

Figure 5-3. The priority weights of the sub-criteria to the UK result

5.2.5. Results analysis of the United Arab Emirates (UAE) data

Figure 5.4 demonstrates the results from the UAE's data. In the UAE, Demand-Pull (DE-P) measures 54.95%, whereas Digitalisation-Push (DI-P) measures 45.05%. Both measures are similar to those of the UK. As with the UAE sub-criteria, the leading factor measuring 11.53% is the User Demands-Innovation (U D-I). Interestingly, the UK, which benefits from advanced technology and education, shares the same leading factor as the UAE. The second most crucial factor with 10.35% is Industry 4.0, which is some 1.2% behind User Demands-Innovation (U.D-I). Artificial Intelligence and Decision Support Systems (A.1. and D.S.S) measures 9.0%, which is 1.35% lower than Industry 4.0. It should be noted that the following four factors all measure equally with a factor of 7.68%, namely Socio-Economic Trends (S-E.Ts); Science, Technology and Innovation Strategy (S.T.&I.S); Business Models (BM) and Competitive Advantages (CAs). These factors measure 1.32% below Artificial Intelligence and Decision Support Systems (A.1. and D.S.S). Measuring 6.59% each are Sustainable Development Goals (SDGs) and Stakeholder Engagement (S-h.E), 1.09% lower than the factors of Socio-Economic Trends (S-E.Ts); Science, Technology and Innovation Strategy (S.T.&I.S); Business Models (BM) and Competitive Advantages (CA). Following, Knowledge Management (KM) measures 6.3%, which is only 0.29% lower than the factors of Sustainable Development Goals (SDGs) and Stakeholder Engagement (S-h.E). Whereas Open Networking (ON), Systems Integration (SI), and Information Technology (IT) all measure 4.95%, some 1.35% below the factor of Knowledge Management (KM). Finally, Simulation Modelling (SM) shows that the bottomed-out factor quantifies 4.05%, which counts about 7.48% more than the leading factor of User Demands-Innovation (U.D-I).

User innovation is still a relatively new concept in the United Arab Emirates (UAE) and it has not been fully embraced by the government yet. But it is gradually gaining momentum as the government has been encouraging innovation and entrepreneurship in recent years, with a focus on technology and digitalization.

One of the main initiatives in the UAE to promote user innovation is the establishment of innovation centers and accelerators, such as the Dubai Future Accelerators and the Abu Dhabi Innovation Hub, which provides funding, mentorship, and resources to help startups and small businesses develop and commercialize new products and services. Also, the UAE government has been investing in infrastructure, such as 5G networks and data centres, to create an enabling environment for technology-based innovation.

The private sector also has played a significant role in driving user innovation, with companies in industries such as real estate, finance, and transportation investing in new technologies and business models to stay competitive. Additionally, the UAE is also home to many expats and entrepreneurs from all over the world, this has created a diverse and dynamic environment for new ideas and user innovation. However, it is still in the early days for user innovation in the UAE, with more work needed to be done to create a more supportive environment for user innovation, such as providing more funding, creating a legal and regulatory framework and increasing collaboration between the government, private sector, and the academia.

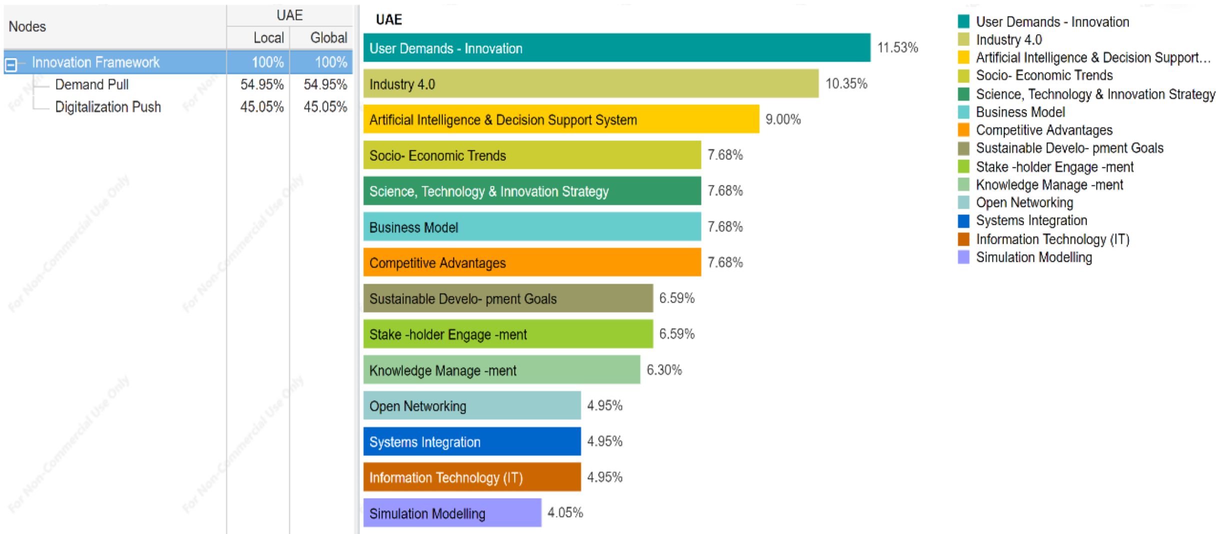

Figure 5-4. The priority weights of the sub-criteria for UAE result

5.2.6. Result analysis of the United States of America (USA) data

Figure 5.5 provides the outcomes from the USA’s data. Digitalisation-Push (DI-P) in the USA measures 52.49%, whereas Demand-Pull (DE-P) measures 47.51%. As shown in the sub-criteria, the significant factor in the USA is Industry 4.0, measuring 11.80%, which is higher than both the UK and the UAE. The second most essential criteria are shared by the Competitive Advantages (CA) and User Demands-Innovation (U.D-I), determining 8.00%, gradually lowering 3.80% to Industry 4.0. The criteria mentioned are followed by Systems Integration (SI) and Simulation Modelling (SM), both measuring 7.28%, just 0.72% showed down noticeably after Competitive Advantages (CA) and User Demands-Innovation (U.D-I). These are closely followed by Business Model (BM) and Sustainable Development Goals (SDGs), measuring 7.06%, merely 0.22% smaller than Systems Integration (SI) and Simulation Modelling (SM) factors.

Correspondingly, these two factors are very closely followed by Artificial Intelligence and Decision Support Systems (A.I. and D.S.S), measuring 6.91%, only 0.15% smaller than the Business Models (BM) and Sustainable Development Goals (SDGs) criteria. With a measurement of 6.86%, Knowledge Management (KM) lies just 0.05% lower than Artificial Intelligence and Decision Support Systems (A.I. and D.S.S). Following this, Information Technology (IT) measures 6.24%, which is 0.62% lower than Knowledge Management (KM), closely followed by Open Networking (ON) gauging 6.13% and Socio-Economic Trends (S-E.Ts) at 6.12%. Open Networking (ON) is 0.11% lower than Information Technology (IT), and Socio-Economic Trends (S-E.Ts) is just 0.01% lower than Open Networking (ON). The last two factors measuring 5.64% are Science, Technology and Innovation Strategy (S.T. and I.S) and Stakeholder Engagement (S-h. E), which are 0.48% smaller than Socio-Economic Trends (S-E.Ts).

Industry 4.0, also known as the Fourth Industrial Revolution, is an important trend in the United States, and it is being driven by a number of factors including advancements in technology, increased automation, and the growing use of data analytics. One of the major drivers for Industry 4.0 in the US is the manufacturing sector, where companies are looking to increase efficiency and productivity through the use of advanced technologies such as IoT, AI, and big data. This is leading to the creation of "smart factories" that are highly automated and connected, and able to make real-time decisions.

The US government also has been promoting Industry 4.0 through various initiatives such as The National Strategic Plan for Advanced Manufacturing and funding for research and development in advanced manufacturing technology. The technology sector also plays a major role in Industry 4.0 in the US, with companies such as IBM, GE, and Cisco investing heavily in IoT and AI. Additionally, many startups and small businesses are working on new technologies and applications for Industry 4.0 such as autonomous vehicles, 3D printing, and advanced robotics.

Furthermore, many leading American universities and research institutions are working on Industry 4.0 related research and development, which is helping to develop and expand the technology in different sectors. However, one of the main challenges that the US faces with Industry 4.0 is the need to develop a more robust cybersecurity infrastructure to protect the connected devices and systems. As well as the concerns of job displacement, lack of skilled workforce and lack of equal access to technology.

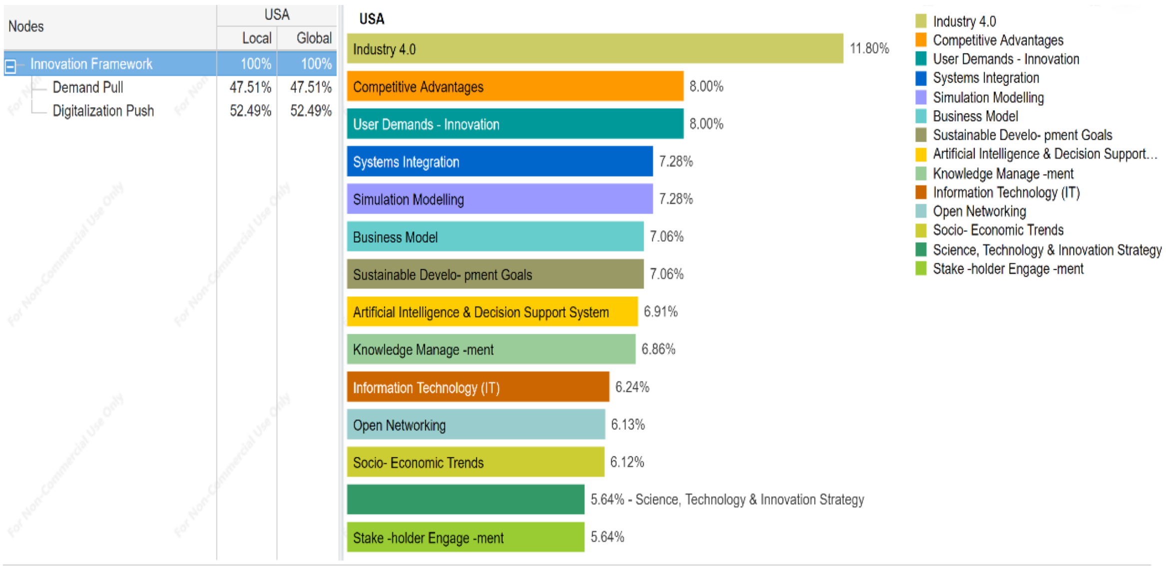

Figure 5-5. The priority weights of the sub-criteria to the USA result

5.2.7. Results analysis of the Germany data

Figure 5.6 shows that Digitalization-Push (DI-P) which dominated Germany's work failed by 56% as a primary criterion, whereas Demand-Pull (DE-P) measures 44%. On the other hand, this part illustrates the peak to the bottom percentage of sub-criteria. It can be observed that there was a significant measure of 12.06% for Industry 4.0, and therefore is the most critical factor in Germany; interestingly, it is similar to the USA. Open Networking (ON) reveals that the second most crucial factor measures 9.44%, which is just 2.62% lower than Industry 4.0. Sustainable Development Goals (SDGs) appear 1.20% to be lower than Open Networking (ON), measuring 8.24%. The data predicted that Artificial Intelligence and Decision Support Systems (A.I. and D.S.S) and Knowledge Management (KM) equally measure 7.87%, only 0.17%, which is not that far from Sustainable Development Goals (SDGs). Both Competitive Advantages (CA) and User Demands-Innovation (U.D-I) measure 7.42%, 0.45% lower than the two factors of Artificial Intelligence and Decision Support Systems (A.1. and D.S.S) and Knowledge Management (KM). Following, Information Technology (IT) measures 7.34%, which is just 0.08% lower than Competitive Advantages (CA) and User Demands-Innovation (U.D-I). Subsequently, Systems Integration (SI) measures 6.29%, which is 1.05% lower than Information Technology (IT). The final five factors are Science, Technology and Innovation Strategy (S.T. and I.S), measuring 5.77%; hence, Socio-Economic Trends (S-E.Ts) at 5.69%, then Business Model (BM) at 5.36%, Simulation Modelling (SM) at 4.72% and finally Stakeholder Engagement (S-h. E) at 4.53%. Just 1.24% separates the final five factors.

Germany is considered a leader in Industry 4.0, also known as the Fourth Industrial Revolution, due to its strong manufacturing sector and advanced technology infrastructure. The German government has been promoting Industry 4.0 through various initiatives and investments in research and development.

One of the main drivers of Industry 4.0 in Germany is the manufacturing sector, where companies are looking to increase efficiency and productivity through the use of advanced technologies such as IoT, AI, and big data. This is leading to the creation of "smart factories" that are highly automated and connected, and able to make real-time decisions. The German Industry 4.0 strategy focuses on the use of these technologies in the manufacturing sector.

The German government has been promoting Industry 4.0 by establishing national and regional innovation centres and clusters, such as the Fraunhofer Institutes, that provide funding, mentorship, and resources to help companies develop and commercialize new products and services. Another driver is the strong engineering and technology tradition in Germany which gives it an advantage in developing new technologies. The country's large automotive industry, for example, have been an early adopter of Industry 4.0 technologies and many of the technologies that are used today in industry 4.0 have been developed by the german industry and engineers

In addition, German universities and research institutions are working on Industry 4.0 related research and development, which is helping to develop and expand the technology in different sectors. However, one of the challenges that Germany faces with Industry 4.0 is the need to develop a more robust cybersecurity infrastructure to protect the connected devices and systems, as well as addressing the concern of job displacement and the need for a skilled workforce to implement and manage these advanced technologies.

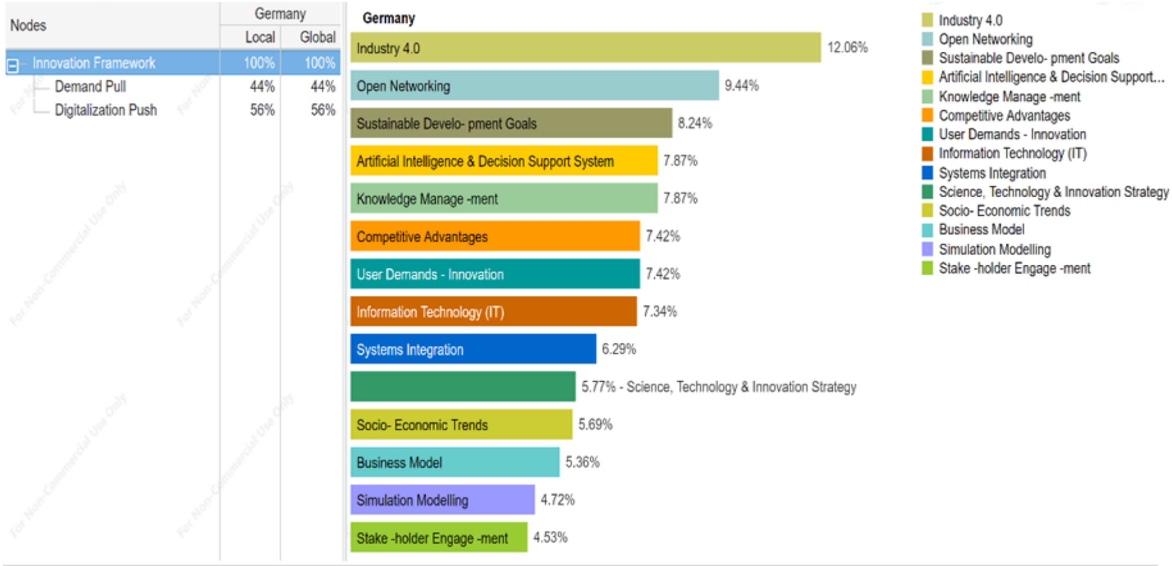

Figure 5-6. The priority weights of the sub-criteria to Germany result

5.2.8. Result Analysis of China Data

Figure 5.7 demonstrates that Digitalisation-Push (DI-P) was dominant in Chinese organisations with 53.62%, as a primary criterion, whereas Demand-Pull (DE-P) measures 46.38%. In likeness to USA and Germany, the leading factor in China is Industry 4.0, measuring 12.33%; by comparison, this is 0.27% higher than the advanced economy of Germany. The second most important criterion is User Demands-Innovation (U.D-I), measuring 9.74%, which is 2.59% lower than the leading factor of Industry 4.0., whereas Artificial Intelligence and Decision Support Systems (A.1. and D.S.S) is the third most important factor, measuring 9.12%; it is just 0.62% lower than User Demands-Innovation (U.D-I).

The fourth most crucial criterion, Systems Integration (SI), measures 6.97%, about 2.15% lower than Artificial Intelligence and Decision Support Systems (A.1. and D.S.S). Correspondingly, Socio-Economic Trends (S-E.Ts) and Competitive Advantages (CA) equally measure 6.49% each, which is just 0.48% lower than Systems Integration (SI). Close to these factors are the three criteria of Knowledge Management (KM), Open Networking (ON) and Simulation Modelling (SM), measuring 6.43%, which is just slightly lower by 0.06% than Socio-Economic Trends (S-E.Ts) and Competitive Advantages (CA). It differs from the three factors of Science, Technology and Innovation Strategy (S.T. and I.S), Business Model (BM), and Sustainable Development Goals (SDGs), which measure 6.03%, just 0.40% smaller than Knowledge Management (KM), Open Networking (ON) and Simulation Modelling (SM). The penultimate factor is Information Technology (IT), measuring 5.90%, which is only 0.13%

smaller than the three factors of Science, Technology and Innovation Strategy (S.T. and I.S), Business Model (BM), and Sustainable Development Goals (SDGs). Finally, the bottommost is Stakeholder Engagement(S-h.E) at 5.57%, just 0.33% lower than the factor of Information Technology (IT).

China is also a leading country in Industry 4.0, also known as the Fourth Industrial Revolution. The Chinese government has been promoting Industry 4.0 through various initiatives and investments in research and development.

The Chinese government's "Made in China 2025" plan is a key driver of Industry 4.0 in the country, which aims to improve the competitiveness of Chinese manufacturing by promoting the adoption of advanced technologies such as IoT, AI, and big data. This has led to the creation of "smart factories" in China, which are highly automated and connected, and able to make real-time decisions.

The Chinese government has also been promoting Industry 4.0 through the establishment of national and regional innovation centres and clusters, such as the National Engineering Research Center for Industrial Internet, which provide funding, mentorship, and resources to help companies develop and commercialize new products and services. Additionally, the Chinese economy has also been a key driver for Industry 4.0 by providing a huge market for innovative products and services as well as making huge investments in R&D to develop new technologies.

The Chinese technology sector is also playing a major role in Industry 4.0 in China, with companies such as Huawei, Baidu and Alibaba investing heavily in IoT and AI. Additionally, many startups and small businesses are working on new technologies and applications for Industry 4.0 such as autonomous vehicles, 3D printing, and advanced robotics.

However, one of the main challenges that China faces with Industry 4.0 is the need to develop a more robust cybersecurity infrastructure to protect the connected devices and systems as well as the concerns of job displacement and the need for a skilled workforce to implement and manage these advanced technologies.

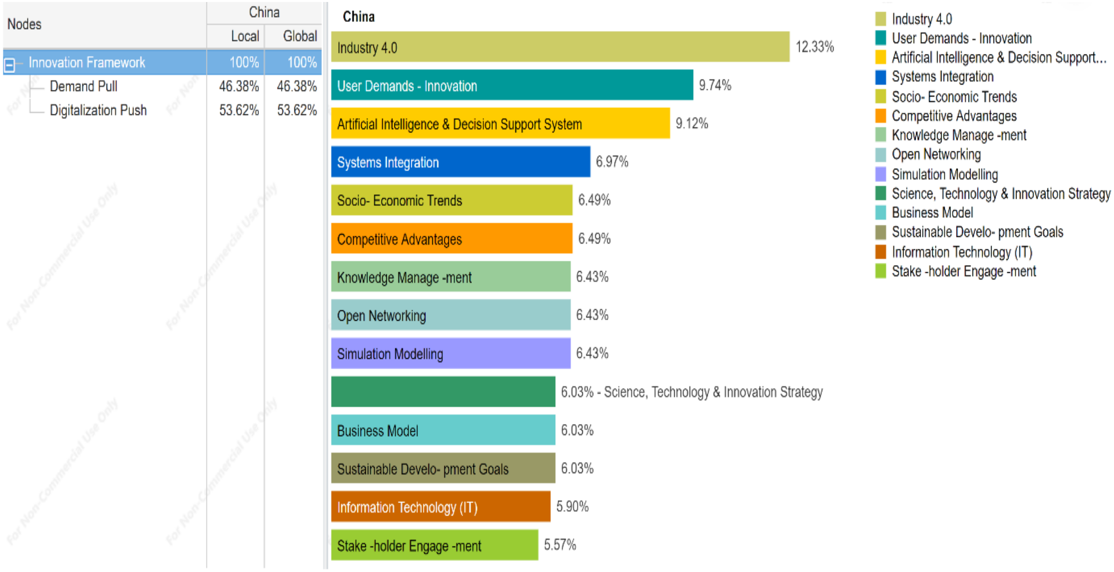

Figure 5-7. The priority weights of the sub-criteria to China result

5.2.9. Result analysis of Japanese data

The Japanese result Figure 5.13., shows that the main priority is Digitalization-Push (DI-P) by 51.9%, just a 3.8% dip from Demand-Pull (DE-P), measuring 48.1%. As with Germany, China, and the USA, the leading criteria in Japan is Industry 4.0, with 12.27%. The second most crucial factor is Open Networking (ON), calculating 11.78%, which is 0.49% smaller than Industry 4.0. Thirdly, the User Demands-Innovation (U.D-I) measures 10.92%; it is 0.86% smaller than Open Networking (ON). Following, Artificial Intelligence and Decision Support Systems, (A.1. and D.S.S) is the fourth most crucial factor, measuring 8.83%; it is just 1.19% lower than User Demands-Innovation (U.D-I). Furthermore, the fifth criterion is Sustainable Development Goals (SDGs), measuring 6.37%, some 2.46% lower than the factor of Artificial Intelligence and Decision Support Systems (A.1. and D.S.S). Nevertheless, Socio-Economic Trends (S-E.Ts); Science, Technology and Innovation Strategy (S.T. and I.S); Competitive Advantages (CA) and Stakeholder Engagement (S-h.E) measure 5.91%. These four factors measure 0.46% less than Sustainable Development Goals (SDGs) criterion. On the contrary, Knowledge Management (KM) measures 5.89%; it is only 0.02% lower than the previous four factors; however, a measurement of 5.40% is the penultimate factor of Systems Integration (SI), Simulation Modelling (SM) and Information Technology (IT). Finally, the bottommost is Business Model (BM), measuring 4.09%, which is 1.31% smaller than the three previous factors.

Japan is also one of the leading countries in Industry 4.0, also known as the Fourth Industrial Revolution. The Japanese government has been promoting Industry 4.0 through various initiatives and investments in research and development. One of the main drivers of Industry 4.0 in Japan is the manufacturing sector, where companies are looking to increase efficiency and productivity through the use of advanced technologies such as IoT, AI, and big data. This is leading to the creation of "smart factories" that are highly automated and connected, and able to make real-time decisions.

The Japanese government has been promoting Industry 4.0 through the establishment of national and regional innovation centers and clusters, such as the Advanced Industrial Science and Technology (AIST) and the Ministry of Economy, Trade and Industry's (METI) Promotion of the Industrial Internet of Things (IIoT) project, which provide funding, mentorship, and resources to help companies develop and commercialize new products and services. The Japanese technology sector also plays a major role in Industry 4.0 in Japan, with companies such as Panasonic, Mitsubishi Electric and Fujitsu investing heavily in IoT and AI. Additionally, many startups and small businesses are working on new technologies and applications for Industry 4.0 such as autonomous vehicles, 3D printing, and advanced robotics.

Moreover, Japan's strong tradition of robots and automation has led to the development of advanced robots and automation technologies, and it plays a key role in Industry 4.0. However, one of the main challenges that Japan faces with Industry 4.0 is the need to develop a more robust cybersecurity infrastructure to protect the connected devices and systems as well as the concerns of job displacement and the need for a skilled workforce to implement and manage these advanced technologies.

