A Framework To Develop Business Models For The Exploitation Of Disruptive Technology

Deepika

https://doi.org/10.34737/w1vq6

A FRAMEWORK TO DEVELOP BUSINESS MODELS FOR THE EXPLOITATION OF DISRUPTIVE TECHNOLOGY

Deepika. MBA, MSc (IT)

School of Computer Science and Engineering

College of Design, Creative and Digital Industries

University of Westminster

A thesis submitted in partial fulfilment of the requirements of the University of Westminster for the Degree of Doctor of Philosophy.

University of Westminster October 2022

ABSTRACT

Adopting new technology to expand business prospects is not a new trend. Certainly, this brings innovation and new opportunities to the business but also raises several challenges. This research addresses the challenges of business modelling in relation to disruptive technologies. Emerging technologies are very dynamic, resulting in continuous new developments. Therefore, businesses need to adjust their business models to stay sustained with this dynamic nature of technology. This research aims to create a conceptual framework and a related methodology to develop business models for the commercial use of disruptive technologies.

The research evaluates the gaps in the major business model development methodologies and argues that these methodologies are not adequate for businesses that offer high-end products and services to their customers. It creates a framework to make a methodical comparison among different business model methodologies. Based on that framework, it conducts a systematic comparison of five significant business model development methodologies to identify possible flaws. It analyses business elements of two use cases, where a disruptive technology, in this case, cloud computing in the form of cloud-based simulation, offers significant value to customers. Thereafter, it compares the components of all the five identified methodologies with each other using business elements of the selected use case. While the analysis highlights the differences and the similarities between the methodologies, it also reveals the limitations of the current approaches and the need for further decomposing technological elements.

Therefore, the study carries out an empirical investigation based on selective sampling. Seven real-life business use cases that execute the application of disruptive technology (i.e., cloud/HPC-based simulation as a solution based on cloud computing & high-performance computing) have been explored, involving 30 individual companies. Thenceforth, a thematic analysis of these use cases, based on a detailed report provided by a European research project, is conducted. Besides, three months of observation is carried out by participating in the same

project as a ‘Research Associate’ from the period of July 2019 to September 2019. This three-month observation supports not only providing access to 26 business use cases and their relevant documents but also validating the information provided, as well as finding clarity in collected data. Moreover, the selected business use cases are particularly useful for identifying the technology elements that are required to create the proposed framework. The analysis has resulted in an understanding of the dynamics of the interrelationship of social and technical factors for developing new technological solutions that push the development of new business models devised for delivering solutions exploiting disruptive technologies.

Based on this understanding, the research extends a widely used business model ontology (Osterwalder’s Business Model Ontology), and offers a new business model methodology with the introduction of new business model elements related to technology. The technological elements are being identified as the results of the above empirical analysis. Utilising this extended ontology, a novel methodology for developing business models for the exploitation of disruptive technologies is suggested and its applicability is demonstrated in the example of cloud-based simulation case studies.

The research creates three main contributions. Firstly, it uses a systematic approach and identifies that the technological elements are not explicitly defined in the analysed business model methodologies, as well as the factors of disruption in the context of the socio-materiality view is missing. Secondly, it conducts an empirical analysis and defines the specific social and technological elements such as ‘Dynamic Capabilities’, ‘Competition Network’, ‘Technology Type’, ‘Technology Infrastructure’, ‘Technology Platform’, and ‘Technology Network’; that are needed to create a new business model methodology. Finally, it extends an existing business model ontology (which was developed by Alexander Osterwalder) and constructs a new ontological framework with an accompanying methodology to develop business models, particularly for organisations that introduce technological solutions as their main value using disruptive technologies.

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Dedication

I have no words to express how grateful, blessed, and proud I am to have Mr Nanda, my partner, without his support and encouragement, this thesis would not have been possible. He always has shown trust in my abilities and provided hope and positivity. I owe him so much for his unconditional love, patience, kindness, and never-ending support.

Next, I would like to show my greatest gratitude to my God, who has always given me the power and strength to fight each obstacle I had on my way.