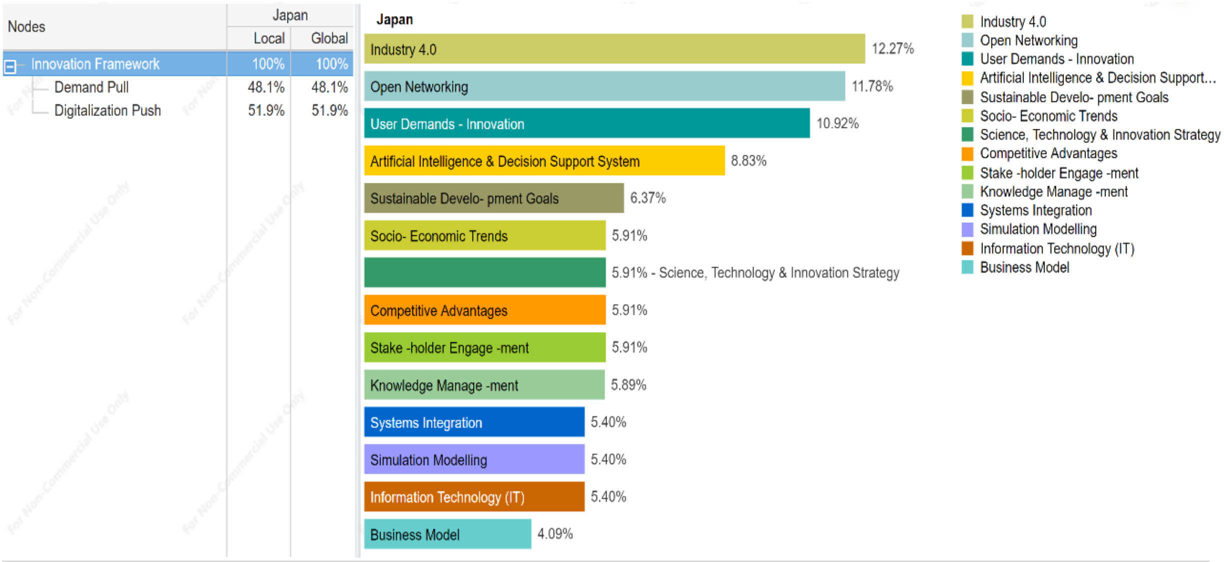

Figure 5-8. The priority weights of the sub-criteria for Japanese result

5.2.10. Result analysis of Canada data

Similar to the last four countries, Canada's data (Figure 5.9) shows that Digitalisation-Push (DI-P) is the main priority criteria accounting for 55.45%, compared to Demand-Pull (DE-P), measuring 44.55%. The significant sub-criteria Industry 4.0 is outstanding, with 13.20%. Next, Artificial Intelligence and Decision Support Systems (A.1., and D.S.S) scores 9.35%, almost 4% lower than Industry 4.0. In the third place is User Demands-Innovation (U.D-I), scoring 8.40%; closely followed by Knowledge Management (KM) which is 7.70%. In the joint fifth place are the three criteria of Open Networking (ON), Systems Integration (SI), and Simulation Modelling (SM), each scoring 6.60% equally. Next, come the three factors of Business Model (BM), Sustainable Development Goals (SDGs), and Science, Technology and Innovation Strategy (S.T. and I.S), each with a score of 6.19%. After these, Socio-economic Trends (S-E.Ts) are measured by 5.97%; in contrast, the score of 5.75% accounts for both Competitive Advantages (CA) and Stakeholder Engagement (S-h. E) equally, which is just 0.22% lower than that of S-E.Ts. Finally, Information Technology (IT) takes the last place with 5.50%, only 0.25% less than Competitive Advantages (CA) and Stakeholder Engagement (S-h. E).

Canada is also actively promoting and investing in Industry 4.0. The Canadian government has been promoting Industry 4.0 through various initiatives and investments in research and development.

The Canadian government has been promoting Industry 4.0 through programs such as the Strategic Innovation Fund and the Industrial Research Assistance Program (IRAP), which provide funding and resources to help companies develop and commercialize new products and services. The Canadian manufacturing sector also plays a major role in Industry 4.0, with companies looking to increase efficiency and productivity through the use of advanced technologies such as IoT, AI, and big data. This leads to the creation of "smart factories" that are highly automated,connected, and able to make real-time decisions.

The Canadian technology sector also plays a major role in Industry 4.0, with companies such as Shopify, Kinross Gold, Bombardier and many others investing in IoT and AI. Additionally, many startups and small businesses are working on new technologies and applications for Industry 4.0 such as autonomous vehicles, 3D printing, and advanced robotics. Canada's strong research and development capabilities and its universities have been promoting Industry 4.0 through research and development.

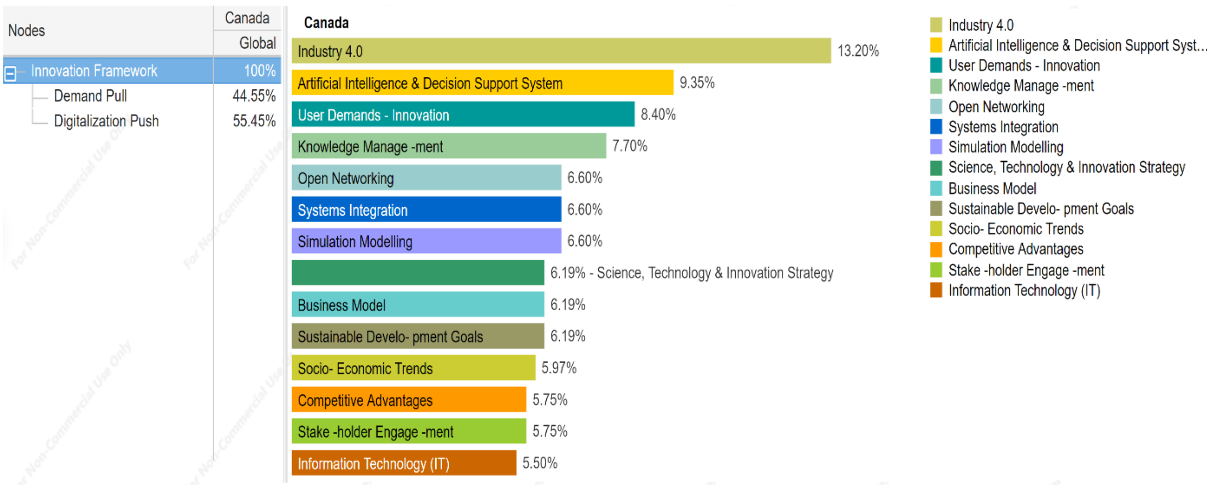

Figure 5-9. The priority weights of the sub-criteria for Canadian result

5.2.11. Summary of the overall main criteria for the seven countries

Figure 5.10 demonstrates that Digitalisation-Push is the most significant criterion among the seven countries in this research. On the other hand, Demand-Pull was the highest main criteria in the UK and UAE. The first countries which approached Digitalisation-Push for the future era were Germany with 56%, the second country was Canada with 55.45%, then China with 53.62%, the USA with 52.49%, followed by Japan with 51.49%. The penultimate is the UAE with 45.05%, and the UK came last with 44.00%, respectively.

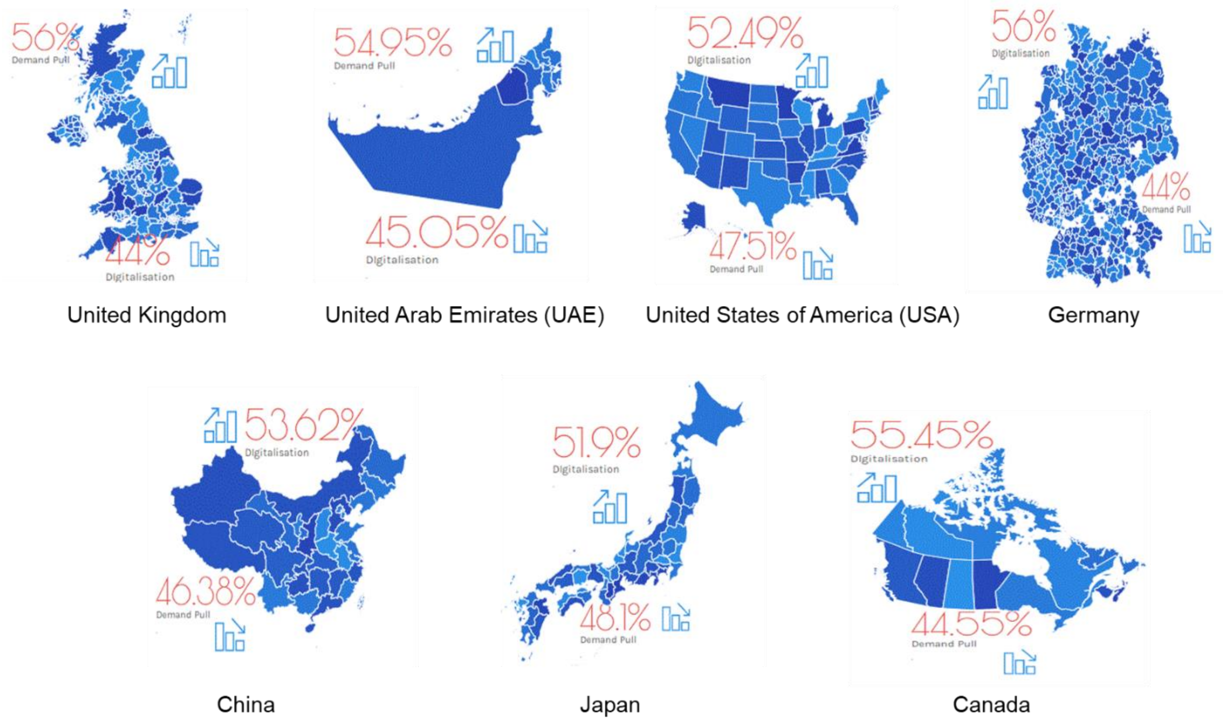

Figure 5-10. The priority weights of the main criteria for the seven countries

On the other hand, the UK came top with Demand-Pull scoring 56%, followed by the UAE scoring 54.95%. Japan had a nearly equalised score of 48.10 %. The USA scored 47.51%, and China scored 46.38%. Canada took the penultimate place with 44.55%, and Germany had the lowest score with 44.00%. See Table 5.1.

Table 5-1. The result for the main criteria per country

Cantry	UK	UAE	USA	Germany	China	Japan	Canada
Main criteria							
DI.P	▼ 44%	▼ 45.05%	▲ 52.49%	▲ 56%	▲ 53.62%	▬ 51.90%	▲ 55.45%
DE.P	▲ 56%	▲ 54.95%	▼ 47.51%	▼ 44%	▼ 46.38%	▼ 48.10%	▼ 44.55%

Based on the data presented, it seems that there are several common trends in the different countries. The first trend is that the "Digitalization-Push (DI-P)" is the leading criterion for all countries, meaning that businesses are prioritising digital transformation initiatives that are driven by internal factors, such as technological advancements and the desire to improve operational efficiency. The second trend is the importance of Industry 4.0, which is the leading sub-criteria in all countries except China, where Open Networking (ON) is the most crucial factor. This highlights the significance of Industry 4.0, which is an overarching term that encompasses various advanced technologies and concepts, including the Internet of Things (IoT), artificial intelligence (AI), and cyber-physical systems (CPS). Another trend is the high importance placed on Artificial Intelligence and Decision Support Systems (A.1 and D.S.S), which is the fourth most crucial factor in the US, Canada, and Japan. This highlights the growing importance of AI in businesses, as it can help automate various processes, improve decision-making, and enhance customer experience. In addition, there is also a trend of placing importance on User Demands-Innovation (U.D-I) and Knowledge Management (KM), which are both considered important sub-criteria in most of the countries. This indicates that businesses are taking into account the needs and demands of their customers and are investing in systems and processes to manage and utilize the vast amounts of data they collect. Lastly, Sustainable Development Goals (SDGs) are also considered an important factor in most of the countries, indicating a growing recognition of the need for businesses to be socially responsible and to take steps to promote environmental sustainability. Overall, the trends highlight a shift towards a more digital, data-driven, and sustainable business landscape.

The priorities of the countries vary depending on the country's industry, economy, and government policies. For instance, Industry 4.0 is the leading priority in Germany, China, Japan, and Canada, reflecting a global trend towards the adoption of Industry 4.0 technologies. This highlights the importance of incorporating automation and data exchange into the manufacturing sector, which is crucial for the competitiveness and efficiency of industries. In the USA, User Demands-Innovation (U.D-I) is the leading criterion, which shows that businesses in the USA are focusing on meeting the demands of their customers by innovating their products and services. This is a significant trend, as it highlights the importance of customer-centric approaches in business. The high ranking of Sustainable Development Goals (SDGs) in China and Canada highlights the importance of environmentally and socially responsible practices, which are becoming increasingly important to businesses and consumers alike. The priority of Knowledge Management (KM) in the USA and Canada shows that companies in these countries value the proper management of information and knowledge, which is crucial for improving processes and decision-making. The priority of Systems Integration (SI), Simulation Modelling (SM) and Information Technology (IT) in Germany and Japan reflects the importance of digital transformation in these countries and the need for an integrated and efficient digital infrastructure.Overall, the varying priorities in different countries show that each country has its unique set of challenges and opportunities and that businesses need to understand and respond to these priorities to remain competitive and relevant.

5.3. Sensitivity Analysis

Sensitivity Analysis (SA) definition varies according to its application to practice. The consensus concludes that SA is a science that studies and quantifies the impact of each input parameter on the outputs via the circulation of uncertainties (Pang et al., 2020). There are three most popular ways to analyse criteria sensitivity (Chen, *et al.*, 2010) explicitly:

i) Firstly, changing criteria values.

ii) Secondly, changing the relative importance of criteria.

iii) Thirdly, changing criteria weights.

This study will examine different scenarios and observe changing the weighted criteria on the alternative ranking. Expert Choice software will be used to carry out the necessary analysis. Implementing sensitivity analysis is crucial to ensure the reliability of the final decision through the investigation of different scenarios and observation of the impact of changing the priority of the criteria on the alternative ranking system. On the other hand, sensitivity graphs present helpful performance, dynamic, gradient, and head-to-head analysis. Furthermore, expert choice offers flexibility to try to change the main objectives' priorities (Digitalisation-Push, Demand-Pull) on the graphs (*on the Left Y-axis*) and to see how the sub-criteria priorities change as a result (*on the Right Y-axis*), see Figure 5.16 as an example.

Therefore, the input data is slightly modified to observe the effect on the outcomes to implement sensitivity analysis. If the ranking does not change, then the results are considered stable, and the uncertainty in the participant's opinion within the percentage of changes in the input data does not affect the final output. Otherwise, the impact should be considered when concluding the study. In this study, a dynamic sensitivity analysis was selected to discover the effect of the different weight alternatives allocated to the main criteria under investigation: Deman-Pull and digitalisation-push.

5.3.1. Sensitivity analysis for the seven countries (Globally)

5.3.1.1. Sensitivity analysis at 50% for both Digitalisation-push and demand-pull

Figure 5.11 illustrates the first scenario, demonstrating the change of the main criteria weight to be almost equally assigned at 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as shown below, where Industry 4.0 is placed at the top of the list with 14.21%. Conversely, Science, Technology & Innovation

Strategy, Business Model and Stakeholder Engagement came at the bottom of the list equally by 2.86%.

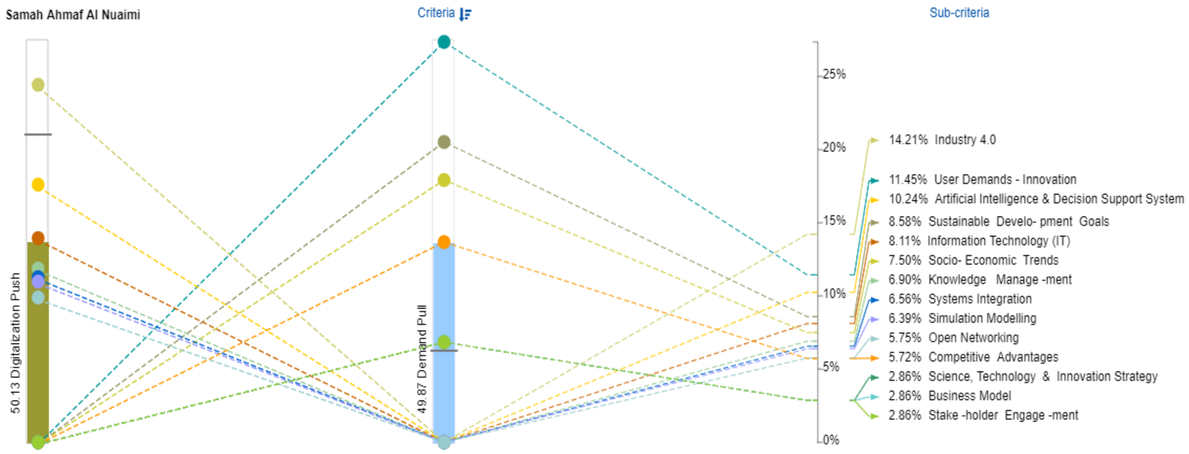

Figure 5-11. Sensitivity analysis with digitalisation-push (50%) and demand-pull (50%) for global result

5.3.1.2. Sensitivity analysis for 40% digitalisation-push and 60% demand-pull

In the second scenario, the weight for the main criteria Demand-Pull and Digitalisation-Push has been changed to 60% and 40%, respectively. Unlike the first scenario graphs, the leading sub-criterion is User Demands-Innovation, calculated to be 14.23%; however, the final three sub-criteria: Business Model; Science, Technology & Innovation Strategy and Stakeholder Engagement, all have a value of 3.56%. See Figure 5.12 below.

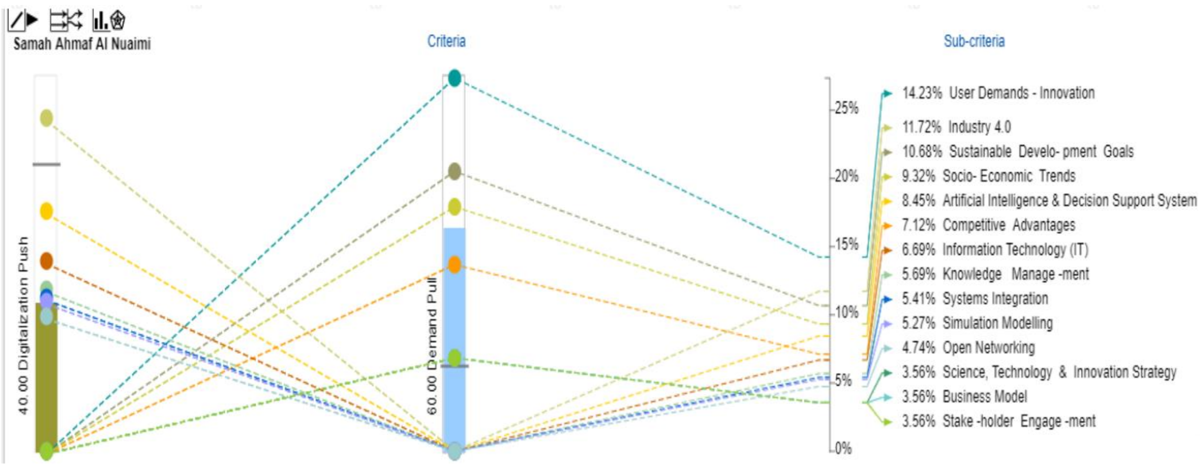

Figure 5-12. Sensitivity analysis with digitalisation-push (40%) and demand-pull (60%) for global result

5.3.1.3. Sensitivity analysis for 60% digitalisation-push and 40% demand-pull

Figure 5.13 exemplifies the third scenario, with the weights for the main criteria being 60% for Digitalisation-Push and 40% for Demand Pull. In the first place, Industry 4.0 scored an outstanding 16.48%. The last three criteria are all equally scored 2.22% each, namely Science, Technology & Innovation Strategy; Business Model and Stakeholder Engagement.

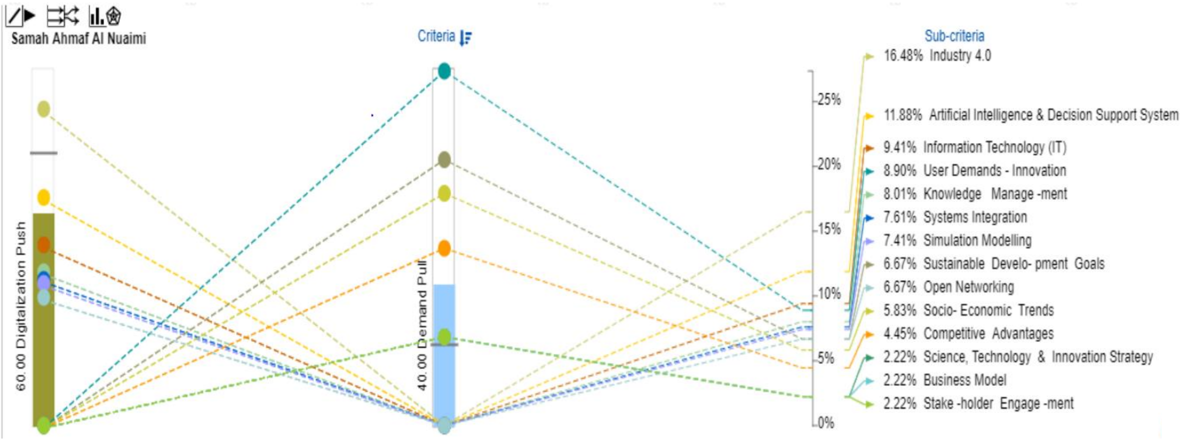

Figure 5-13. Sensitivity analysis with digitalisation-push (60%) and demand-pull (40%) for global result

5.3.1.4. Sensitivity analysis for 70% digitalisation-push and 30% demand-pull

Figure 5.14 illustrates the fourth scenario, whereby the main criteria weights are changed to 70% for Digitalisation-Push and 30% for Demand-Pull. The highest and lowest priority of the final ranking of lower sub-criteria scoring each 1.62% is the latest three criteria of Science, Technology & Innovation Strategy; Business Model, and Stakeholder Engagement. In contrast, the highest priority is Industry 4.0, with 18.64%.

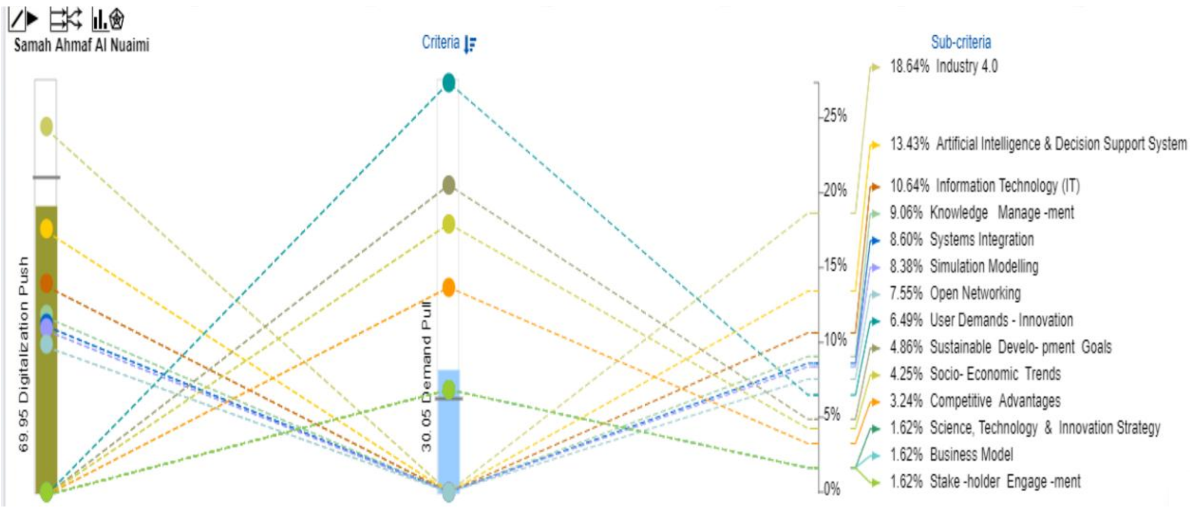

Figure 5-14. Sensitivity analysis with digitalisation-push (70%) and demand-pull (30%) for global result

5.3.1.5. Sensitivity analysis for 30% digitalisation-push and 70% demand pull

Figure 5.15 demonstrates the final and fifth scenario in the global results when the priority of the main criteria swapped to 70% for Demand-Pull and 30% for Digitalisation-Push. This scenario shows that the uppermost sub-criteria was User Demands – Innovation which scored 17.23%. At the same time, Open Networking ranked at the bottommost of the sub-criteria with 3.66%.

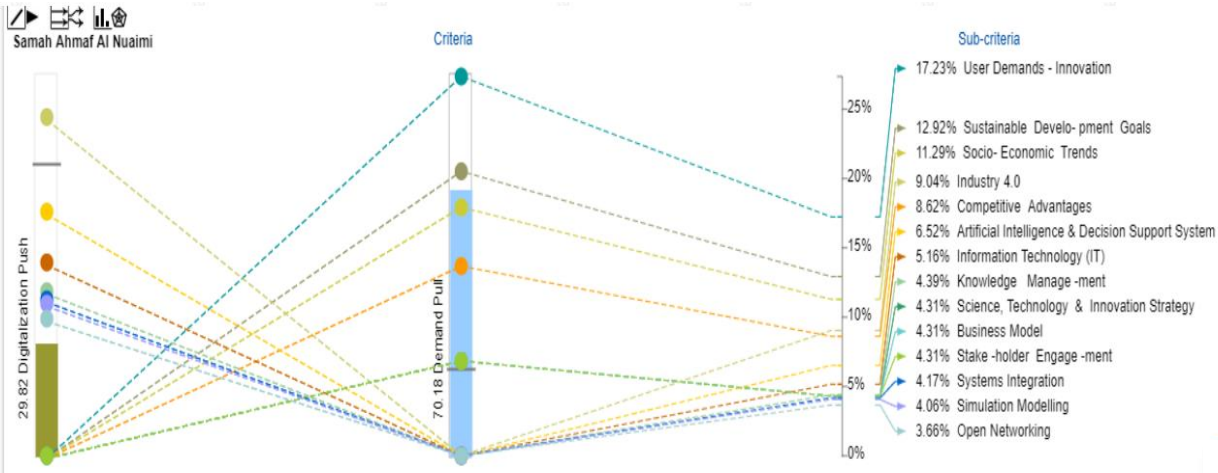

Figure 5-15. Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull(70%) for Global result

Table 5-2. Summary of the sensitivity analysis for the seven counteris (global scenario)

Performance Sensitivity of Global (Seven Countries) Scenarios									
%	**Digitalisation-Push (50%) and Demand-Pull (50%)**	**%**	**Digitalisation-Push (40%) and Demand-Pull (60%)**	**%**	**Digitalisation-Push (60%) and Demand-Pull (40%)**	**%**	**Digitalisation-Push (70%) and Demand-Pull (30%)**	**%**	**Digitalisation-Push (30%) and Demand-Pull (70%)**
14.21%	Industry 4.0	14.23%	User Demands – Innovation	16.48%	Industry 4.0	18.64%	Industry 4.0	17.23%	User Demands – Innovation
11.45%	User Demands – Innovation	11.72%	Industry 4.0	11.88%	Artificial Intelligence and Decision Support Systems	13.43%	Artificial Intelligence and Decision Support Systems	12.92%	Sustainable Development Goals
10.24%	Artificial Intelligence and Decision Support Systems	10.68%	Sustainable Development Goals	9.41%	Information Technology	10.64%	Information Technology	11.29%	Socio-Economic Trends
8.58%	Sustainable Development Goals	9.32%	Socio-Economic Trends	8.90%	User Demands – Innovation	9.06%	Knowledge Management	9.04%	Industry 4.0
8.11%	Information Technology	8.45%	Artificial Intelligence and Decision Support Systems	8.01%	Knowledge Management	8.60%	Systems Integration	8.62%	Competitive Advantages
7.50%	Socio-Economic Trends	7.12%	Competitive Advantages	7.61%	Systems Integration	8.38%	Simulation Modelling	6.52%	Artificial Intelligence and Decision Support Systems
6.90%	Knowledge Management	6.69%	Information Technology	7.41%	Simulation Modelling	7.55%	Open Networking	5.16%	Information Technology
6.59%	Systems Integration	5.69%	Knowledge Management	6.67%	Sustainable Development Goals	6.49%	User Demands – Innovation	4.39%	Knowledge Management
6.39%	Simulation Modelling	5.41%	Systems Integration	6.67%	Open Networking	4.86%	Sustainable Development Goals	4.31%	Science, Technology, and Innovation Strategy
5.75%	Open Networking	5.27%	Simulation Modelling	5.83%	Socio-Economic Trends	4.25%	Socio-Economic Trends	4.31%	Business Models
5.72%	Competitive Advantages	4.74%	Open Networking	4.45%	Competitive Advantages	3.24%	Competitive Advantages	4.31%	Stakeholder Engagement
2.86%	Science, Technology, and Innovation Strategy	3.56%	Science, Technology, and Innovation Strategy	2.22%	Science, Technology, and Innovation Strategy	1.62%	Science, Technology, and Innovation Strategy	4.17%	Systems Integration
2.86%	Business Models	3.56%	Business Models	2.22%	Business Models	1.62%	Business Models	4.06%	Simulation Modelling
2.86%	Stakeholder Engagement	3.56%	Stakeholder Engagement	2.22%	Stakeholder Engagement	1.62%	Stakeholder Engagement	3.66%	Open Networking

5.3.2. Sensitivity Scenarios for the UK

5.3.2.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.16 illustrates the first scenario, demonstrating the change of the main criteria weight to be likewise recorded by almost 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below. Nonetheless, Industry 4.0 is shown at the top of the list with 10.19%, while Open Networking and Systems Integration were exhibited equally at the bottom at 5.10%.

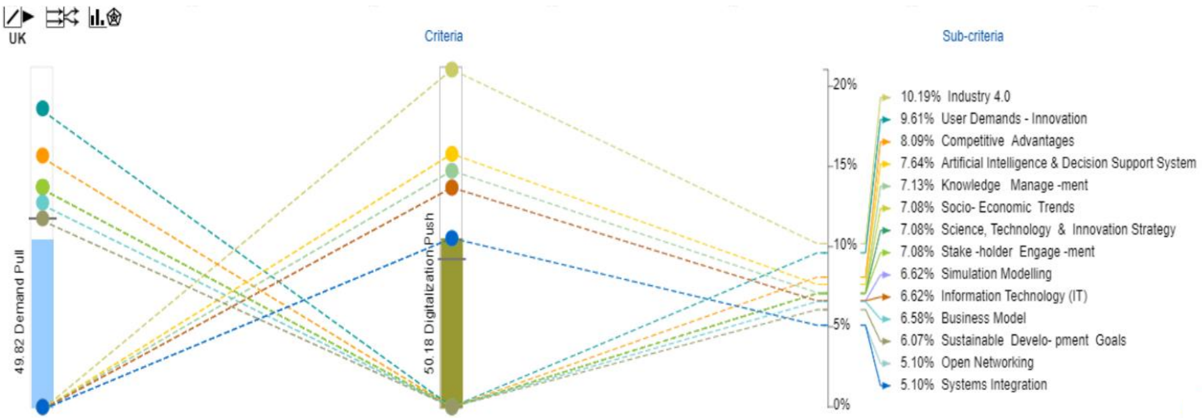

Figure 5-16. Sensitivity analysis with Digitalisation-Push (50%) and Demand-Pull (50%) for the UK result

5.3.2.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario is presented in Figure 5.17 indicating the weight for the main criteria Demand-Pull 60%, and Digitalisation-Push 40%. Unlike the first scenario graphs, the leading sub-criterion is User Demands–Innovation measuring 11.49%; however, the final two sub-criteria, Open Networking and Systems Integration, are shown at the bottom of the sub-criteria list, accounting for 4.03% each.

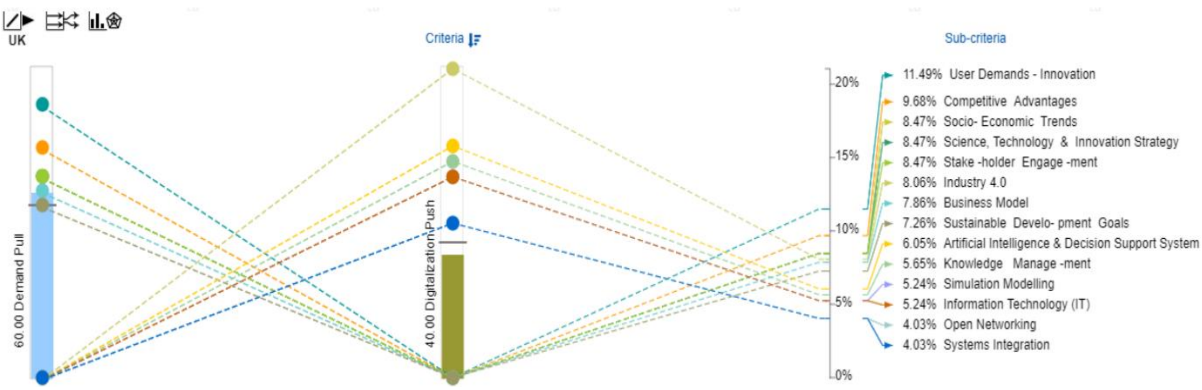

Figure 5-17. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (60%) for the UK result

5.3.2.3. Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull

Figure 5.18 demonstrates the third scenario, with the weights for the main criteria being 60% for Digitalisation-Push and 40% for Demand-Pull. Industry 4.0 has appeared as the highest priority with 12.27%; the last lowest sub-criteria were the Sustainable Development Goals scoring 4.91%.

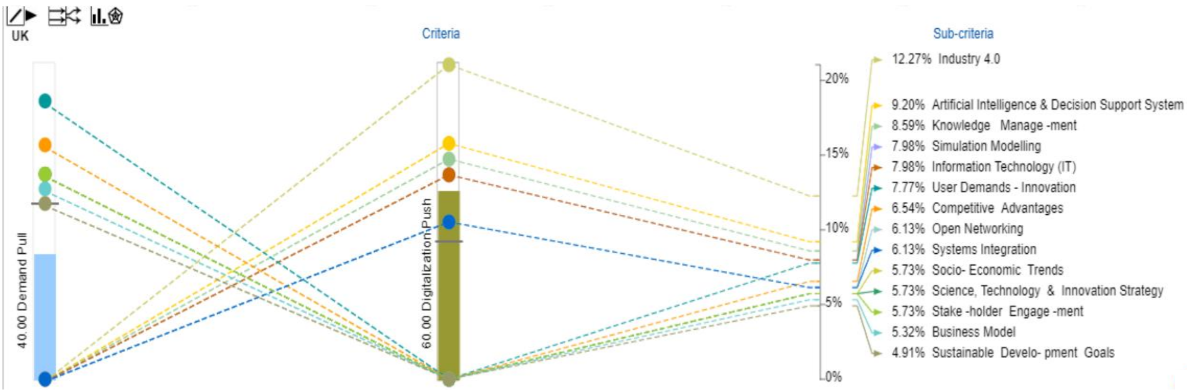

Figure 5-18. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for the UK result

5.3.2.4. Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull

Figure 5.19 clarifies the fourth scenario, where the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 and Sustainable Development Goals are the highest and lowest sub-criteria with 14.46% and 3.69 respectively.

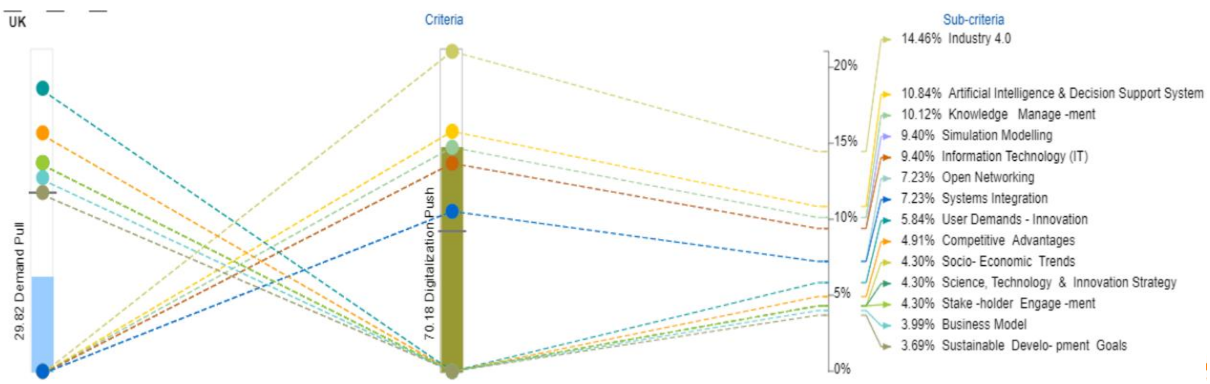

Figure 5-19. Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull(30%) for the UK result

5.3.2.5. Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull

Figure 5.20 explains the final and fifth scenario for the UK results when the priority of the main criteria changed to 70% for Demand-Pull and 30% for Digitalisation-Push. This scenario shows that the uppermost sub-criteria were User Demands – Innovation, with a score of 13.35%. At the same time, Open Networking and System Integration ranked at the bottommost of the sub-criteria, scoring 2.98%.

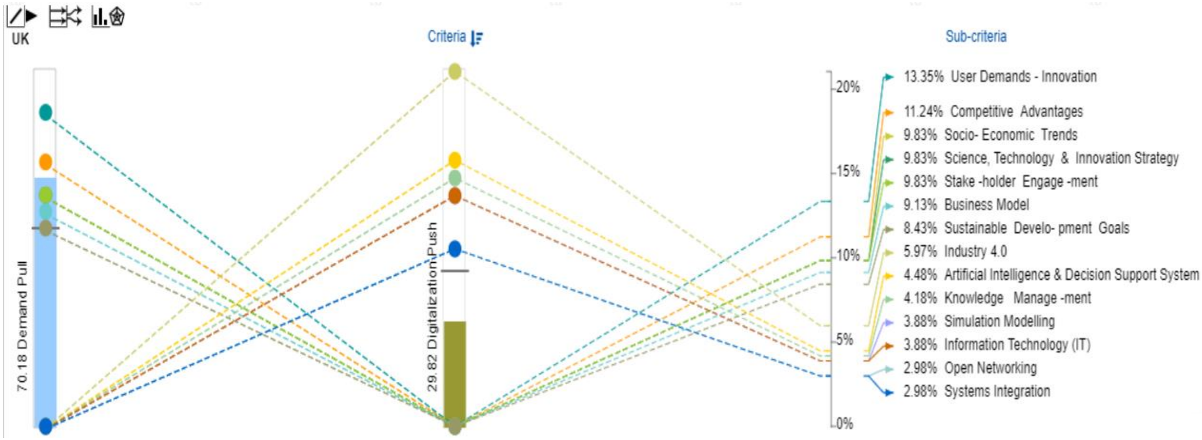

Figure 5-20. Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull(70%) for the UK

Table 5-3. Summary of the sensitivity analysis for the United Kingdom Scenarios

Performance Sensitivity of United Kingdom Scenarios									
%	**Digitalisation-Push (50%) and Demand-Pull (50%)**	**%**	**Digitalisation-Push (40%) and Demand-Pull (60%)**	**%**	**Digitalisation-Push (60%) and Demand-Pull (40%)**	**%**	**Digitalisation-Push (70%) and Demand-Pull (30%)**	**%**	**Digitalisation-Push (30%) and Demand-Pull (70%)**
10.19%	Industry 4.0	11.49%	User Demands – Innovation	12.27%	Industry 4.0	14.46%	Industry 4.0	13.35%	User Demands – Innovation
9.61%	User Demands – Innovation	9.68%	Competitive Advantages	9.20%	Artificial Intelligence and Decision Support Systems	10.84%	Artificial Intelligence and Decision Support Systems	11.24%	Competitive Advantages
8.09%	Competitive Advantages	8.47%	Socio-Economic Trends	8.59%	Knowledge Management	10.12%	Knowledge Management	9.83%	Socio-Economic Trends
7.64%	Artificial Intelligence and Decision Support Systems	8.47%	Science, Technology, and Innovation Strategy	7.98%	Simulation Modelling	9.40%	Simulation Modelling	9.83%	Science, Technology, and Innovation Strategy
7.13%	Knowledge Management	8.47%	Stakeholder Engagement	7.98%	Information Technology	9.40%	Information Technology	9.83%	Stakeholder Engagement
7.08%	Socio-Economic Trends	8.06%	Industry 4.0	7.77%	User Demands – Innovation	7.23%	Open Networking	9.13%	Business Models
7.08%	Science, Technology, and Innovation Strategy	7.86%	Business Models	6.54%	Competitive Advantages	7.23%	Systems Integration	8.43%	Sustainable Development Goals
7.08%	Stakeholder Engagement	7.26%	Sustainable Development Goals	6.13%	Open Networking	5.84%	User Demands – Innovation	5.97%	Industry 4.0
6.62%	Simulation Modelling	6.05%	Artificial Intelligence and Decision Support Systems	6.13%	Systems Integration	4.91%	Competitive Advantages	4.48%	Artificial Intelligence and Decision Support Systems
6.62%	Information Technology	5.65%	Knowledge Management	5.73%	Socio-Economic Trends	4.30%	Socio-Economic Trends	4.18%	Knowledge Management
6.58%	Business Models	5.24%	Simulation Modelling	5.73%	Science, Technology, and Innovation Strategy	4.30%	Science, Technology, and Innovation Strategy	3.88%	Simulation Modelling
6.07%	Sustainable Development Goals	5.24%	Information Technology	5.73%	Stakeholder Engagement	4.30%	Stakeholder Engagement	3.88%	Information Technology
5.10%	Open Networking	4.03%	Open Networking	5.32%	Business Models	3.99%	Business Models	2.98%	Open Networking
5.10%	Systems Integration	4.03%	Systems Integration	4.91%	Sustainable Development Goals	3.69%	Sustainable Development Goals	2.98%	Systems Integration

5.3.3. Sensitivity Scenarios for the UAE

5.3.3.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.21 illustrates the first scenario, representing the change of the main criteria weight to be almost likewise recorded by 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below . Nonetheless, Industry 4.0 is shown at the top of the list, accounting for 11.54%, while Simulation Modelling is exhibited at the bottom with 4.52%.

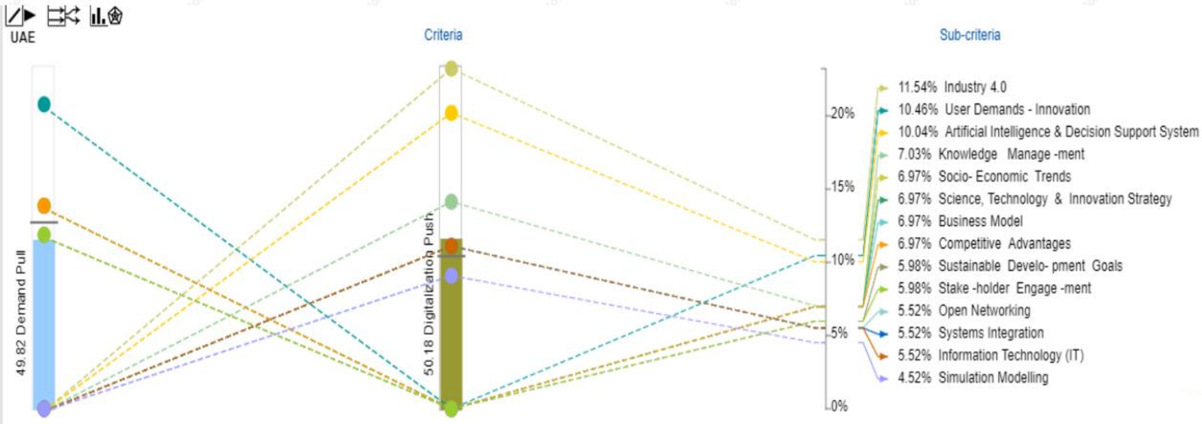

Figure 5-21. Sensitivity analysis with Digitalisation Push (50%) and Demand-Pull (50%) for the UAE result

5.3.3.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario is realized in Figure 5.22 indicating the weight for the main criteria Demand-Pull to 60% and Digitalisation-Push to 40%. Dissimilar to the first scenario graphs, the leading sub-criterion is User Demands – Innovation measuring 12.57%; however, the final sub-criteria, Simulation Modelling, is shown at the bottom of the sub-criteria list, accounting for by 3.59%.

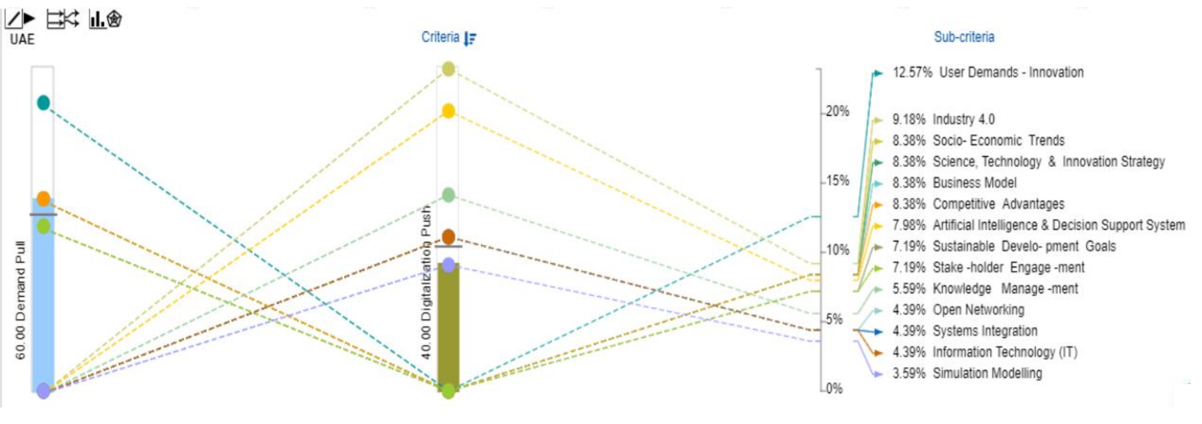

Figure 5-22. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (60%) for the UAE result

5.3.3.3. Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull

Figure 5.23 demonstrates the third scenario, with the weights for the main criteria being 60% for Digitalisation-Push and 40% for Demand-Pull. Relative to the first scenario graphs presented, the highest priority is Industry 4.0, which scores an outstanding 13.83%. In joint last place, recording 4.81% each is Sustainable Development Goals and Stakeholder Engagement.

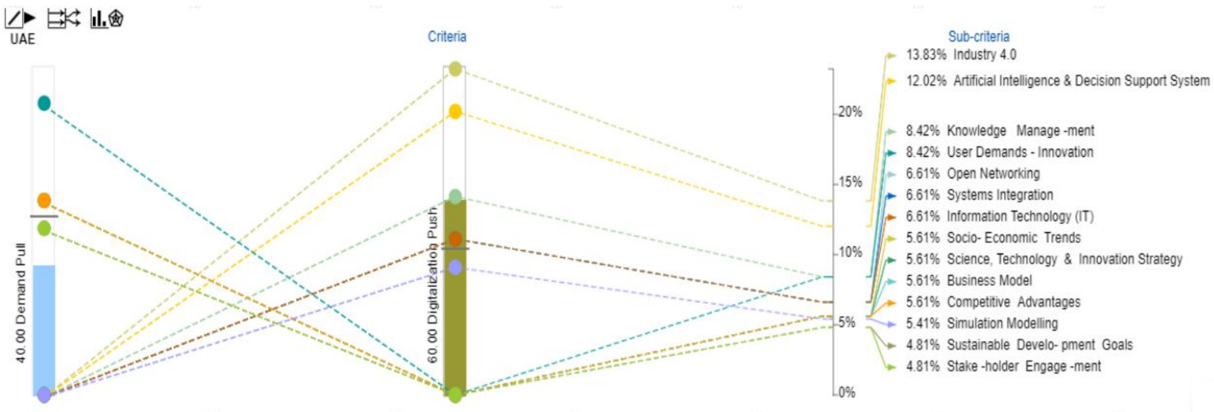

Figure 5-23. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for the UAE result

5.3.3.4. Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull

Figure 5.24 clarifies the fourth scenario, where the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 is found to be the highest sub-criteria, scoring 16.64%. The lowest sub-criterion is Sustainable Development Goals and Stakeholder Engagement, equally scored at 3.62%.

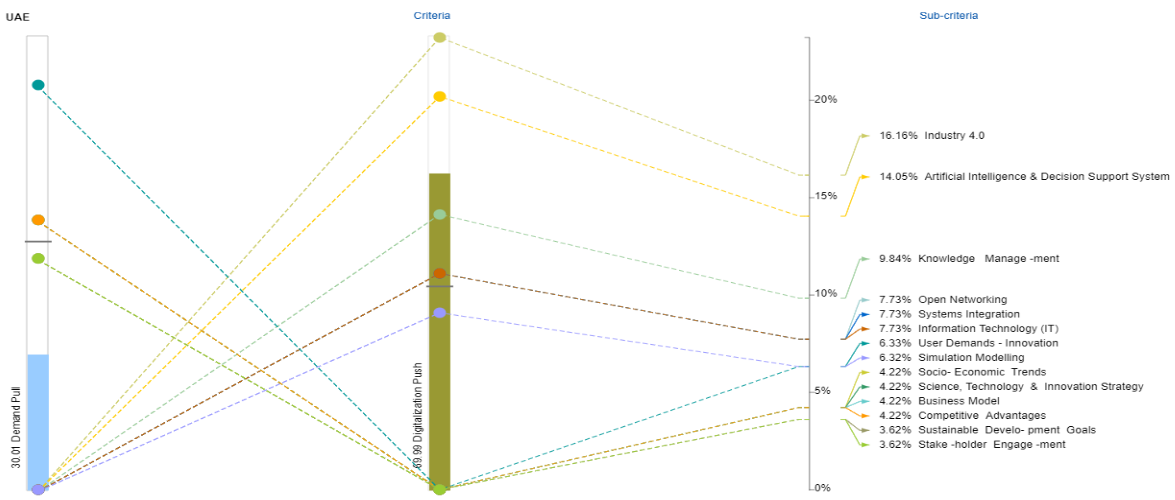

Figure 5-24. Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull (30%) for the UAE result

5.3.3.5. Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull

Figure 5.25 clarifies the final and fifth scenario in the UAE results when the priority of the main criteria is changed to 70% for Demand-Pull and 30% for Digitalisation-Push. This scenario shows that the topmost sub-criterion is User Demands-Innovation, scoring 14.64%. At the same time, Simulation Modeling ranked at the bottommost of the sub-criteria, scoring 2.69%.

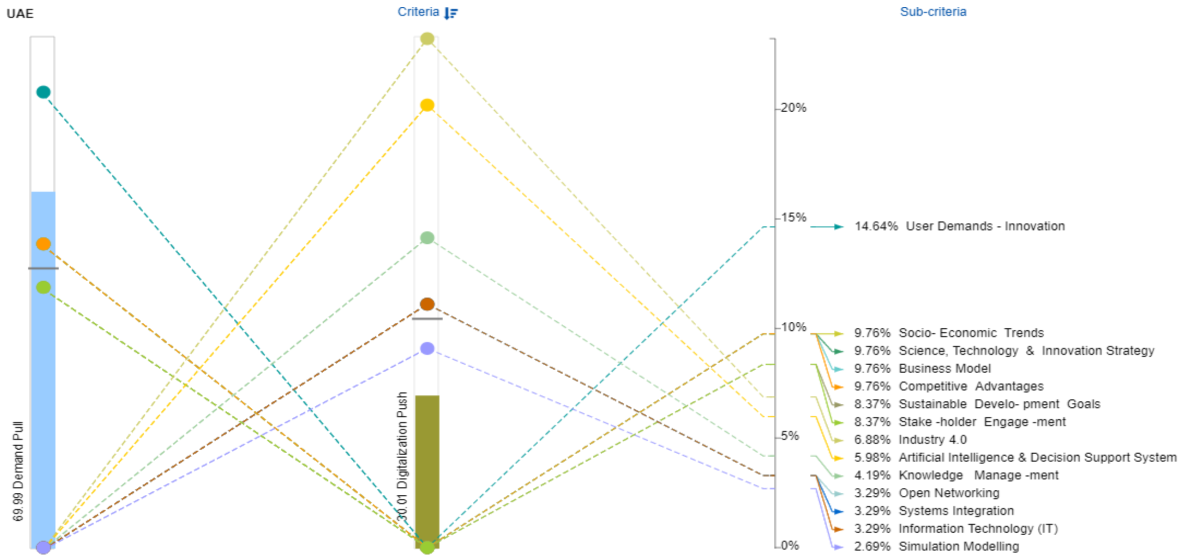

Figure 5-25. Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull (70%) for the UAE result

Table 5-4 Summary of sensitivity analysis for the United Arab Emirates Scenarios

Performance Sensitivity of United Arab Emirates Scenarios									
%	Digitalisation-Push (50%) and Demand-Pull (50%)	%	Digitalisation-Push (40%) and Demand-Pull (60%)	%	Digitalisation-Push (60%) and Demand-Pull (40%)	%	Digitalisation-Push (70%) and Demand-Pull (30%)	%	Digitalisation-Push (30%) and Demand-Pull (70%)
11.54%	Industry 4.0	12.57%	User Demands – Innovation	13.83%	Industry 4.0	16.16%	Industry 4.0	14.64%	User Demands – Innovation
10.46%	User Demands – Innovation	9.18%	Industry 4.0	12.02%	Artificial Intelligence and Decision Support Systems	14.05%	Artificial Intelligence and Decision Support Systems	9.76%	Socio-Economic Trends
10.04%	Artificial Intelligence and Decision Support Systems	8.38%	Socio-Economic Trends	8.42%	Knowledge Management	9.84%	Knowledge Management	9.76%	Science, Technology, and Innovation Strategy
7.03%	Knowledge Management	8.38%	Science, Technology, and Innovation Strategy	8.42%	User Demands – Innovation	7.73%	Open Networking	9.76%	Business Models
6.97%	Socio-Economic Trends	8.38%	Business Models	6.61%	Open Networking	7.73%	Systems Integration	9.76%	Competitive Advantages
6.97%	Science, Technology, and Innovation Strategy	8.38%	Competitive Advantages	6.61%	Systems Integration	7.73%	Information Technology	8.37%	Sustainable Development Goals
6.97%	Business Models	7.98%	Artificial Intelligence and Decision Support Systems	6.61%	Information Technology	6.33%	User Demands – Innovation	8.37%	Stakeholder Engagement
6.97%	Competitive Advantages	7.19%	Sustainable Development Goals	5.61%	Socio-Economic Trends	6.32%	Simulation Modelling	6.88%	Industry 4.0
5.98%	Sustainable Development Goals	7.19%	Stakeholder Engagement	5.61%	Science, Technology, and Innovation Strategy	4.22%	Socio-Economic Trends	5.98%	Artificial Intelligence and Decision Support Systems
5.98%	Stakeholder Engagement	5.59%	Knowledge Management	5.61%	Business Models	4.22%	Science, Technology, and Innovation Strategy	4.19%	Knowledge Management
5.52%	Open Networking	4.39%	Open Networking	5.61%	Competitive Advantages	4.22%	Business Models	3.29%	Open Networking
5.52%	Systems Integration	4.39%	Systems Integration	5.41%	Simulation Modelling	4.22%	Competitive Advantages	3.29%	Systems Integration
5.52%	Information Technology	4.39%	Information Technology	4.81%	Sustainable Development Goals	3.62%	Sustainable Development Goals	3.29%	Information Technology
4.52%	Simulation Modelling	3.59%	Simulation Modelling	4.81%	Stakeholder Engagement	3.62%	Stakeholder Engagement	2.69%	Simulation Modelling

5.3.4. Sensitivity Scenarios for the USA

5.3.4.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.26 illustrates the first scenario, demonstrating the main criteria weight to be almost 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below.

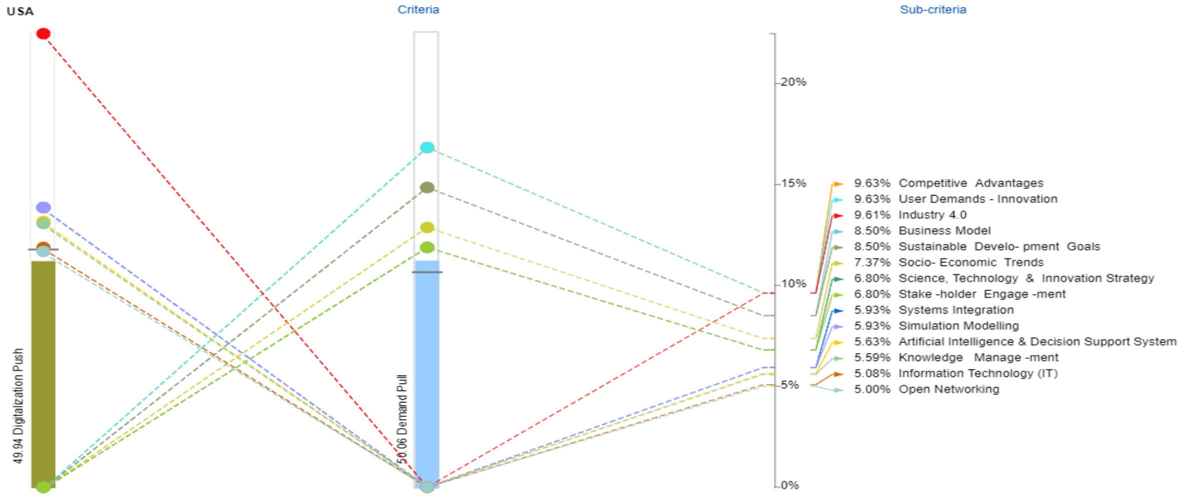

Figure 5-26. Sensitivity analysis with Digitalisation-Push (50%) and Demand-Pull (50%) for the USA result

5.3.4.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario in Figure 5.27 changed the weight for the main criteria Demand-Pull to 60% and Digitalisation-Push to 40%. Unlike the first scenario graph, the leading sub-criterion is Competitive Advantages measuring 11.24%, and the final sub-criteria Open Networking, is shown at the bottom of the list, scoring 3.88%.

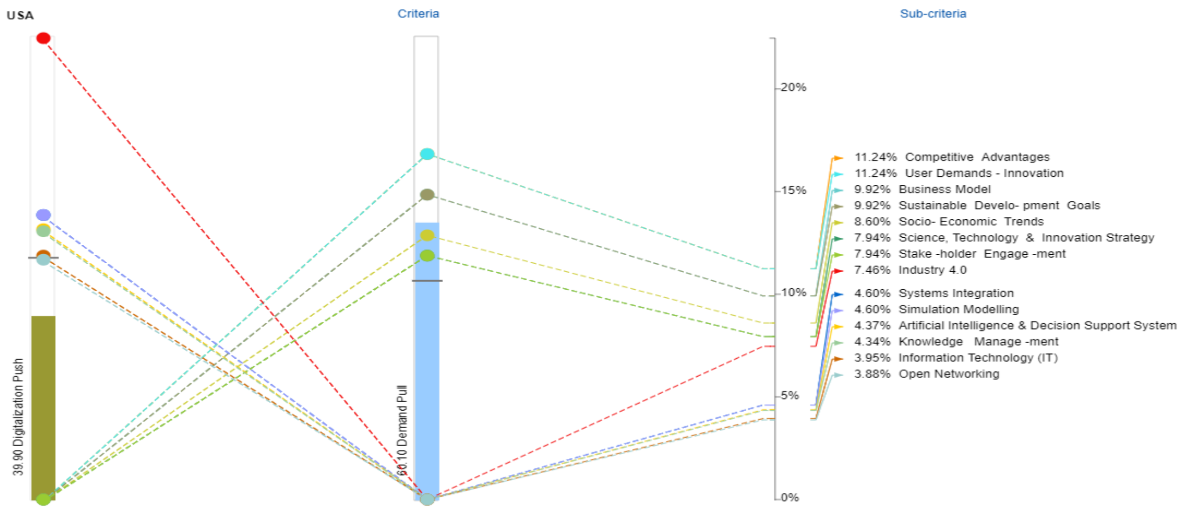

Figure 5-27. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (60%) for the USA result

5.3.4.3. *Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull*

Figure 5.28 demonstrates the *third scenario*, with the weights for the main criteria being 60% for Digitalisation-Push and 40% for Demand-Pull. Industry 4.0 is the highest priority, with a score of 11.91%. The least sub-criteria are Science, Technology and Innovation Strategy (S.T&I.S) and Stakeholder Engagement, which jointly scored at 5.58%.

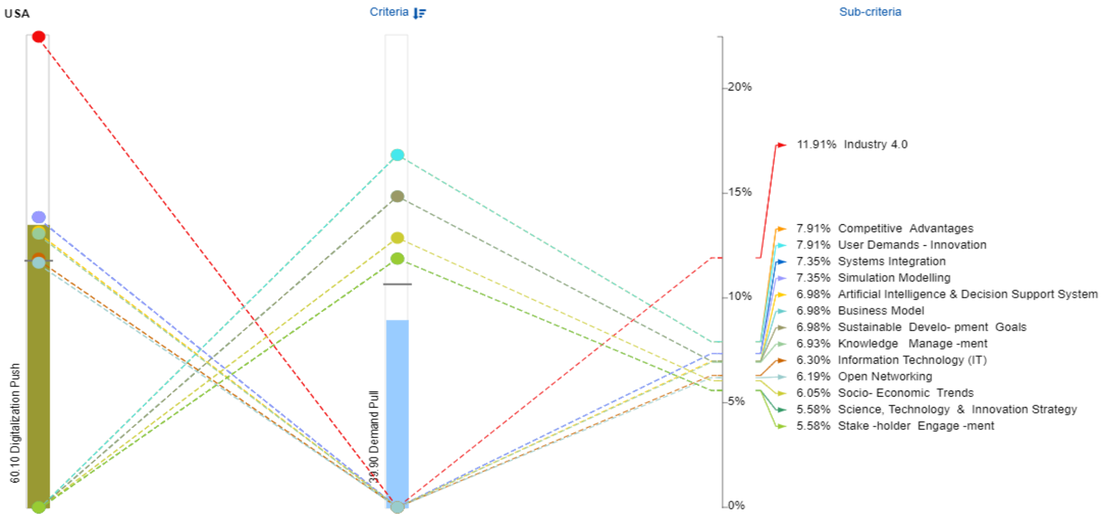

Figure 5-28. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for the USA result

5.3.4.4. *Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull*

Figure 5.29 clarifies the fourth scenario, where the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 has been the highest scoring sub-criteria, with S.T&I.S and Stakeholder Engagement scoring lowest, at 14.28% and 4.33%, respectively.

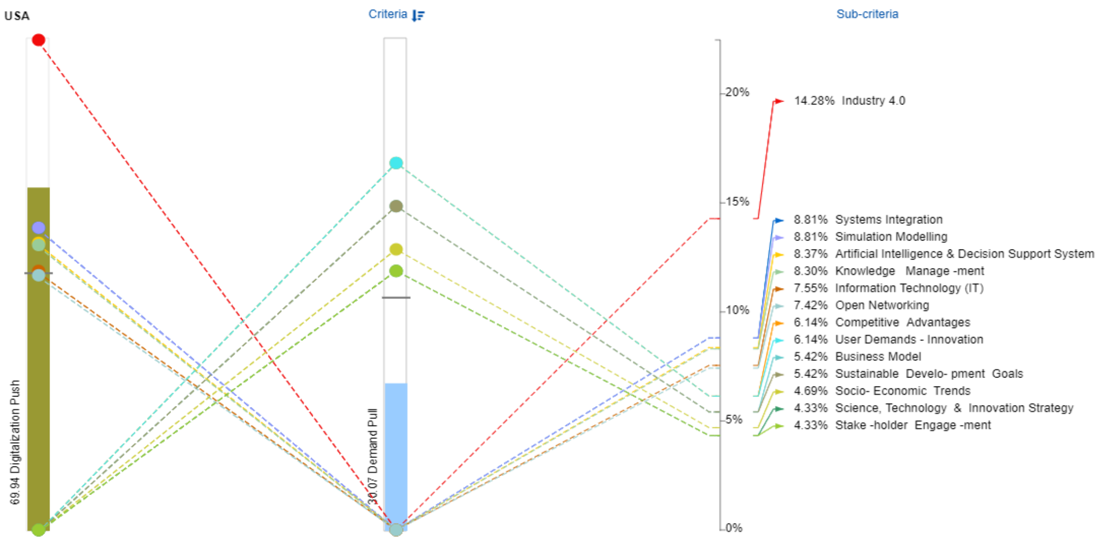

Figure 5-29. Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull (30%) for the USA result

5.3.4.5. *Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull*

Figure 5.30 explains the final and fifth scenario for the USA results when the priority of the main criteria is changed to 30% for Digitalisation-Push and 70% for Demand-Pull. This scenario shows that the uppermost sub-criterion is Competitive Advantages, with 12.74%. At the same time, Open Networking ranks at the bottommost of the sub-criteria, scoring 2.84%.

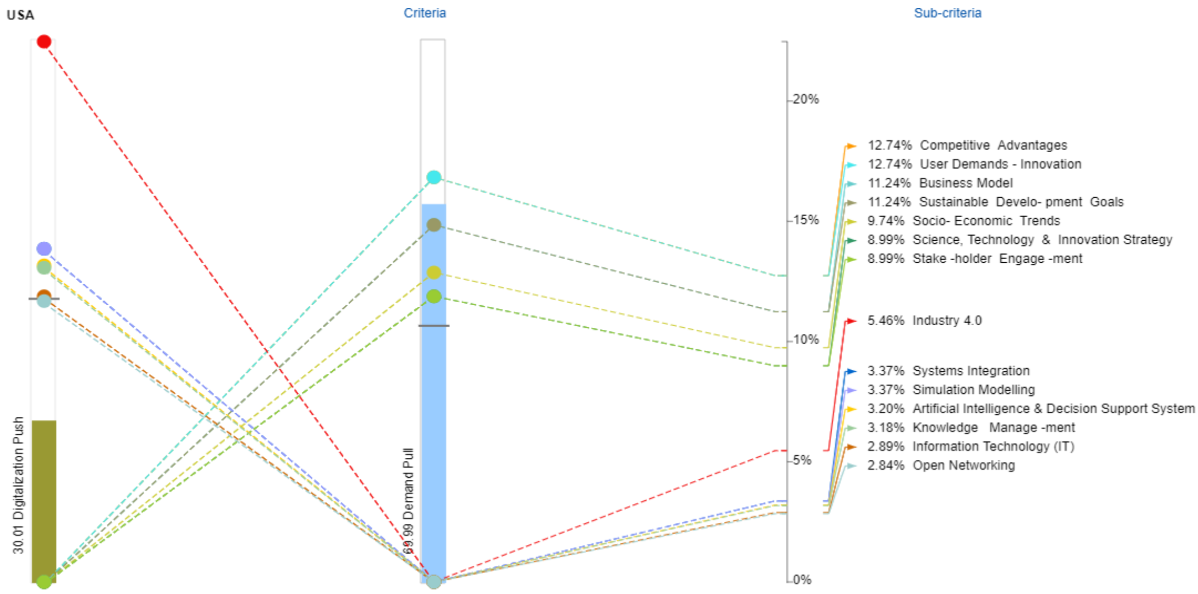

Figure 5-30. Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull (70%) for the USA result

Table 5-5. Summary of sensitivity analysis for the United States of America Scenarios

Performance Sensitivity of United States of America Scenarios									
%	**Digitalisation-Push (50%) and Demand-Pull (50%)**	**%**	**Digitalisation-Push (40%) and Demand-Pull (60%)**	**%**	**Digitalisation-Push (60%) and Demand-Pull (40%)**	**%**	**Digitalisation-Push (70%) and Demand-Pull (30%)**	**%**	**Digitalisation-Push (30%) and Demand-Pull (70%)**
9.63%	Competitive Advantages	11.24%	Competitive Advantages	11.91%	Industry 4.0	14.28%	Industry 4.0	12.74%	Competitive Advantages
9.63%	User Demands – Innovation	11.24%	User Demands – Innovation	7.91%	Competitive Advantages	8.81%	Systems Integration	12.74%	User Demands – Innovation
9.61%	Industry 4.0	9.92%	Business Models	7.91%	User Demands – Innovation	8.81%	Simulation Modelling	11.24%	Business Models
8.50%	Business Models	9.92%	Sustainable Development Goals	7.35%	Systems Integration	8.37%	Artificial Intelligence and Decision Support Systems	11.24%	Sustainable Development Goals
8.50%	Sustainable Development Goals	8.60%	Socio-Economic Trends	7.35%	Simulation Modelling	8.30%	Knowledge Management	9.74%	Socio-Economic Trends
7.37%	Socio-Economic Trends	7.94%	Science, Technology, and Innovation Strategy	6.98%	Artificial Intelligence and Decision Support Systems	7.55%	Information Technology	8.99%	Science, Technology, and Innovation Strategy
6.80%	Science, Technology, and Innovation Strategy	7.94%	Stakeholder Engagement	6.98%	Business Models	7.42%	Open Networking	8.99%	Stakeholder Engagement
6.80%	Stakeholder Engagement	7.46%	Industry 4.0	6.98%	Sustainable Development Goals	6.14%	Competitive Advantages	5.45%	Industry 4.0
5.93%	Systems Integration	4.60%	Systems Integration	6.93%	Knowledge Management	6.14%	User Demands – Innovation	3.37%	Systems Integration
5.93%	Simulation Modelling	4.60%	Simulation Modelling	6.30%	Information Technology	5.42%	Business Models	3.37%	Simulation Modelling
5.63%	Artificial Intelligence and Decision Support Systems	4.37%	Artificial Intelligence and Decision Support Systems	6.19%	Open Networking	5.42%	Sustainable Development Goals	3.20%	Artificial Intelligence and Decision Support Systems
5.59%	Knowledge Management	4.37%	Knowledge Management	6.05%	Socio-Economic Trends	4.69%	Socio-Economic Trends	3.18%	Knowledge Management
5.08%	Information Technology	3.95%	Information Technology	5.58%	Science, Technology, and Innovation Strategy	4.33%	Science, Technology, and Innovation Strategy	2.89%	Information Technology
5.00%	Open Networking	3.88%	Open Networking	5.58%	Stakeholder Engagement	4.33%	Stakeholder Engagement	2.84%	Open Networking

5.3.5. Sensitivity Scenarios for Germany

5.3.5.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.31 illustrates the first scenario, demonstrating the change of the main criteria weight to be almost likewise recorded by almost 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below. Nonetheless, Industry 4.0 is shown at the top of the list with 10.72%, while Simulation Modelling was exhibited at the bottom, recorded at 4.19%.

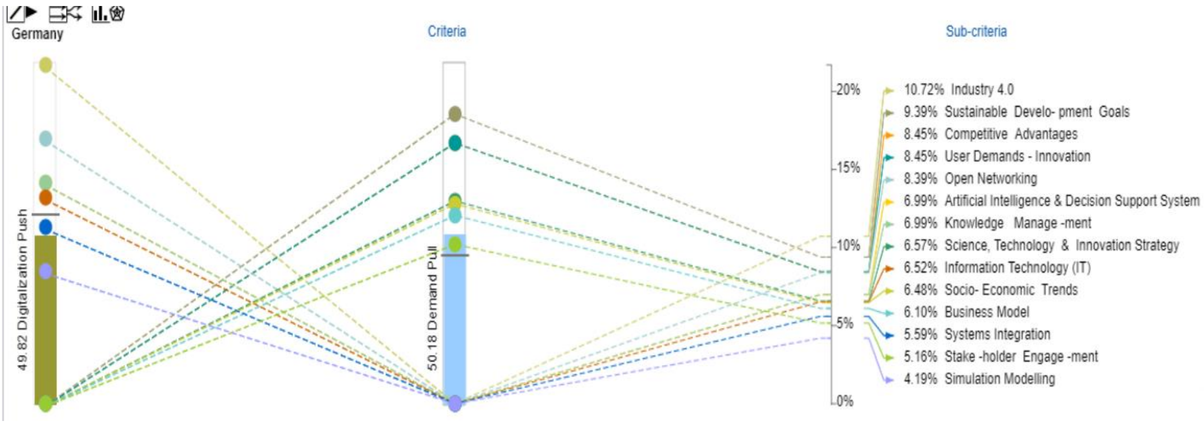

Figure 5-31. Sensitivity analysis with Digitalisation-Push (50%) and Demand-Pull (50%) for Germany's result

5.3.5.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario presented in Figure 5.32 corrected the weight for the main criteria Demand-Pull to 60% and Digitalisation Push to almost 40%. Dissimilar to the first scenario graphs, the leading sub-criteria are Sustainable Development Goals measuring 11.23%; however, the final sub-criteria, Simulation Modelling, are shown at the bottom sub-criteria list, accounting for 3.35%.

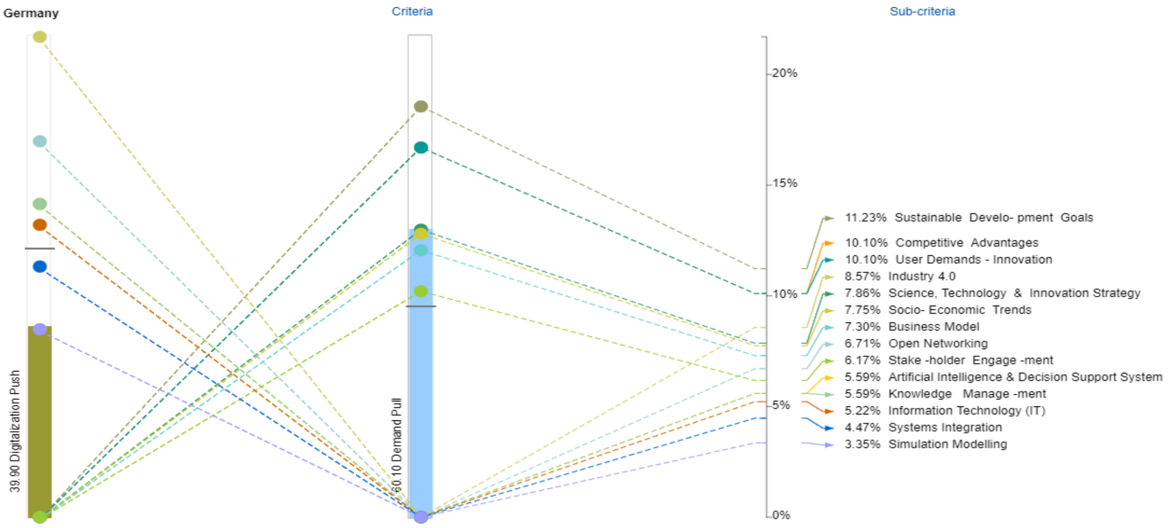

Figure 5-32. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (60%) for Germany's result

5.3.5.3. Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull

Figure 5.33 demonstrates the third scenario, with the weights for the main criteria being 60% for Digitalisation-Push and almost 40% for Demand-Pull. Relative to the first scenario graphs presented, the highest priority is Industry 4.0, which scores an outstanding 12.95%; Stakeholder Engagement is the least of the sub-criteria, scoring 4.11%.

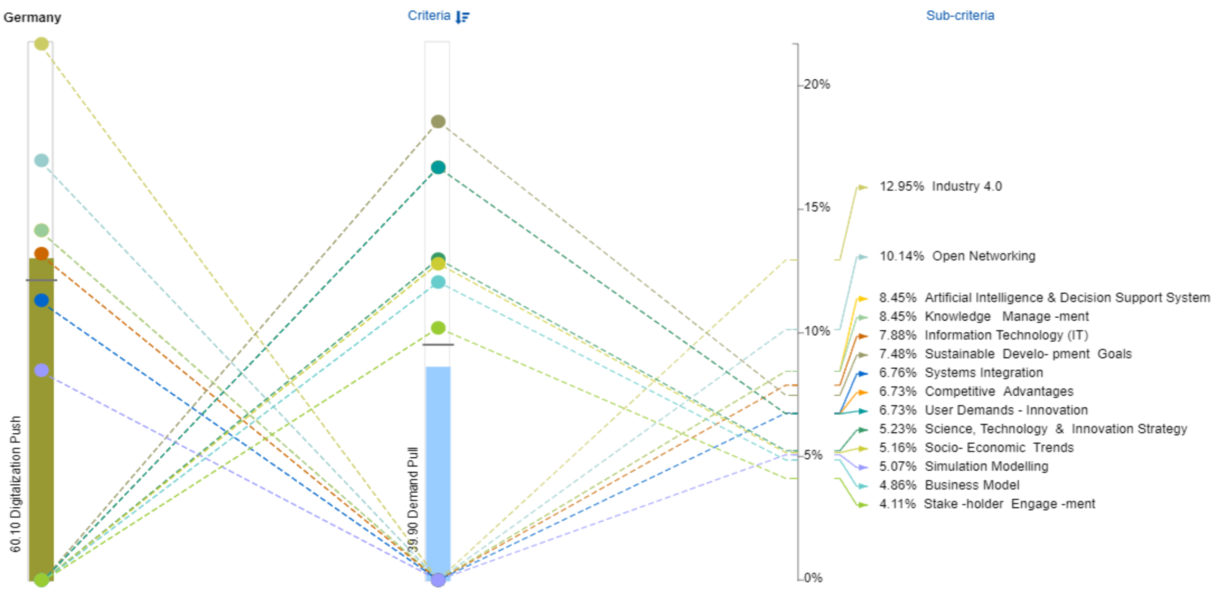

Figure 5-33. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull(40%) for Germany's result

5.3.5.4. Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull

Figure 5.34 clarifies the fourth scenario, where the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 and

Stakeholder Engagement are the highest and lowest sub-criteria with 15.11% and 3.10%, respectively.

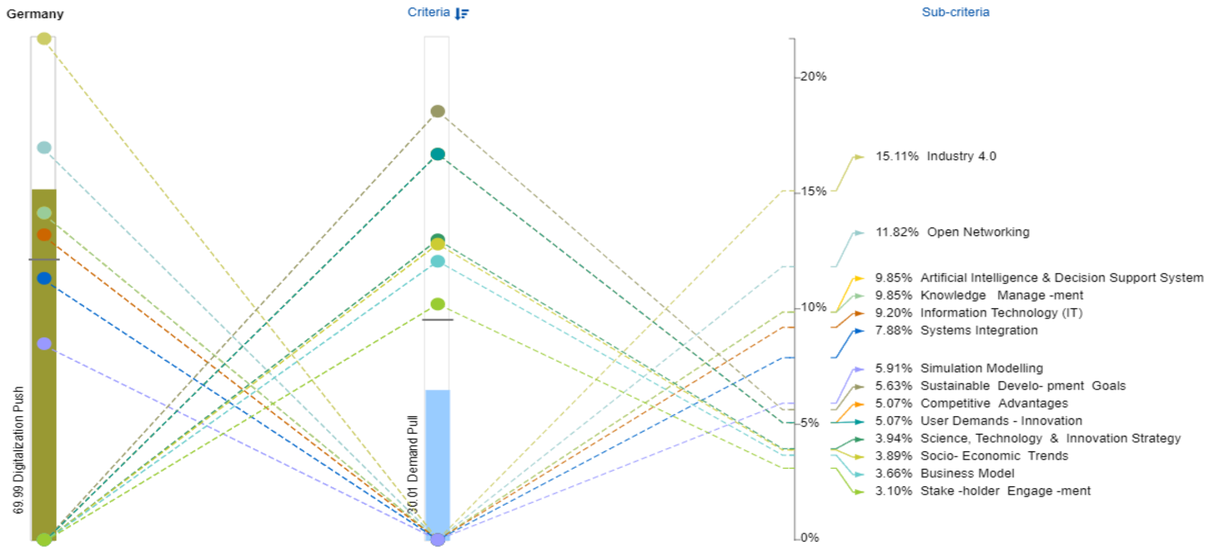

Figure 5-34. Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull (30%) for Germany's result

5.3.5.5. Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull

Figure 5.35 clarifies the final and fifth scenario for the German results when the priority of the main criteria is changed to 70% for Demand-Pull and 30% for Digitalisation-Push. This scenario shows that the topmost sub-criteria were Sustainable Development Goals, recorded at 13.05%. At the same time, Simulation Modeling ranked at the bottommost of the sub-criteria, scoring 2.58%.

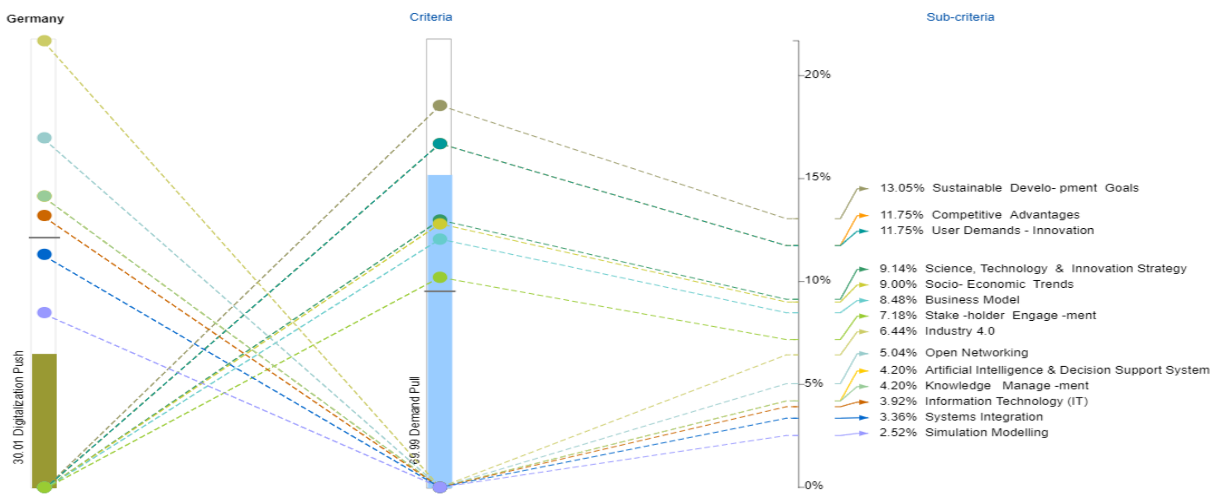

Figure 5-35. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (70%) for Germany's result

Table 5-6. Summary of the sensitivity analysis for Germany Scenarios

Performance Sensitivity of Germany Scenarios									
%	Digitalisation-Push (50%) and Demand-Pull (50%)	%	Digitalisation-Push (40%) and Demand-Pull (60%)	%	Digitalisation-Push (60%) and Demand-Pull (40%)	%	Digitalisation-Push (70%) and Demand-Pull (30%)	%	Digitalisation-Push (30%) and Demand-Pull (70%)
10.72%	Industry 4.0	11.23%	Sustainable Development Goals	12.95%	Industry 4.0	15.11%	Industry 4.0	13.05%	Sustainable Development Goals
9.39%	Sustainable Development Goals	10.10%	Competitive Advantages	10.14%	Open Networking	11.82%	Open Networking	11.75%	Competitive Advantages
8.45%	Competitive Advantages	10.10%	User Demands – Innovation	8.45%	Artificial Intelligence and Decision Support Systems	9.85%	Artificial Intelligence and Decision Support Systems	11.75%	User Demands – Innovation
8.45%	User Demands – Innovation	8.57%	Industry 4.0	8.45%	Knowledge Management	9.85%	Knowledge Management	9.14%	Science, Technology, and Innovation Strategy
8.39%	Open Networking	7.86%	Science, Technology, and Innovation Strategy	7.88%	Information Technology	9.20%	Information Technology	9%	Socio-Economic Trends
6.99%	Artificial Intelligence and Decision Support Systems	7.75%	Socio-Economic Trends	7.48%	Sustainable Development Goals	7.88%	Systems Integration	8.48%	Business Models
6.99%	Knowledge Management	7.30%	Business Models	6.76%	Systems Integration	5.91%	Simulation Modelling	7.18%	Stakeholder Engagement
6.57%	Science, Technology, and Innovation Strategy	6.71%	Open Networking	6.73%	Competitive Advantages	5.63%	Sustainable Development Goals	6.44%	Industry 4.0
6.52%	Information Technology	6.17%	Stakeholder Engagement	6.73%	User Demands – Innovation	5.07%	Competitive Advantages	5.04%	Open Networking
6.48%	Socio-Economic Trends	5.59%	Artificial Intelligence and Decision Support Systems	5.23%	Science, Technology, and Innovation Strategy	5.07%	User Demands – Innovation	4.20%	Artificial Intelligence and Decision Support Systems
6.10%	Business Models	5.59%	Knowledge Management	5.16%	Socio-Economic Trends	3.94%	Science, Technology, and Innovation Strategy	4.20%	Knowledge Management
5.59%	Systems Integration	5.22%	Information Technology	5.07%	Simulation Modelling	3.89%	Socio-Economic Trends	3.92%	Information Technology
5.16%	Stakeholder Engagement	4.47%	Systems Integration	4.86%	Business Models	3.66%	Business Models	3.36%	Systems Integration
4.19%	Simulation Modelling	3.35%	Simulation Modelling	4.11%	Stakeholder Engagement	3.10%	Stakeholder Engagement	2.52%	Simulation Modelling

5.3.6. Sensitivity Scenarios for China

5.3.6.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.36 illustrates the first scenario, demonstrating the change of the main criteria weight to be almost likewise recorded by 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below. Nonetheless, Industry 4.0 is shown at the top of the list with 11.49%; Information Technology is exhibited at the bottom, recorded at 5.50%.

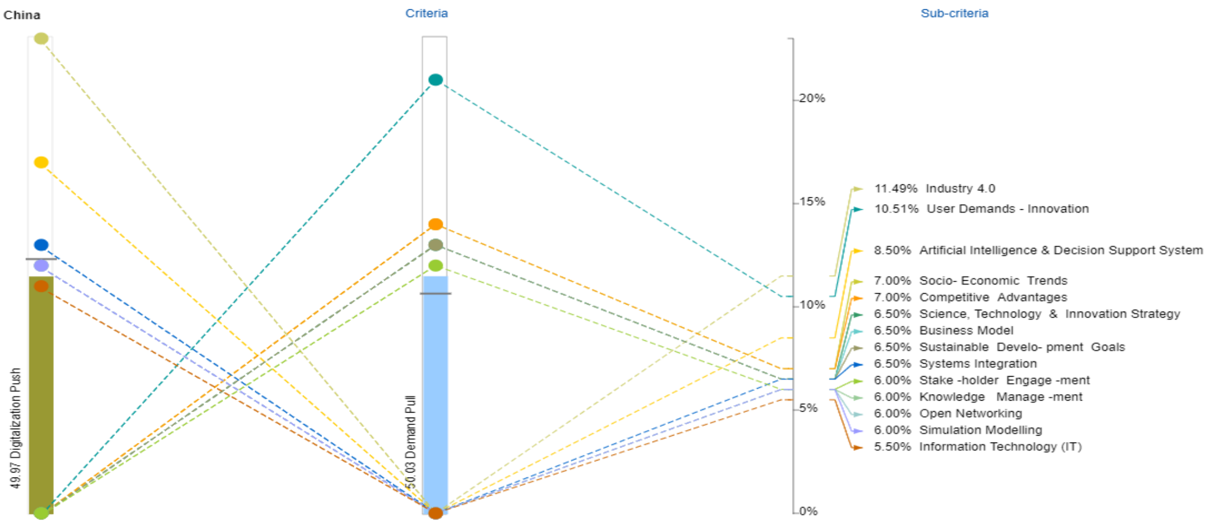

Figure 5-36. Sensitivity analysis with Digitalisation-Push (50%) and Demand-Pull(50%) for China's result

5.3.6.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario presented in Figure 5.37 corrected the weight for Demand-Pull to 60% and Digitalisation-Push to 40%. Unlike the first scenario graph, the leading sub-criterion is User Demands-Innovation measuring 12.62%; however, Information Technology is shown at the bottom of the sub-criteria list, accounting for 4.39%.

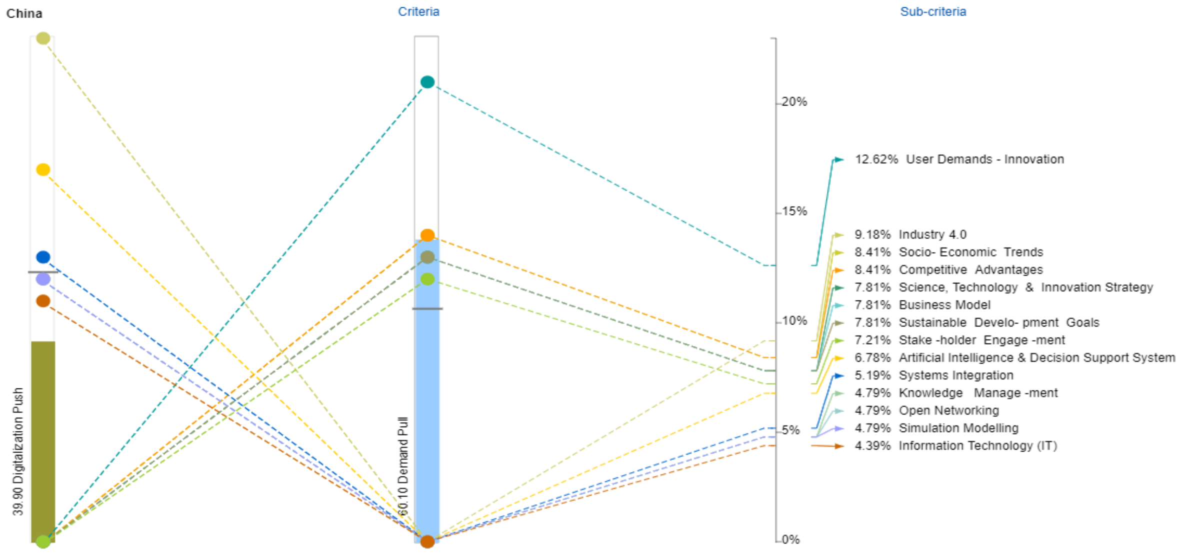

Figure 5-37. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for China result

5.3.6.3. Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull

Figure 5.38 demonstrates the third scenario, with the weights for the main criteria being 40% for Demand-Pull and 60% for Digitalisation-Push. Industry 4.0 has appeared as the highest priority with 13.82%; the lowest sub-criterion is Stakeholder Engagement scoring 4.79%.

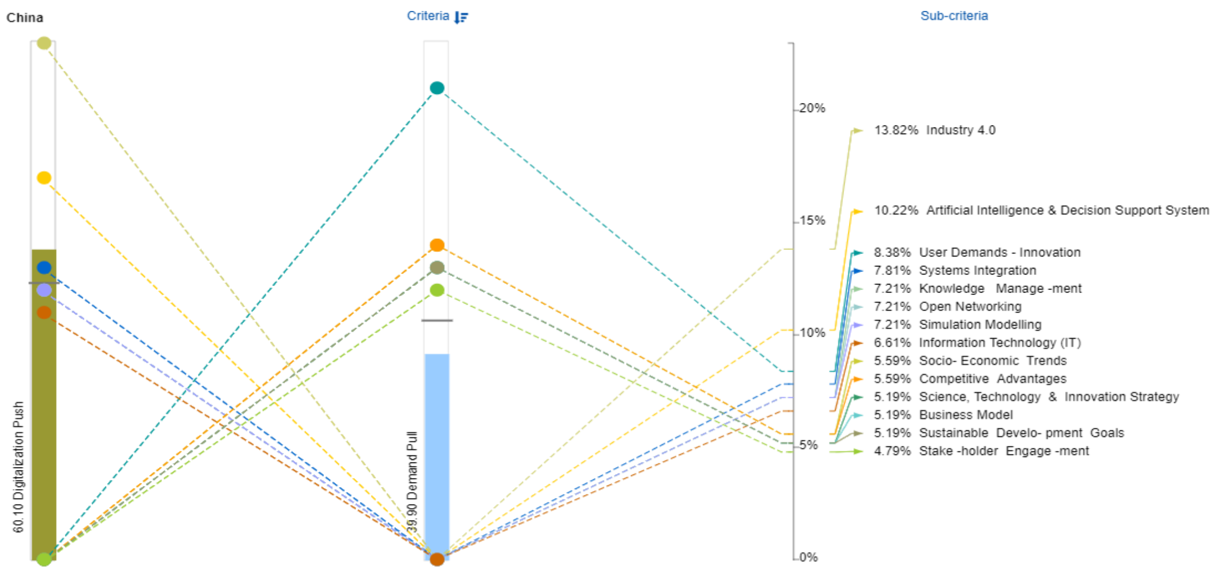

Figure 5-38.Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for China result

5.3.6.4. Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull

Figure 5.39 clarifies the fourth scenario, whereby the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 and Stakeholder Engagement are the highest and the lowest sub-criteria, with 16.09% and 3.61%, respectively.

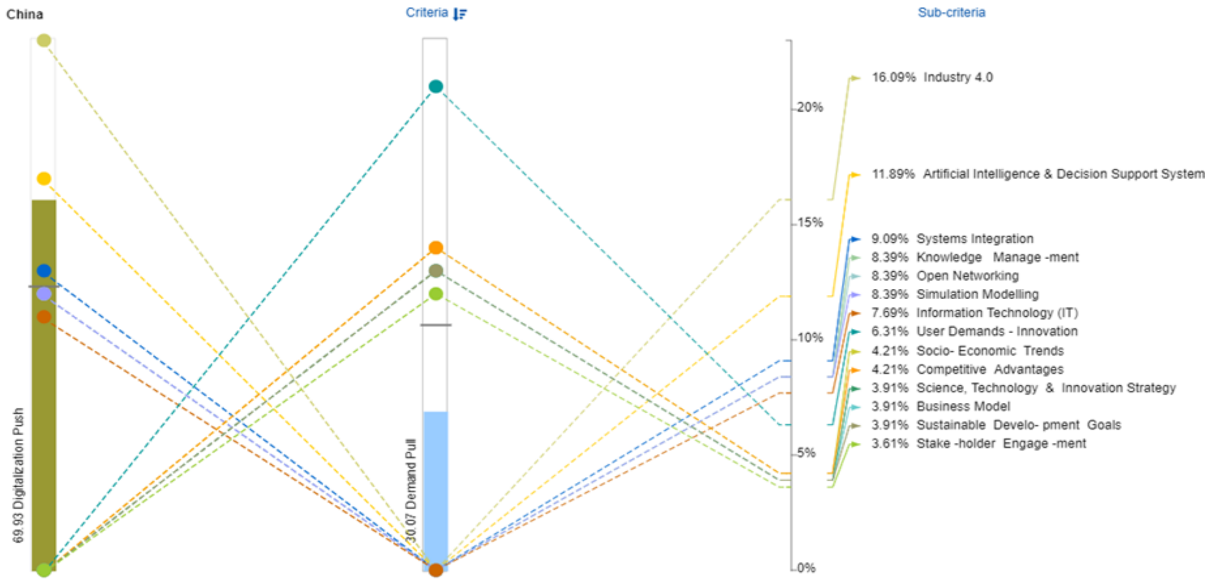

Figure 5-39.Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull (30%) for China's result

5.3.6.5. Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull

Figure 5.40 clarifies the final and fifth scenario in the China results whereby the priority of the main criteria is changed to 70% for Demand-Pull and 30% for Digitalisation-Push. This scenario shows that the topmost sub-criterion was User Demands-Innovation, with a score of 14.70%. At the same time, Information Technology ranked at the bottommost of the sub-criteria, scoring 3.30%.

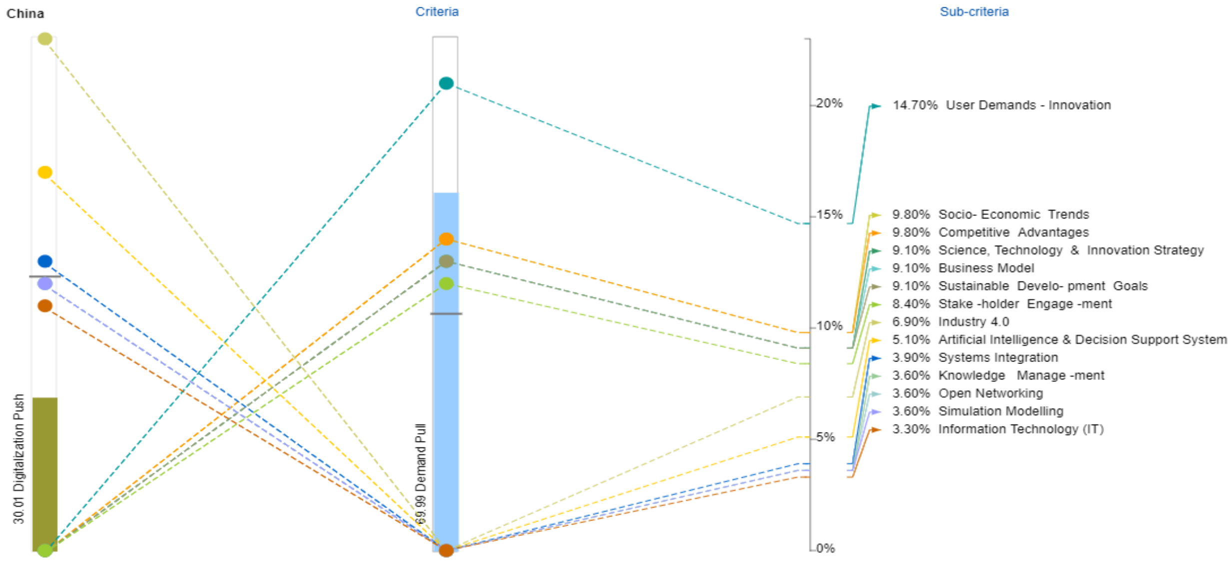

Figure 5-40.Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull (70%) for China's result

Table 5-7. Summary of sensitivity analysis for China Scenarios

Performance Sensitivity of China Scenarios									
%	**Digitalisation-Push (50%) and Demand-Pull (50%)**	**%**	**Digitalisation-Push (40%) and Demand-Pull (60%)**	**%**	**Digitalisation-Push (60%) and Demand-Pull (40%)**	**%**	**Digitalisation-Push (70%) and Demand-Pull (30%)**	**%**	**Digitalisation-Push (30%) and Demand-Pull (70%)**
11.49%	Industry 4.0	12.62%	User Demands – Innovation	13.82%	Industry 4.0	14.70%	User Demands – Innovation	16.09%	Industry 4.0
10.51%	User Demands – Innovation	9.18%	Industry 4.0	10.22%	Artificial Intelligence and Decision Support Systems	9.80%	Socio-Economic Trends	11.89%	Artificial Intelligence and Decision Support Systems
8.50%	Artificial Intelligence and Decision Support Systems	8.41%	Socio-Economic Trends	8.38%	User Demands – Innovation	9.80%	Competitive Advantages	9.09%	Systems Integration
7.00%	Socio-Economic Trends	8.41%	Competitive Advantages	7.81%	Systems Integration	9.10%	Science, Technology, and Innovation Strategy	8.39%	Knowledge Management
7.00%	Competitive Advantages	7.81%	Science, Technology, and Innovation Strategy	7.21%	Knowledge Management	9.10%	Business Models	8.39%	Open Networking
6.50%	Science, Technology, and Innovation Strategy	7.81%	Business Models	7.21%	Open Networking	9.10%	Sustainable Development Goals	8.39%	Simulation Modelling
6.50%	Business Models	7.81%	Sustainable Development Goals	7.21%	Simulation Modelling	8.40%	Stakeholder Engagement	7.69%	Information Technology
6.50%	Sustainable Development Goals	7.21%	Stakeholder Engagement	6.61%	Information Technology	9.60%	Industry 4.0	6.31%	User Demands – Innovation
6.50%	Systems Integration	6.78%	Artificial Intelligence and Decision Support Systems	5.59%	Socio-Economic Trends	5.10%	Artificial Intelligence and Decision Support Systems	4.21%	Socio-Economic Trends
6.00%	Stakeholder Engagement	5.19%	Systems Integration	5.59%	Competitive Advantages	3.90%	Systems Integration	4.21%	Competitive Advantages
6.00%	Knowledge Management	4.79%	Knowledge Management	5.19%	Science, Technology, and Innovation Strategy	3.60%	Knowledge Management	3.91%	Science, Technology, and Innovation Strategy
6.00%	Open Networking	4.79%	Open Networking	5.19%	Business Models	3.60%	Open Networking	3.91%	Business Models
6.00%	Simulation Modelling	4.79%	Simulation Modelling	5.19%	Sustainable Development Goals	3.60%	Simulation Modelling	3.91%	Sustainable Development Goals
5.50%	Information Technology	4.39%	Information Technology	4.79%	Stakeholder Engagement	3.30%	Information Technology	3.61%	Stakeholder Engagement

5.3.7. Sensitivity Scenarios for Japan

5.3.7.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.41 shows the first scenario, representing the change of the main criteria weight to be almost 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below. Nonetheless, Industry 4.0 is shown at the top of the list with 11.85%; Business Model was exhibited at the bottom of the list, recorded at 4.26%.

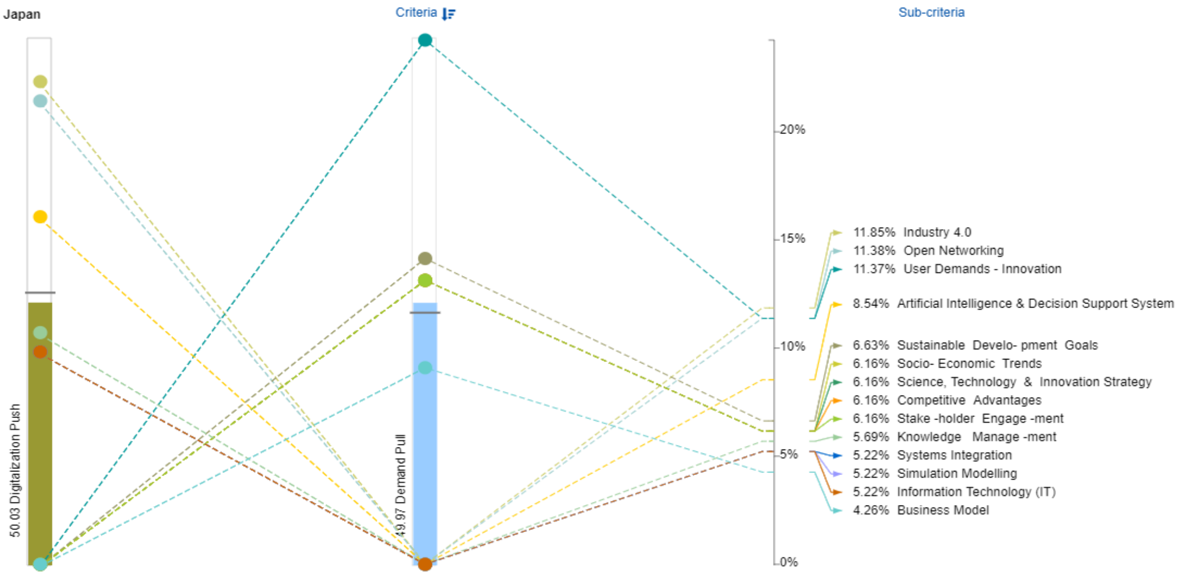

Figure 5-41. Sensitivity analysis with Digitalisation-Push (50%) and Demand-Pull (50%) for Japan result

5.3.7.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario presented in Figure 5.42 changed the weight for Demand-Pull to 60% and Digitalisation-Push to 40%. Unlike the first scenario graph, the leading sub-criterion is the User Demands-Innovation measuring 13.83%; however, Information Technology, Systems Integration, and Simulation Modeling are shown at the bottom of the sub-criteria list, equally accounting for by 4.22%.

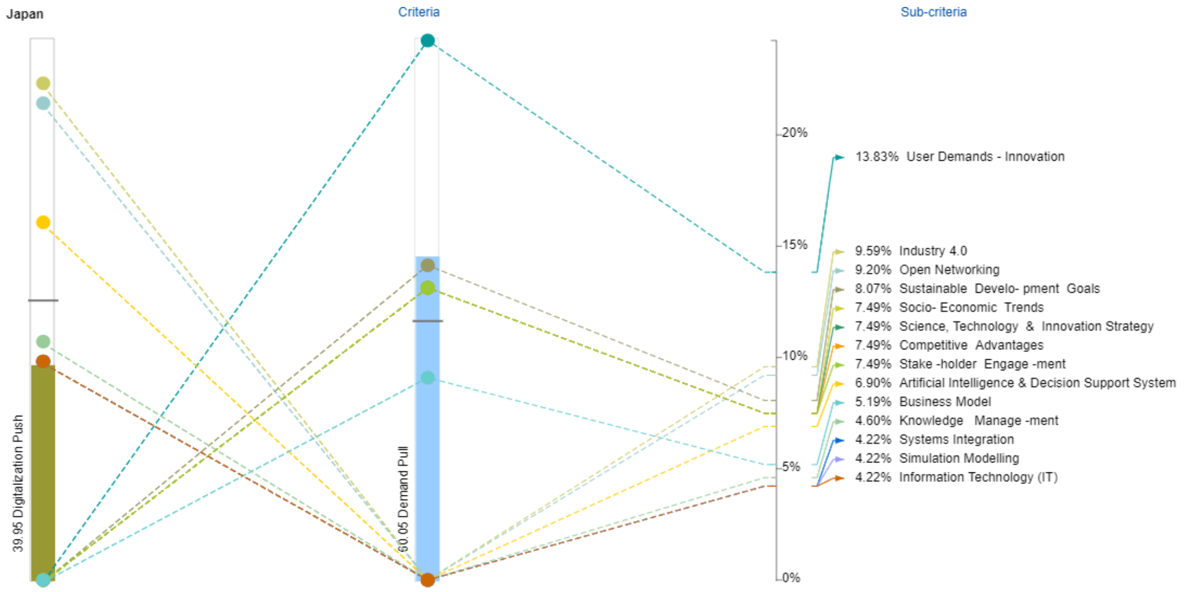

Figure 5-42. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (60%) for Japan result

5.3.7.3. Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull

Figure 5.43 demonstrates the third scenario, with the weights for the main criteria being 40% for Demand-Pull and 60% for Digitalisation-Push. Industry 4.0 has appeared as the highest priority with 14.06%; the lowest sub-criterion is Business Model scoring 3.37%.

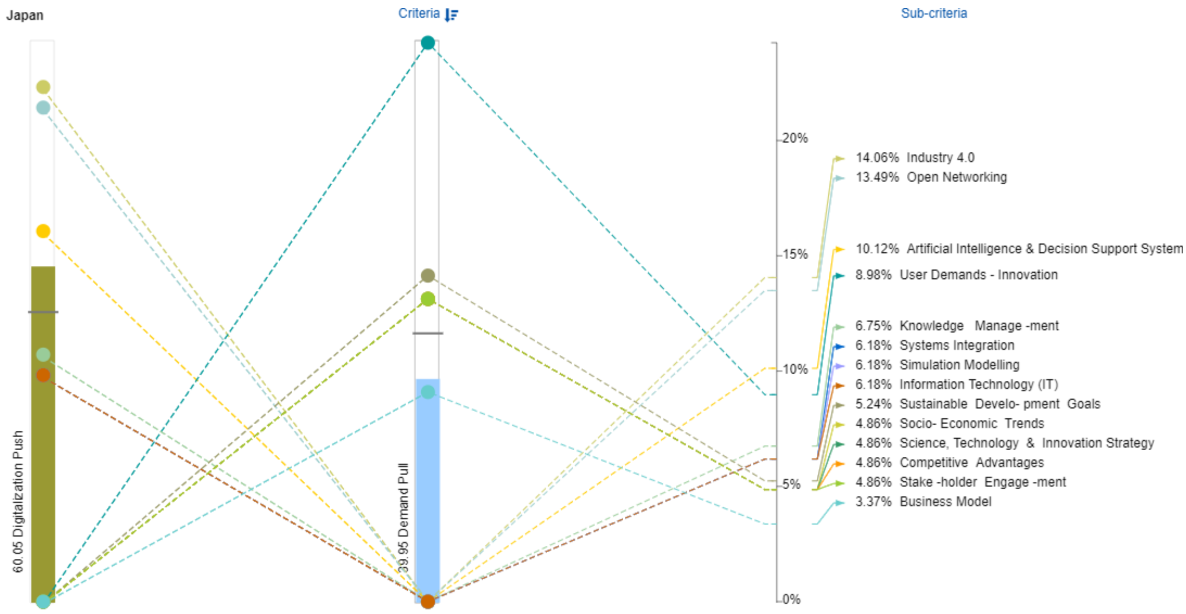

Figure 5-43. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for Japan result

5.3.7.4. Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull

Figure 5.44 clarifies the fourth scenario, where the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 and Business Model are the highest and lowest sub-criteria with 16.19% and 2.50%, respectively.

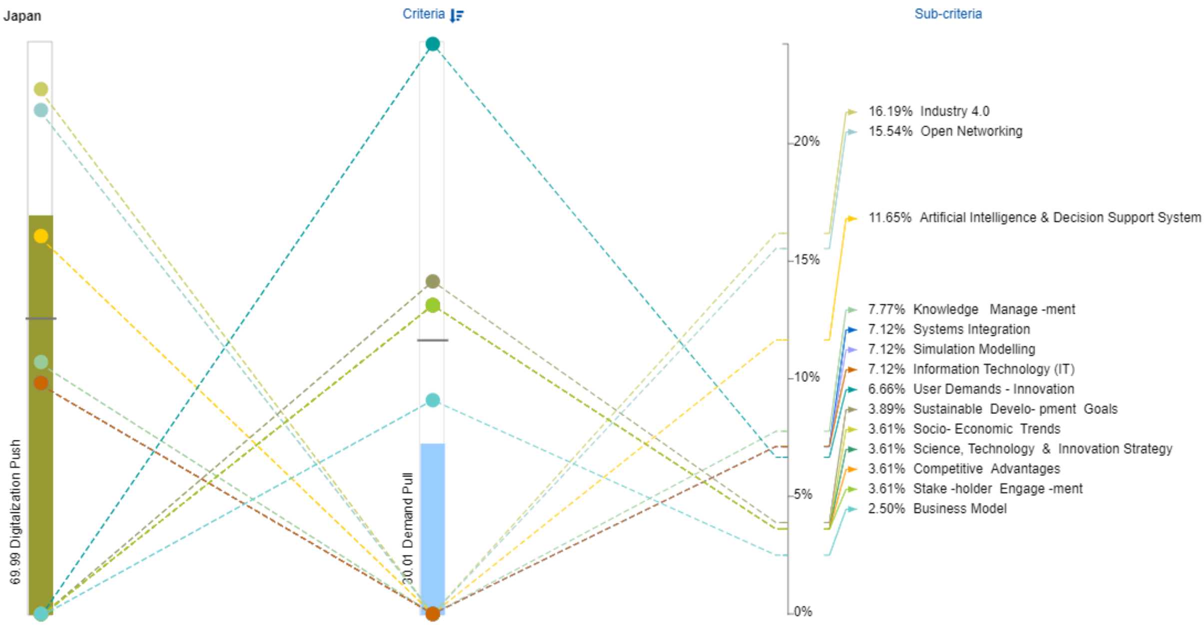

Figure 5-44. Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull (30%) for Japan result

5.3.7.5. Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull

Figure 5.45 clarifies the final and *fifth scenario* for the Japan results when the priority of the main criteria is changed to 70% for ***Demand-Pull*** and 30% for ***Digitalisation-Push***. This scenario shows that the topmost sub-criterion was ***User Demands-Innovation,*** recorded at 16.32%. At the same time, ***Information Technology*** ranked at the bottommost of the sub-criteria, scoring 3.21%.

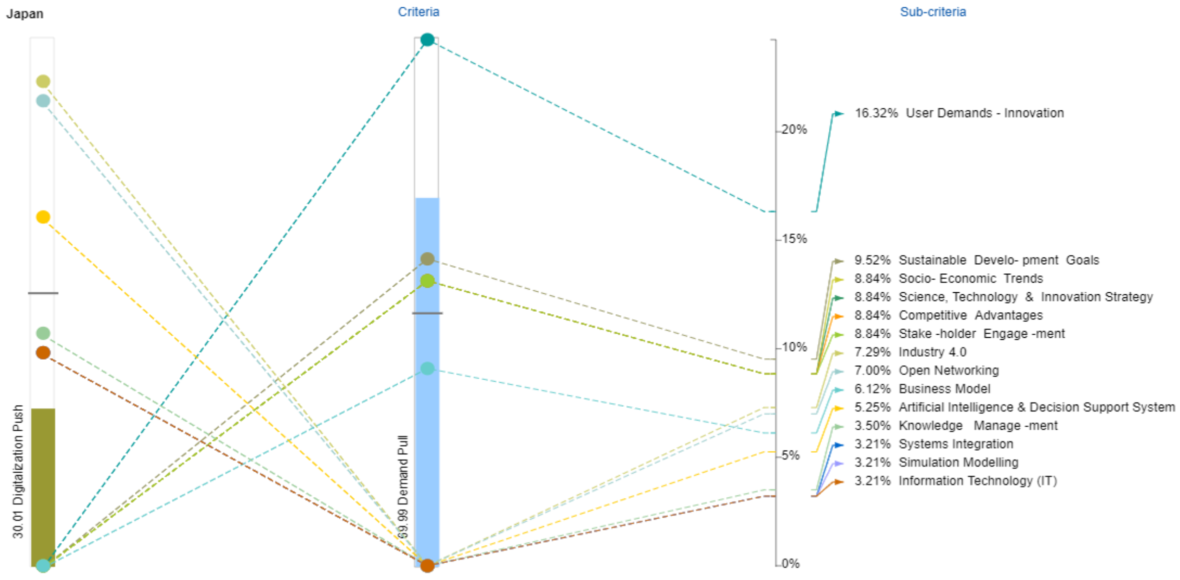

Figure 5-45. Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull (70%) for Japan result

Table 5-8. Summary of sensitivity analysis for Japan Scenarios

Performance Sensitivity of Japan Scenarios									
%	Digitalisation-Push (50%) and Demand-Pull (50%)	%	Digitalisation-Push (40%) and Demand-Pull (60%)	%	Digitalisation-Push (60%) and Demand-Pull (40%)	%	Digitalisation-Push (70%) and Demand-Pull (30%)	%	Digitalisation-Push (30%) and Demand-Pull (70%)
11.84%	Industry 4.0	13.83%	User Demands – Innovation	14.06%	Industry 4.0	16.32%	User Demands – Innovation	16.19%	Industry 4.0
11.38%	Open Networking	9.59%	Industry 4.0	13.49%	Open Networking	9.52%	Sustainable Development Goals	15.54%	Open Networking
11.37%	User Demands – Innovation	9.20%	Open Networking	10.12%	Artificial Intelligence and Decision Support Systems	8.84%	Socio-Economic Trends	11.65%	Artificial Intelligence and Decision Support Systems
8.54%	Artificial Intelligence and Decision Support Systems	8.07%	Sustainable Development Goals	8.98%	User Demands – Innovation	8.84%	Science, Technology, and Innovation Strategy	7.77%	Knowledge Management
6.63%	Sustainable Development Goals	7.49%	Socio-Economic Trends	6.75%	Knowledge Management	8.84%	Competitive Advantages	7.12%	Systems Integration
6.16%	Socio-Economic Trends	7.49%	Science, Technology, and Innovation Strategy	6.18%	Systems Integration	8.84%	Stakeholder Engagement	7.12%	Simulation Modelling
6.16%	Science, Technology, and Innovation Strategy	7.49%	Competitive Advantages	6.18%	Simulation Modelling	7.29%	Industry 4.0	7.12%	Information Technology
6.16%	Competitive Advantages	7.49%	Stakeholder Engagement	6.18%	Information Technology	7.00%	Open Networking	6.66%	User Demands – Innovation
6.16%	Stakeholder Engagement	9.90%	Artificial Intelligence and Decision Support Systems	5.24%	Sustainable Development Goals	6.12%	Business Models	3.89%	Sustainable Development Goals
5.69%	Knowledge Management	5.19%	Business Models	4.86%	Socio-Economic Trends	5.25%	Artificial Intelligence and Decision Support Systems	3.61%	Socio-Economic Trends
5.22%	Systems Integration	4.60%	Knowledge Management	4.86%	Science, Technology, and Innovation Strategy	3.50%	Knowledge Management	3.61%	Science, Technology, and Innovation Strategy
5.22%	Simulation Modelling	4.22%	Systems Integration	4.86%	Competitive Advantages	3.21%	Systems Integration	3.61%	Competitive Advantages
5.22%	Information Technology	4.22%	Simulation Modelling	4.86%	Stakeholder Engagement	3.21%	Simulation Modelling	3.61%	Stakeholder Engagement
4.26%	Business Models	4.22%	Information Technology	3.37%	Business Models	3.21%	Information Technology	2.50%	Business Models

5.3.8. Sensitivity Scenarios for Canada

5.3.8.1. Sensitivity analysis at 50% for both Digitalisation-Push and Demand-Pull

Figure 5.46 shows the first scenario, representing the change of the main criteria weight to be almost likewise recorded by 50% for both Digitalisation-Push and Demand-Pull. The rest of the sub-criteria are ranked, respectively, as presented below. Nonetheless, Industry 4.0 is shown at the top of the list with 11.90%; Information Technology was exhibited at the bottom of the list, recorded at 4.96%.

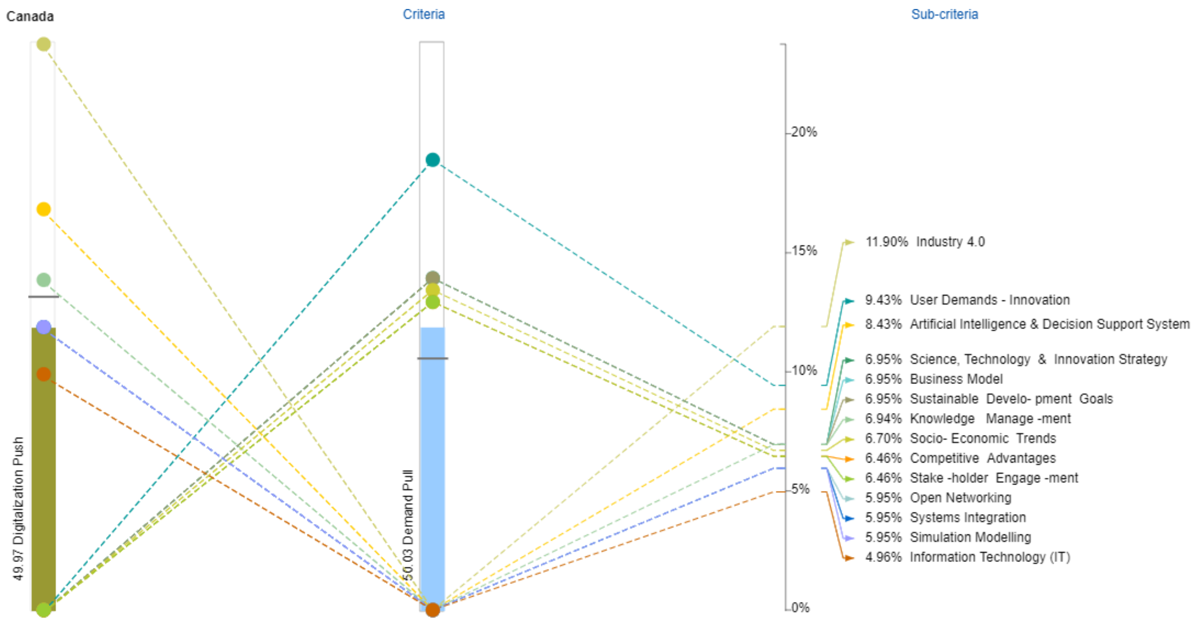

Figure 5-46. Sensitivity analysis with Digitalisation-Push (50%) and Demand-Pull (50%) for Canada's result

5.3.8.2. Sensitivity analysis for 40% Digitalisation-Push and 60% Demand-Pull

The second scenario presented in Figure 5.52 changed the weight for Demand-Pull to 60% and Digitalisation-Push to 40%. Unlike the first scenario graph, the leading sub-criterion is User Demands-Innovation measuring 11.30%; however, Information Technology is shown at the bottom of the sub-criteria list, all equally accounted for by 3.98%.

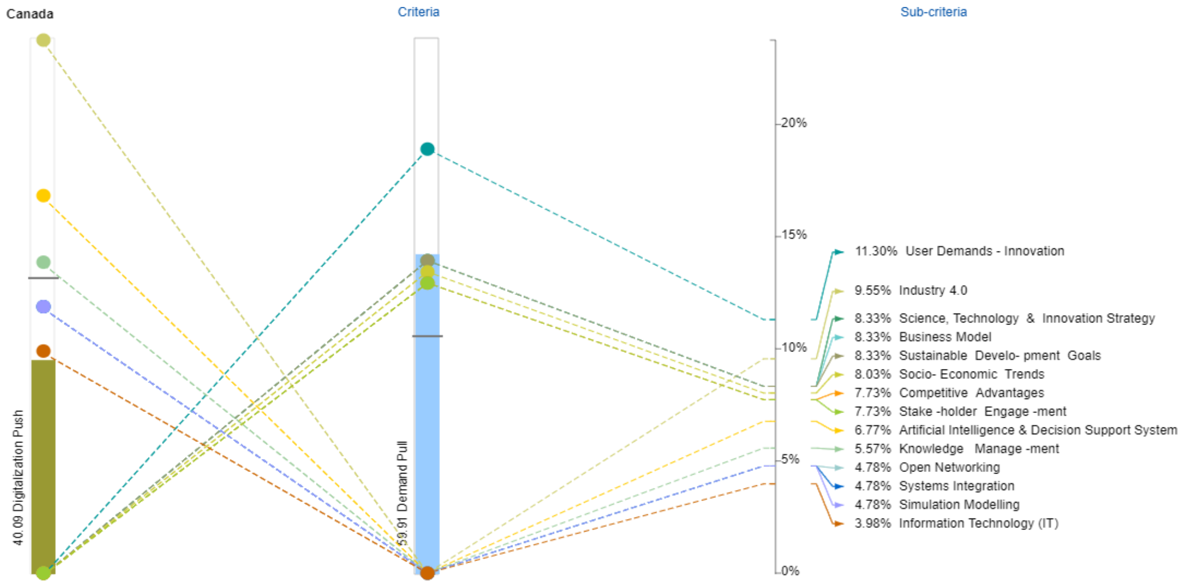

Figure 5-47. Sensitivity analysis with Digitalisation-Push (40%) and Demand-Pull (60%) for Canada's result

5.3.8.3. Sensitivity analysis for 60% Digitalisation-Push and 40% Demand-Pull

Figure 5.48 demonstrates the third scenario, with the weights for the main criteria being 40% for Demand-Pull and 60% for Digitalisation-Push. Industry 4.0 has appeared as the highest priority with 14.30%; the lowest sub-criteria are Competitive Advantages and Stakeholder Engagement scoring 5.15% each.

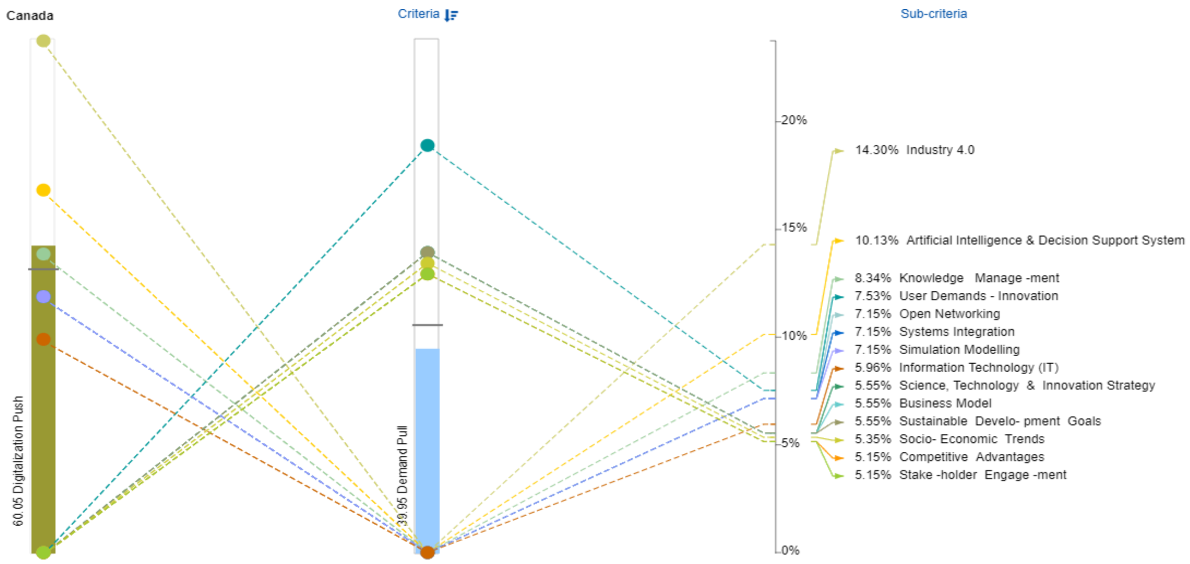

Figure 5-48. Sensitivity analysis with Digitalisation-Push (60%) and Demand-Pull (40%) for Canada's result

5.3.8.4. Sensitivity analysis for 70% Digitalisation-Push and 30% Demand-Pull

Figure 5.49 clarifies the fourth scenario, where the main criteria weights are almost 70% for Digitalisation-Push and 30% for Demand-Pull. In this case, Industry 4.0 is the highest sub-criterion, scoring 16.66%, and both Competitive Advantages and Stakeholder Engagement are the lowest sub-criterion with 3.87% each.

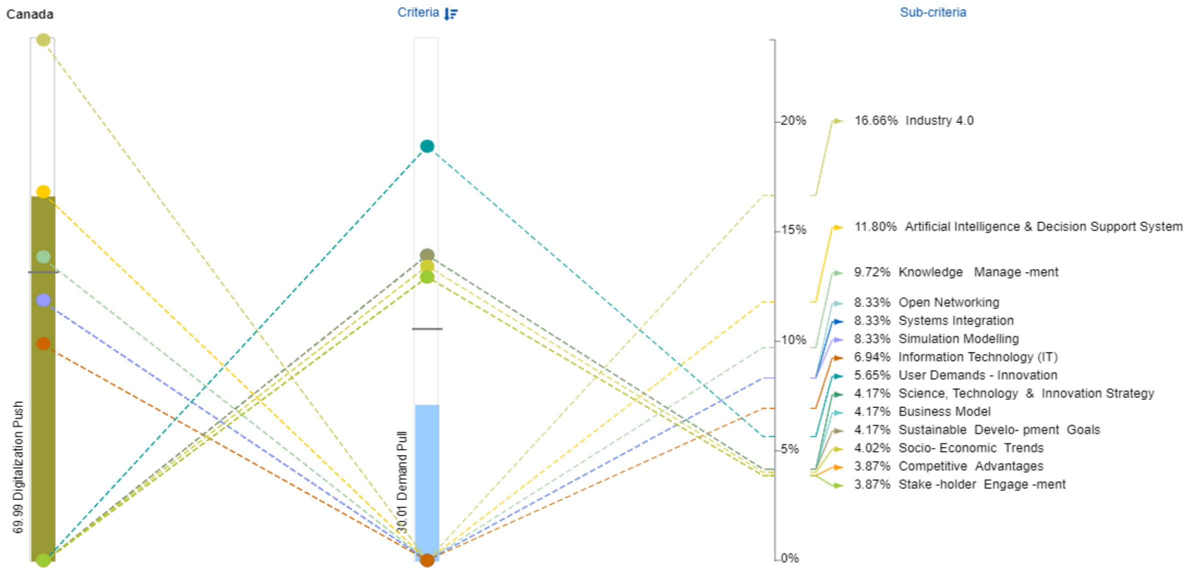

Figure 5-49. Sensitivity analysis with Digitalisation-Push (70%) and Demand-Pull (30%) for Canada's result

5.3.8.5. Sensitivity analysis for 30% Digitalisation-Push and 70% Demand-Pull

Figure 5.50 clarifies the final and fifth scenario for the Canada results, where the priority of the main criteria weights are 30% for Digitalisation-Push and 70% for Demand-Pull. This scenario shows that the uppermost sub-criterion is User Demands-Innovation, with a score of 13.21%. At the same time, Information Technology is ranked as the bottommost with a score of 2.98%.

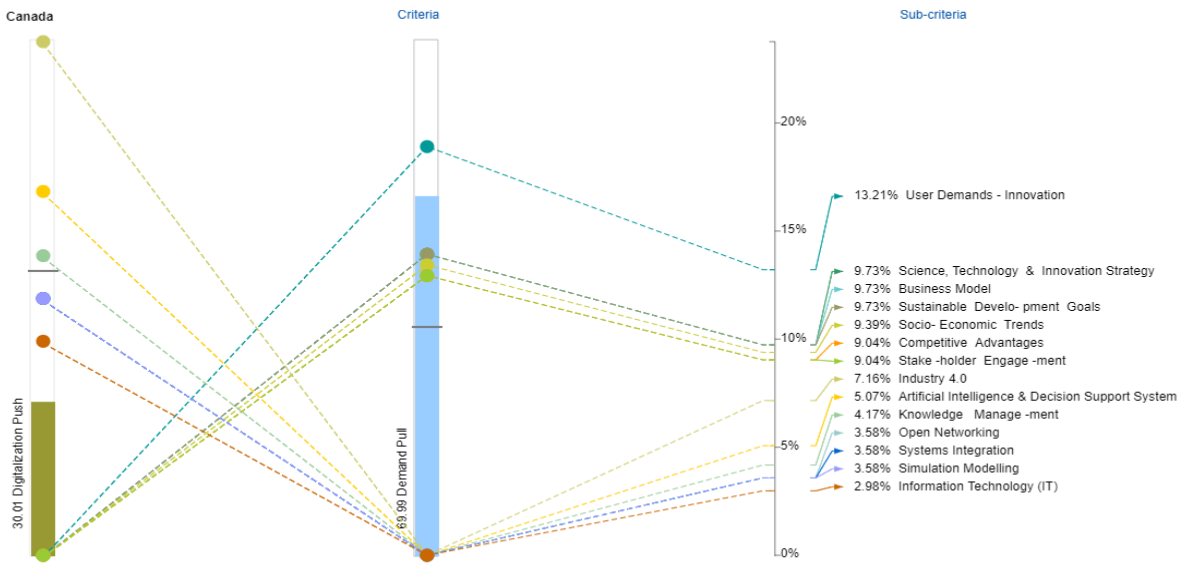

Figure 5-50. Sensitivity analysis with Digitalisation-Push (30%) and Demand-Pull (70%) for Canada's result

Table 5-9. Summary of sensitivity analysis for Canada Scenarios

Performance Sensitivity of Canada Scenarios									
%	**Digitalisation-Push (50%) and Demand-Pull (50%)**	**%**	**Digitalisation-Push (40%) and Demand-Pull (60%)**	**%**	**Digitalisation-Push (60%) and Demand-Pull (40%)**	**%**	**Digitalisation-Push (70%) and Demand-Pull (30%)**	**%**	**Digitalisation-Push (30%) and Demand-Pull (70%)**
11.90%	Industry 4.0	11.30%	User Demands – Innovation	14.30%	Industry 4.0	16.66%	Industry 4.0	13.21%	User Demands – Innovation
9.43%	User Demands – Innovation	9.55%	Industry 4.0	10.13%	Artificial Intelligence and Decision Support Systems	11.80%	Artificial Intelligence and Decision Support Systems	9.73%	Science, Technology, and Innovation Strategy
8.43%	Artificial Intelligence and Decision Support Systems	8.33%	Science, Technology, and Innovation Strategy	8.34%	Knowledge Management	9.72%	Knowledge Management	9.73%	Business Models
6.95%	Science, Technology, and Innovation Strategy	8.33%	Business Models	7.53%	User Demands – Innovation	8.33%	Open Networking	9.73%	Sustainable Development Goals
6.95%	Business Models	8.33%	Sustainable Development Goals	7.15%	Open Networking	8.33%	Systems Integration	9.39%	Socio-Economic Trends
6.95%	Sustainable Development Goals	8.03%	Socio-Economic Trends	7.15%	Systems Integration	8.33%	Simulation Modelling	9.04%	Competitive Advantages
6.94%	Knowledge Management	7.73%	Competitive Advantages	7.15%	Simulation Modelling	6.94%	Information Technology	9.04%	Stakeholder Engagement
6.70%	Socio-Economic Trends	6.77%	Stakeholder Engagement	5.96%	Information Technology	5.65%	User Demands – Innovation	7.16%	Industry 4.0
6.46%	Competitive Advantages	5.57%	Artificial Intelligence and Decision Support Systems	5.55%	Science, Technology, and Innovation Strategy	4.17%	Science, Technology, and Innovation Strategy	5.07%	Artificial Intelligence and Decision Support Systems
6.46%	Stakeholder Engagement	4.78%	Knowledge Management	5.55%	Business Models	4.17%	Business Models	4.17%	Knowledge Management
5.95%	Open Networking	4.78%	Open Networking	5.55%	Sustainable Development Goals	4.17%	Sustainable Development Goals	3.58%	Open Networking
5.95%	Systems Integration	4.78%	Systems Integration	5.35%	Socio-Economic Trends	4.02%	Socio-Economic Trends	3.58%	Systems Integration
5.95%	Simulation Modelling	4.78%	Simulation Modelling	5.15%	Competitive Advantages	3.87%	Competitive Advantages	3.58%	Simulation Modelling
4.96%	Information Technology	3.98%	Information Technology	5.15%	Stakeholder Engagement	3.87%	Stakeholder Engagement	2.98%	Information Technology

5.4. Discussion and Conclusions

The validation of the proposed new generation-innovation framework through feedback from the questionnaires drawn from the seven global countries was crucial for the research methodology. The responses could be used to confirm its usefulness to industry professionals. By creating a questionnaire consisting of pair-wise comparisons and feeding the reaction to the AHP software, strong judgements could be made about how the various criteria fared in the contributor's needs. The diverse Digitalisation-Push and Demand-Pull components were carefully chosen after conducting a thorough literature review and studying developing trends in the economy. Thus, if the priorities of these criteria were closely placed around each other, it would imply that the proposed form is fit for its purpose. However, if, on the other hand, some components had relatively low priority compared to the rest, then it would imply that participants did not share the view of the former being included in the framework. In this case, these could even be removed from the framework.

Firstly, Digitalisation-Push and Demand-Pull were crucial as primary criteria for accomplishing the goal of the future innovation framework. There was substantial evidence from the seven countries participating in the research that Digitalisation-Push and Demand-Pull play equally significant roles in successful innovation, identification and delivery.

The Digitalisation-Push criteria show that technological advancements such as Industry 4.0 are the topmost required in the seven countries. Artificial Intelligence and Decision Support systems, Information Technology, and Simulation Modeling were the most influential in assisting innovation. The rest of the sub-criteria, such as Knowledge Management, Open Networking, and System Integration, were less critical compared to other sub-criteria within Digitalisation Push. Technological developments such as additive manufacturing within Industry 4.0 are undoubtedly emerging technology and digital methods.

On the other hand, in the Demand-Pull criteria, User-demand Innovation fared the highest among participants in terms of how important this was to trigger innovation. It was expected that international organisations' main drivers behind innovation needs are to be industry leaders and gain market share. The value of customer feedback and experience was also demonstrated by how strongly the seven global countries felt about the user of innovation as innovation triggers.

It can be said that customers are more empowered in today's economy and that they are quite aware of how to make the best use of the products and services they use.

Thus, among the Demand-pull component, limited performers were Socio-Economic Trends and Competitive advantages, Stakeholder Engagements, and Business models. Conversely, User-demand Innovation, Sustainable Development Goals, and Science, Technology and Innovation strategies were preferred for global needs.

Chapter 6

Innovation Processes Model within the Proposed Framework

6.1. Introduction

This chapter introduces the necessary processes through which the sustainable system of innovation concept investigates the interdependencies and dynamics of the multiple factors that enable sustainable economic development and competitiveness. Sustainable innovations are a crucial component of businesses' innovation capabilities, as sustainable economic growth depends upon a steady investment in technological and organisational variations to manage the production process more efficiently (Rennings, 2000; Fernandes et al., 2022).

The concept of an innovation system or framework appears relevant to executing the innovation processes model required to illustrate the innovation processes in various industries in different countries. One of the primary goals of an innovation framework is that it contributes to the development and diffusion of innovations, which need to function and very often stimulate sustainable initiatives (Freeman, *et al.*, 2007).

On the other hand, the definition of innovation systems is extended through the explicit inclusion of natural elements: 'a sustainable system of innovation is constituted by human and natural elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge' (Johnson, 1999). Sustainability then provides a vision of a desirable state of what the future should present and sustain a set of rules that imply what ought to happen for this state to be realized (Renn et al., 2009). The following part discusses the implications of a new sustainable process model for innovative ideas from a management perspective for the theory and the practice of Demand-Pull and Digitalisation-Push.

6.2. The proposed innovation processes within the proposed innovation management framework

Innovation can be linked to products, processes, services, operations, and people (Hermans et al., 2019). Moreover, companies demand innovation to adapt their organisational structure and integrate strategies to achieve an alignment toward sustainability (Hernandez-Vivanco, *et al.*, 2018). Previous studies revealed various types of innovation: processes, organisational frameworks, and marketing systems; those types improve customer satisfaction and have effects intrinsically attributed to new and improved sustainable product innovation (Rebelo, *et al.*, 2016).

The innovation processes model is of prime importance; it can be applied to test the ideas of experts to obtain the appropriateness of the innovation framework for manufacturing, firms, and organisations. Furthermore, considerable attention to the sustainability loop is paid to successfully implement the propose innovation framework and reduce barriers impeding the implementation ideas process. Several processes are illustrated in Figure 6.1 for any firm to reduce uncertainty by providing information through the dynamic loop for an organisation to meet market demand "competitive market" in the digital era. The processes based on the author's understanding are listed with a brief explanation in Table 6.1, and their interrelationships with the proposed framework are presented in Figure 6.1.

Table 6-1 Definitions of the proposed innovation processes impeded in the innovation framework

	Definition
Idea Proposal	Propose and screen a new idea that will be created based on future needs or glances, and the view from two perspectives, either "demand-pull "or "digitalisation-push."
Research & Development	This stage still screens the new idea. The system considers the allocation of resources to R&D activities, the results of the innovation system (where R&D is one of its determinants) for efficient productivity, where innovation performance is also included as the core of its determinants. The potential impact of the results of an R&D project can be more significant in large firms.
Evaluate innovation capabilities	This stage is considered necessary in the innovation dynamics system. *Evaluating innovation capabilities* are the most crucial factor in organisations. It also is an essential source for firms in the industry for modernisation and competitiveness; moreover, it responds to customer satisfaction and changes in service innovation (customer service, after-sales service, and delivery service), additional significantly positive impact on marketing innovation, also incremental improvements by approaching existing capabilities.
Global Benchmark/ Stakeholder involvement	Subsequently, the stage investigating the global industry benchmark needs a digital vision to transform from a new market requirement to a competition of key favourable advantages for executing recent manufacturing advancements and innovations.

	In this respect, the current study proposes a positive relationship between stakeholders, and customer orientation, by firms' innovation capability translates through a commitment to long-term relationships. This stage addresses the previous stage, using the decision evaluation scale
Innovative Initiatives	Next stage, several initiatives involve any organisation that collaboratively seeks innovative solutions. More innovative initiatives work to enhance an organisation's work. Internal screen from the organisation
- **Measurement** - **Performance** - **Internal Assessment**	- Measurement: significant direct and indirect effect on the results of the innovative project - Performance: improves innovative performance and product development - Internal Assessment: generates a positive impact on the performance of different organisational processes, such as increased individual involvement, better problem-solving, creative solutions, and effective implementation of decisions After three processes, theories to investigate and make the prioritisation scale for the idea
Idea Acceptance	In this stage, the decision-maker scales play the primary role in accepting the idea
Roll-out/ Development/ Commercialisation	The final system stage is in the implementation scale for success in economic and industrial development in developing countries

The proposed innovation processes cover an interaction network of sustainability feature loops. Furthermore, displaying and interacting with the innovation framework, a dynamic analysis is necessary to monitor the interactions between the innovation processes, considering the sequence of all the relevant processes. An appropriate method is described as the 'process approach' or 'sequence analysis.

The innovation processes embrace components of several integration functions, including the interaction between "Demand-pull" and "Digitalisation-push". Conversely, they generate ideas from both ways to accelerate organisations' processes, products, and services. As a result of this innovation processes model, feedback from the selection idea leads to innovations and increasing diversity in improvements and developments in organisations and industries.

Integrating the innovation processes model with the proposed innovation framework can be helpful in various ways, such as: **Reusability:** Innovation frameworks provide a set of common components and patterns that can be reused across multiple projects. By integrating the innovation processes model with the proposed innovation framework, developers can take advantage of these pre-built components and patterns, which can save time and effort when building new features or functionality.

- **Consistency:** Innovation frameworks with the innovation processes model can help to ensure consistency in the design and creation of new and validated ideas, by adhering to the conventions and best practices set out by the framework.

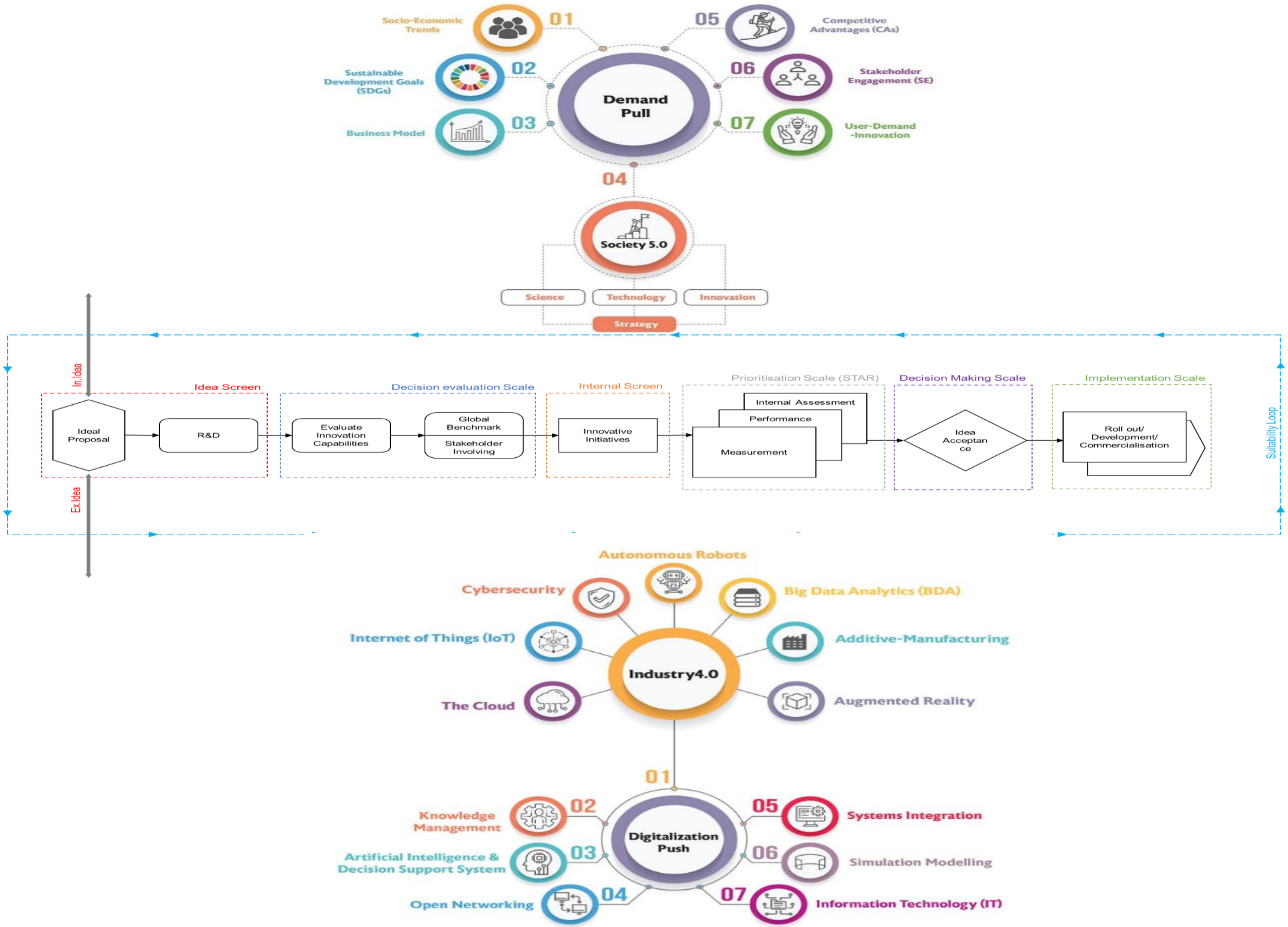

Figure 6-1. The proposed innovation framework and the impeding innovation processes model

6.3. Conclusion

In conclusion, the proposed innovation processes model comprises several functions related to the characteristics and interactions between the elements. They provide the circumstances for business activities and innovative performances. Nowadays, organisations focus on creating value for the customer, who is becoming more aware and demanding regarding lead time delivery services, product availability, and reliability.

This linkage between the sustainable system and framework sheds light on the existing state of extant research on the topic and offers several directions to advance the field rather than to provide an essential solution. The researcher hopes that the study inspires scholars and executive readers and that it paves the way for more insightful research on the multidisciplinary interplay between innovation theory and implementation of innovation management in various industries.

Chapter 7
Conclusion, Contribution to knowledge, limitations and future work

7.1. Introduction

In this chapter, the conclusion is stated; besides the contributions to knowledge, future work and the research limitations.

7.2. Conclusion

It is anticipated that the new proposed innovation management framework could fill the gap in knowledge in the 21st century. Moreover, it influences innovation outcomes in different sectors of industries, firms, manufacturers, and organizations, either government, private or academic, to enhance the effectiveness and efficiency of achieving marketplace demand and digital push in the era of the digital economy.

Scholars broadly viewed innovation management as an essential advantage, a survival for economic growth. The seven previous models for innovation are presented in the systematic literature review chapter; this study developed a combined theoretical model which aims to help understand appropriate organisations and market demand and concurrently maintain the latest innovative pull. In addition, the proposed innovation framework is essential to sustain and reform the current system structure from a vertical and deterrent system to a cross-sectional, flexible and open one.

The competitive, transforming world has made it impractical to use ready-made solutions to the problems ahead; therefore, managers at different levels must invent new procedures and actions to solve them. In addition, organisations require a practical value to achieve a competitive advantage. Innovation is one of the essential factors in economic growth and improving the competitiveness of nations is the primary source of prosperity production in economics. The proposed new innovation framework was developed based on two main criteria, the demand-pull and digitalisation-push. The first main criterion, "*Demand-Pull*", contains seven sub-criteria, and their main characteristic is the existence of interactive relationships with each other; they play a crucial role in improving innovation performance. Socity.5.0 is a leading sub-criterion the Japanese government presents to enhance future human needs.

Innovation in enhanced manufacturing technology includes product innovation and industry model innovation. Moreover, digitalisation is the broad empowering technology for products, services and digital manufacturing innovation. However, from that context, the second main criterion for the innovation framework, "*Digitalisation-Push"*, plays a significant performance and critical role in the future of firms and industries. Industry 4.0 is the primary digitalisation-push sub-criteria which draws a relatively comprehensive picture of the innovation framework in addition to the other six sub-criteria proposed in the framework.

This study exposes qualitative survey results from seven prestigious countries: the "United Kingdom, United Arab Emirates, United States, China, Japan, Germany and Canada.". Moreover, the analytic hierarchy process, AHP methods have provided a practical methodology for the proposed innovation framework to be analysed and validated. The model is generally used to evaluate importance criteria based on the concept of paired comparison; in addition, pair-wise comparison aims to stimulate preferences by comparing criteria and/or attributes by standard rating (or ranking) them in pairs; it has revealed interesting results. In the Demand-Pull criteria, User-demand Innovation fared the highest among participants in terms of how important this was to trigger innovation. It was expected that international organisations' main drivers behind innovation needs are to be an industry leader, gaining market share. The value of customer feedback and experience was also demonstrated by how strongly the seven global countries felt about the user of innovation as the innovation trigger.

On the other hand, Industry 4.0 is the topmost required in the seven countries. Artificial Intelligence and Decision Support systems, Information Technology, and Simulation Modelling were most influential in assisting innovation. The rest of the sub-criteria, such as Knowledge Management, Open Networking, and System Integration, were less critical than other sub-criteria within Digitalisation Push. Technological developments such as additive manufacturing within Industry 4.0 are digital approaches.

7.3. Contributions to knowledge

The following points are considered based on the analyses of data collected from the participants who are identified to make contributions to knowledge and to exchange services/innovation in their organisations/ industries:

1. ***Developing the innovation management framework for the digital era***:

   Through this, innovative solutions can be provided by focusing on the digital transformation and adopting the digital technologies in the 21st-century.

2. ***The introduction of the innovation processes:***

   The innovation processes required to integrate both the Demand-Pull and Digitalisation push were introduced to help in the innovation management steps.

3. ***The usage of the Analytic Hierarchy Process (AHP) in the innovation management:***

   As can be seen, AHP provided a very practical research method which allowed for the analysis of the data collected, the validation of the proposed innovation framework and also for carrying out the sensitivity analysis procedures, which are crucial to understanding the model behaviour and its limitations; Besides, measuring the inconsistency ratio of the participants' contribution toward building the proposed innovation framework.

4. ***The involvement of the seven prestigious countries:***

   The contribution of these seven countries (UK, UAE, USA, Germany, Japan, China, and Canada), recruited a large sample size of 360 participants from different fields of innovation, which added to the credibility of the proposed innovation framework.

7.4. Limitations and future work

Although the author of this thesis and the supervisory team are experts in the innovation field, out of which the innovation processes were recommended, however, as for future work, these need to be validated.

In addition, for future work, the tools required for each process must be identified to facilitate the innovation processes. Furthermore, a performance measures model through which organisations can evaluate their innovation performance and hence allow benchmarking practice to achieve the required competitive advantages is needed and scheduled for future work.

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Zuo, W., Zhang, X., & Ge, Y. (2021). The economic globalization for sustainable management of overseas trade enterprise logistics. *Expert Systems*, *July*, 1–13. https://doi.org/10.1111/exsy.12887

Appendix – Surveys

Survey in English (Monkey Survey Online)

Link for the survey: https://www.surveymonkey.com/r/6thGen-Innovation

Research Questionnaire

Author: Samah Alnuaimi

University: Sheffield Hallam University

Faculty/Department: Faculty of Science, Technology & Arts (Department of Engineering)

Background:
Innovation is the process of transforming ideas into marketable products or services so that they can produce value for customers and generate revenue for producers. It has played a vital part in creatively disrupting industries and ushering in new trends, markets, and approaches. Since the 1950s, this process has undergone generational changes to make it relevant to the current economic environment.

Innovation Framework	Timeline	Characteristics
First generation	1950s – Mid 1960s	Technological Push (technology-driven business, industrial revolution)
Second generation	Mid1960s – Early 1970s	Market / Demand Pull (R&D driven by market development)
Third generation	Early 1970s – Mid1980s	Coupling Model (Combination of technological push and market pull)
Fourth generation	Mid1980s – Early 1990s	Integration Management (integration of cross-functional teams, Parallel processes)
Fifth generation	Early 1990s – Mid 2000s	System Integration (extensive networking, focus on fast product development)
Sixth generation	Mid 2000s – Present	Network Integration (interactive networks in line with business strategy, value perception in customer experience)

The aim of this research is to propose a "**New Generation Innovation Framework for future Digital Economy**", which defines the process life-cycle from idea generation through to commercialisation, and the factors affecting it. This has been developed keeping in mind the current socio-economic environment, the evolution of business processes, technological advancements and market trends.

This questionnaire has been developed for circulation among professionals in the industry so that their feedback can be used to validate/amend the framework and confirm its usefulness to organisations.

Survey in Japanese

<u>Research Questionnaire /研究アンケート</u>

Author /著者: Samah Alnuaimi

University/大学 : Sheffield Hallam University

Faculty/Department 学部/学部 : Faculty of Science, Technology & Arts (Department of Engineering) 理工学部

Background/ バックグラウンド:

Innovation is the process of transforming ideas into marketable products or services so that they can produce value for customers and generate revenue for producers. It has played a vital part in creatively disrupting industries and ushering in new trends, markets, and approaches. Since the 1950s, this process has undergone generational changes to make it relevant to the current economic environment.

それは彼らが顧客のために価値を生み出し、生産者のための機会を生み出すことができるようにサービスやサービスのための新しいアイデアや製品のための創造的なアイデアの一部として再生されました。このプロセスは、現在の経済環境に関連するものにするために世代交代を受けました。

Innovation Framework イノベーション フレームワーク	Timeline タイムライン		Characteristics 特徴的
First generation **初代**	1950s – Mid 1960s	1950年代 - 1960年代半ば	Technological Push (technology-driven business, industrial revolution) 技術プッシュ（技術主導のビジネス、産業革命）
Second generation **第2世代**	Mid1960s – Early 1970s	1960年代半ば - 1970年代初頭	Market / Demand Pull (R&D driven by market development) マーケット/デマンドプル（市場開拓による研究開発）
Third generation **第三世代**	Early 1970s – Mid1980s	1970年代初頭 - 1980年代半ばs	Coupling Model (Combination of technological push and market pull) カップリングモデル（技術プッシュとマーケットプルの組み合わせ）
Fourth generation **4代目**	Mid1980s – Early 1990s	1980年代半ば - 1990年代初頭	Integration Management (integration of cross-functional teams, Parallel processes) 統合管理（機能横断型チームの統合、並列プロセス
Fifth generation **5代目**	Early 1990s – Mid 2000s	1990年代初頭 2000年代半ば	System Integration (extensive networking, focus on fast product development) システムインテグレーション（広範囲なネットワーキング、迅速な製品開発への注力
Sixth generation **第六世代**	Mid 2000s – Present	2000年代半ば ～現在	Network Integration (interactive networks in line with business strategy, value perception in customer experience)

	ネットワーク統合（事業戦略に沿った対話型ネットワーク、顧客体験における価値認識）

The aim of our research is to propose a ***"New Generation Innovation Framework for future Digital Economy"***, which defines the process lifecycle from idea generation through to commercialization, and the factors affecting it. This has been developed keeping in mind the current socio-economic environment, evolution of business processes, technological advancements and market trends.

This questionnaire has been developed for circulation among professionals in industry so that their feedback can be used to validate/amend the framework and confirm its usefulness to organizations.

As an experienced director, manager, engineer, consultant or researcher, your valuable input is requested in the form of this questionnaire which will form an essential part of our research methodology. Your information and responses will be treated as confidential, the latter will be used for statistical purposes in this research.

研究の目的は、アイデアの生成から事業化までのプロセスライフサイクルを定義する「未来のデジタル経済のための新世代イノベーションフレームワーク」を提案することです。現在の社会経済環境、ビジネスプロセスの進化、技術の進歩、市場動向を念頭に置いて開発されています。

この調査は、業界の専門家の間で循環するために開発され、そのフィードバックは、フレームワーク/変更を検証し、組織への有用性を検証するために使用することができます。

経験豊富なディレクター、マネージャー、エンジニア、コンサルタント、研究者として、このアンケートの形で貴重なフィードバックを聞き、研究方法論の重要な部分を形成します。お客様の情報と回答は機密情報として扱われ、後者は本研究で統計的な目的で使用されます。

Participant information/ 参加者情報:

Please fill in the following (* are mandatory) 以下のご記入ください(*必須です)。

Full Name/ 名前 ....

*Job Title/ *役職 ....

Company Name/ 会社名 ....

Department/ 部署 ....

*Industry Field (e.g. energy, transport, utilities, IT, etc.) / *産業分野(エネルギー、輸送、公益事業、ITなど) ....

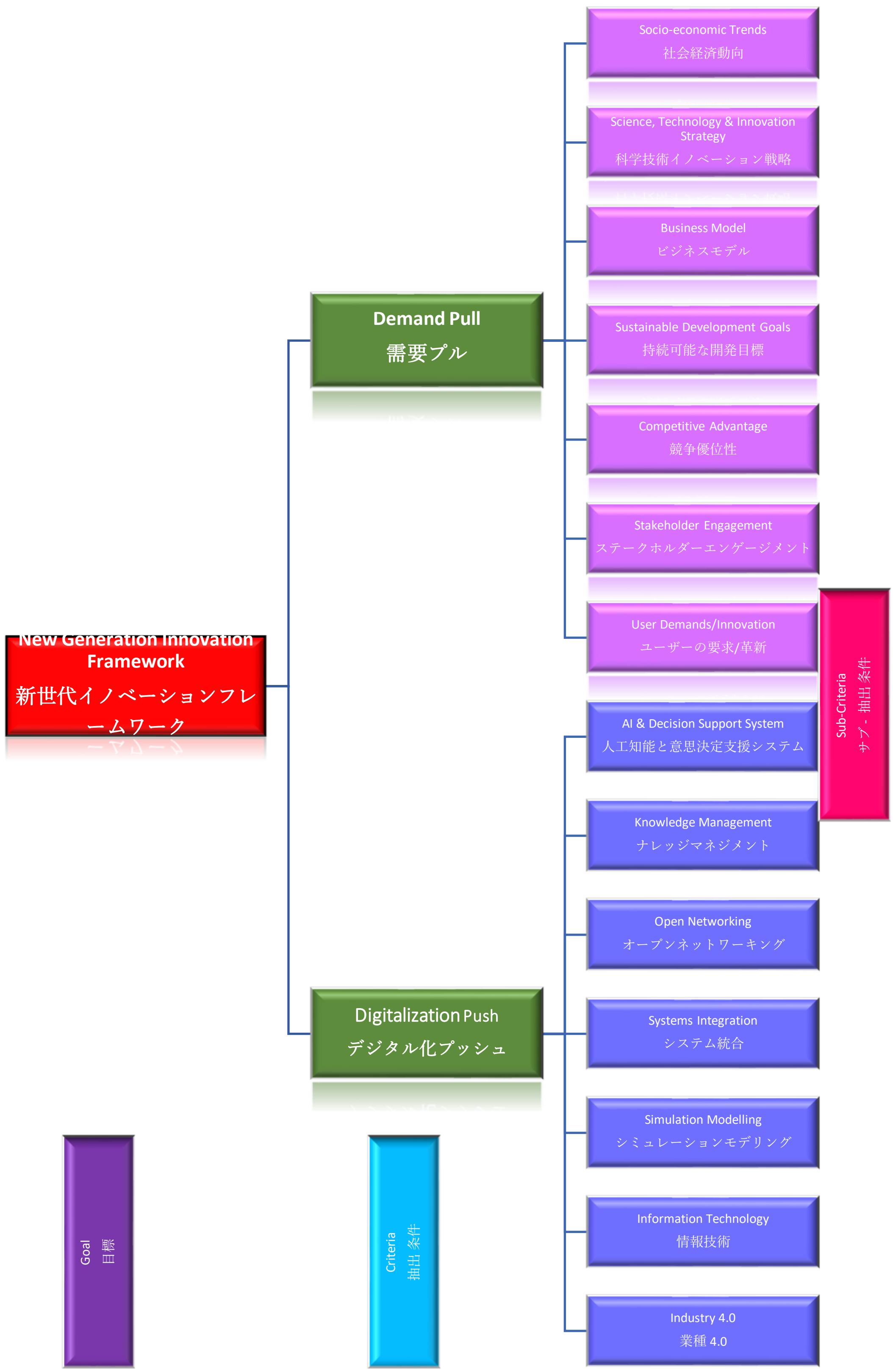
*Years of experience/ *長年の経験 ....

Contact Email /*長年の経験 ....

* Country / 国: ....

Innovation Framework Proposal

イノベーションフレームワーク提案



New Generation Innovation Framework
新世代イノベーションフレームワーク
Demand Pull
需要プル
Digitalization Push
デジタル化プッシュ
Socio-economic Trends
社会経済動向
Science, Technology & Innovation Strategy
科学技術イノベーション戦略
Business Model
ビジネスモデル
Sustainable Development Goals
持続可能な開発目標
Competitive Advantage
競争優位性
Stakeholder Engagement
ステークホルダーエンゲージメント
User Demands/Innovation
ユーザーの要求/革新
AI & Decision Support System
人工知能と意思決定支援システム
Knowledge Management
ナレッジマネジメント
Open Networking
オープンネットワーキング
Systems Integration
システム統合
Simulation Modelling
シミュレーションモデリング
Information Technology
情報技術
Industry 4.0
業種 4.0
Sub-Criteria
サブ - 抽出 条件
Goal
目標
Criteria
抽出 条件

Guidance on answering questionnaire

アンケートに回答する方法に関するガイダンス:

Questions below have been produced in a format to allow a pairwise comparison to mathematically model factors' relative importance to each other. Every question has a scale up to 8 at each end. Please tick/shade/circle in the relevant box as a measure of your view of the item's relative importance. If you don't have an opinion or feel the items have equal importance, please tick/shade/circle '1'.

次の質問は、数学的モデル因子の相対的な重要性を相互に比較できる形式で作成されます。すべての質問は、各端に最大8のスケールを持っています。項目ビューの相対的な重要度の尺度として、関連するボックスにチェック/シェード/円を入力します。あなたが意見を持っていないか、アイテムが等しい重要性を感じる場合は、/シェード/円'1'をチェックしてください。

The following example shows pairwise comparison of two criteria, Demand Pull and Digitilization Push. If you think Demand Pull is 8 times more important than Digitilization Push, shade '8' on the left hand side.

次の例は、デマンド プルとデジタル化プッシュの 2 つの基準のペアワイズ比較を示しています。デマンドプルがデジタル化プッシュの8倍重要だと思う場合は、左側のシェード「8」を表示します。

Demand Pull /需要プル		**Digitalization Push /デジタル化プッシュ**
Demand Pull are triggers for organizations to innovate, either to stay relevant in industry or to further strengthen its market position. 需要引き上げは、企業が業界で関連性を維持し続けたり、市場での地位をさらに強化したりする機会です。		Digitalization Push are enabling factors that assist organizations to innovate in the era of digital economic. デジタル化プッシュは、組織がデジタル経済の時代に革新を支援する要因を可能にしています。

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Similarly, if you think Demand Pull is equally as important as Digitalisation Push, shade '1'.

同様に、デマンドプルがデジタル化プッシュと同じくらい重要であると思う場合は、シェード '1' です。

Demand Pull /需要プル									Digitalization Push /デジタル化プッシュ							
Demand Pull are triggers for organizations to innovate, either to stay relevant in industry or to further strengthen its market position. 需要引き上げは、企業が業界で関連性を維持し続けたり、市場での地位をさらに強化したりする機会です。									Digitalization Push are enabling factors that assist organizations to innovate in the era of digital economic. デジタル化プッシュは、組織がデジタル経済の時代に革新を支援する要因を可能にしています。							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Section A

セクション A

There is only one question in this section. Please circle an appropriate number in the scale to indicate the relative importance of two factors shown in each question.

このセクションには 1 つの質問しかありません。各質問に示す 2 つの要因の相対的な重要性を示すために、スケール内の適切な数値を丸で囲んでください。

Demand Pull /需要プル									Digitalization Push /デジタル化プッシュ							
Demand Pull are triggers for organizations to innovate, either to stay relevant in industry or to further strengthen its market position. 需要引き上げは、企業が業界で関連性を維持し続けたり、市場での地位をさらに強化したりする機会です。									Digitalization Push are enabling factors that assist organizations to innovate in the era of digital economic. デジタル化プッシュは、組織がデジタル経済の時代に革新を支援する要因を可能にしています。							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Section B / セクション B

(Demand Pull 需要プル）

Please use the same way as above to compare the importance of the following sub-criteria:

以下の重要性を比較するには、上記と同じ方法で使用してください サブ - 抽出 条:

<table>
<tr><td colspan="8">Socio-Economic Trends /
社会経済動向</td><td></td><td colspan="8">Science, Technology & Innovation Strategy / 科学・技術・イノベーション戦略</td></tr>
<tr><td colspan="8">Field of study that examines trends of social and economic factors to better understand how the combination of both creates a new pathway of products and services(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, et al., 2005),
社会的・経済的要因の動向を調べ、両者の組み合わせが製品とサービスの新しい経路を作り出す方法をよりよく理解する研究分野。</td><td></td><td colspan="8">Innovation Strategy is a Company’s strategy publication that describes its approach to innovation, using development in science and technology as the main catalysts.
イノベーション戦略は、科学技術開発の主な触媒としてイノベーションへのアプローチを説明する企業戦略出版物です。</td></tr>
<tr><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
</table>

<table>
<tr><td>Socio-Economic Trends / 社会経済動向</td><td></td><td>Business Model/ ビジネスモデル</td></tr>
<tr><td>Field of study that examines trends of social and economic factors to better understand how the combination of both creates a new pathway of products and services (Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt,</td><td></td><td>It is a Company’s plan to make profit by identifying key products/services to sell, the target market it has identified and the expense it anticipates.
これは、販売する主要な製品/サービス、特定したターゲット市場、および予想される経費を特定することによって利益を上げる会社の計画です。</td></tr>
</table>

2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, *et al.*, 2005), 社会的・経済的要因の動向を調べ、両者の組み合わせが製品とサービスの新しい経路を作り出す方法をよりよく理解する研究分野。		

9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Socio-Economic Trends / 社会経済動向		**Sustainable Development Goals / 持続可能な開発目標**
Field of study that examines trends of social and economic factors to better understand how the combination of both creates a new pathway of products and services (Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, *et al.* 2005) 社会的・経済的要因の動向を調べ、両者の組み合わせが製品とサービスの新しい経路を作り出す方法をよりよく理解する研究分野。		These are 17 goals set out by the United Nations to create a sustainable future for all, such as affordable and clean energy, responsible production and consumption. これらは、手頃な価格、クリーンエネルギー、責任ある生産と消費を含むすべての人のための持続可能な未来を作成するために国連によって設定された17の目標です。

9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Socio-Economic Trends / 社会経済動向		**Competitive Advantage / 競争優位性**
Field of study that examines trends of social and economic factors to better understand how the combination of both creates a new pathway of products and services (Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant		Superior position in industry and market share gained providing same value as its competitors but at a lower price, or charging higher prices by providing greater value through differentiation. 業界と市場シェアの優位性は、競合他社と同じ価値を提供しますが、より低い価格で、または差別化を通じてより大きな価値を提供することにより、より高い価格を請求します。

and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, *et al.*, 2005) 社会的・経済的要因の動向を調べ、両者の組み合わせが製品とサービスの新しい経路を作り出す方法をよりよく理解する研究分野。		

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Socio-Economic Trends / **社会経済動向**		**Stakeholder Engagement /** **ステークホルダーエンゲージメント**
Field of study that examines trends of social and economic factors to better understand how the combination of both creates a new pathway of products and services (Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, *et al.*, 2005) 社会的・経済的要因の動向を調べ、両者の組み合わせが製品とサービスの新しい経路を作り出す方法をよりよく理解する研究分野。		Engagement with stakeholders through conferences and workshops to better understand consumer needs and behaviour as well as listening to their ideas. カンファレンスやワークショップを通じてステークホルダーと関わり、消費者のニーズや行動をより深く理解し、アイデアに耳を傾けます。

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Socio-Economic Trends / **社会経済動向**		**User Demands - Innovation /** **ユーザーの要求 - イノベーション**
Field of study that examines trends of social and economic factors to understand better how the combination of both creates a new pathway of products and services (Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd et al., 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant		User-demand could be internal, which can be effectively used to create a product/ services to exceed their expectations, or external as a secondary organization benefit in creating a better work culture/environment. ユーザーの需要は、より良い仕事文化/環境を作成する際に二次的な組織の利益として、期待を超える製品/サービスを作成するために効果的に使用することができる内部である可能性があります。

<table>
<tr><td colspan="8">and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, Bessant and Pavitt, 2005)(Tidd, et al., 2005)
社会的・経済的要因の動向を調べ、両者の組み合わせが製品とサービスの新しい経路を作り出す方法をよりよく理解する研究分野。</td><td></td><td colspan="8"></td></tr>
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<table>
<tr><td colspan="8">Science, Technology & Innovation Strategy /
科学・技術・イノベーション戦略</td><td></td><td colspan="8">Business Model/
ビジネスモデル</td></tr>
<tr><td colspan="8">Innovation Strategy is a Company’s strategy publication that describes its approach to innovation, using development in science and technology as the main catalysts.
イノベーション戦略は、科学技術開発の主な触媒としてイノベーションへのアプローチを説明する企業戦略出版物です。</td><td></td><td colspan="8">A Company plans to profit by identifying essential products/services to sell, its target market, and the expense it anticipates.
これは、販売する主要な製品/サービス、特定したターゲット市場、および予想される経費を特定することによって利益を上げる会社の計画です。</td></tr>
<tr><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
</table>

<table>
<tr><td colspan="8">Science, Technology & Innovation Strategy /
科学・技術・イノベーション戦略</td><td></td><td colspan="8">Sustainable Development Goals /
持続可能な開発目標</td></tr>
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Section C /セクション C

(Digitalization Pushデジタル化プッシュ)

Artificial Intelligence & Decision Support System / 人工知能・意思決定支援システム		**Knowledge Management / ナレッジマネジメント**
Use intelligent technology (such as fuzzy logic) to gather and analyze information, identify and diagnose problems, determine the course of best behavior, and emulate human consultants as rigorously as possible. インテリジェントな技術(ファジーロジックなど)を使用して、情報の収集と分析、問題の特定と診断、最善の行動の経過を決定し、人間のコンサルタントを可能な限り厳密にエミュレートします。		This is the process of capturing, retrieving, evaluating, and sharing your organization's information assets, such as policies, procedures, databases, and experiences that were not previously acquired by individual workers. これは、組織の情報資産 (ポリシー、手順、データベース、以前は個々の作業者で取得されなかった経験など) をキャプチャ、取得、評価、共有するプロセスです。

9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Artificial Intelligence & Decision Support System / 人工知能・意思決定支援システム		**Open Networking / オープンネットワーキング**
Use intelligent technology (such as fuzzy logic) to gather and analyze information, identify and diagnose problems, determine the course of best behavior, and emulate human consultants as rigorously as possible. インテリジェントな技術(ファジーロジックなど)を使用して、情報の収集と分析、問題の特定と診断、最善の行動の経過を決定し、人間のコンサルタントを可能な限り厳密にエミュレートします。		It forms a partnership or strategic alliance with an external organization for new product development. これは、新製品開発のための外部組織とのパートナーシップまたは戦略的提携を形成しています。

9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Artificial Intelligence & Decision Support System / 人工知能・意思決定支援システム		**Systems Integration/ システム統合**
Use intelligent technology (such as fuzzy logic) to gather and analyze information, identify and diagnose problems, determine the course of best behavior, and emulate human consultants as rigorously as possible.		This is an organization's strategic capability to integrate components, skills and knowledge from external organizations (suppliers, users, production partners, Government) to produce products and services.

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これは、コンピュータソフトウェアを使用して現実のシステムをエミュレートしようとする数学的および論理的な概念の両方を組み合わせた仮想モデルです。</td></tr>
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これは、コンピュータとネットワーク システムを使用して、情報を格納、取得、および交換します。</td></tr>
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インテリジェントな技術(ファジーロジックなど)を使用して、情報の収集と分析、問題の特定と診断、最善の行動の経過を決定し、人間のコンサルタントを可能な限り厳密にエミュレートします。		manufacturing and a digital convergence between industry, businesses and other processes. インダストリー4.0は、製造業におけるサイバー物理的変革です。モノのインターネット、自律型ロボット、サイバーセキュリティ、クラウド、シミュレーション、ビッグデータ分析、アディティブマニュファクチャリング、拡張現実、システム統合で構成されています。この名前は、ドイツの産業4.0、コネクテッド・マニュファクチャリング、産業、企業、その他のプロセス間のデジタル・コンバージェンスを促進する政府のイニシアチブに触発されています。

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Knowledge Management / **ナレッジマネジメント**		**Open Networking /** **オープンネットワーキング**
This is the process of capturing, retrieving, evaluating, and sharing your organization's information assets, such as policies, procedures, databases, and experiences that were not previously acquired by individual workers. これは、組織の情報資産（ポリシー、手順、データベース、以前は個々の作業者で取得されなかった経験など）をキャプチャ、取得、評価、共有するプロセスです。		It forms a partnership or strategic alliance with an external organization for new product development. これは、新製品開発のための外部組織とのパートナーシップまたは戦略的提携を形成しています。

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9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

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