I am delighted to also dedicate my thesis to my mum, who has given me a love of both a mother and a father. She has always put me before herself, whether in finance or consolation. Being the youngest of five, I have always been a protected child, but she encouraged me to endeavour this PhD and follow my passion. I am tremendously thankful to you mum, and I owe you also.

I am also extremely thankful to all my family in India and in the UK for their love, support, and blessings throughout this journey. Particular thanks go to all my cousins and friends for their best wishes.

Lastly, I dedicate my work in memory of my heavenly father and sister, Dad, you left us when I was very young, but you had worked to protect your children’s future. I cannot thank you enough. Didi, being the eldest sister, you would have been the happiest to see my achievements. I know you are watching over me and cheering these moments. I still cannot believe you are gone; I miss you so very much.

Acknowledgements

Besides the support from my family, I have received tremendous support from numerous people whom I am grateful for. To begin with, I would like to express my cordial appreciation to my Director of Studies, Prof Tamas Kiss, for his exceptional guidance and kind support. I could not have wished for a better supervisor. He has always helped me with his due knowledge and provided me with his valuable time whenever I needed it. He always has sound solutions to problems and is truly an inspiration. It would not have been possible to complete my work without his invaluable support and direction. I am sincerely very grateful to him.

I would like to extend my deepest gratitude to my other supervisory team, Prof Gabor Terstyanszky and specifically to Dr Farjam Eshraghian for their valuable knowledge, time, and generous support. Their constructive comments, logical ideas and critical insights have enhanced my thinking and learning process. I am very thankful to them for sharing their unique experience and making this PhD achievable. I would also like to show my profound appreciation to Senior Lecturer Huseyin Dagdeviren for all his kindest support throughout my journey toward this PhD. Despite not being a part of my formal supervisory team, he has motivated me immensely. He has not only provided me with his valued time and help but has shown a sincere interest in my research. He has provided a complete involvement, and I am gratified to acknowledge him as an esteemed part of this research.

I am also very grateful to the University of Westminster, the graduate school, and the School of Computer Science and Engineering for their help and support. Finally, and importantly, I would like to thank my fellow PhD researchers Dr Oliver Van Zwanenberg and Mahmoud Aldraimli, for their companionship and support. I am very grateful to my former colleagues from CPC (Centre for Parallel Computing, UoW), Dr Hai-Van Dang and Dr Amjad Ullah, for their kind support and comradeship. This journey of my PhD would not have been that easy without you all.

Author’s Declaration

I, the undersigned, hereby declare that this thesis is a presentation of my own original research. Wherever inputs or contributions of others are involved, every effort is made to reference and acknowledge their work clearly.

Deepika. MBA, MSc (IT)

October 2022

Chapter 1 Introduction

1.1 Overview

This chapter introduces the research and provides an insight into the use/role of business models and disruptive technologies for organisations (like software vendors), that develop high-end products/services for the commercial use of disruptive technologies. Besides, the chapter describes problems and motivations behind this project. Next, research questions along with the aim and objectives are defined. Subsequently, research contexts, main contributions and thesis structure is outlined.

1.2 Research Background

Undoubtedly, the concept of business models has been a predominant topic recently. However, there is no specific definition of the business model, and it has been defined in various contexts. Generally, the business model is all about value (Peric, Durkin and Vitezic, 2017). A business model creates or adds value to the organisation, as well as helps deliver value to the customers (Mark W Johnson, Christensen and Kagermann, 2008; Osterwalder and Pigneur, 2010; Casadesus-Masanell and Ricart, 2011; Kaplan, 2012; Raphael Amit and Zott, 2012; Achtenhagen, Melin and Naldi, 2013a; Biloshapka and Osiyevskyy, 2018; Fjeldstad and Haanæs, 2018; Costa Climent and Haftor, 2021). It is essential to employ/re-employ an effective business model for a firm to succeed, whether a start-up or an established business because it is a central part of a business which provides insight into how an enterprise works (Magretta, 2002).

The use of efficient business models become more significant while arranging disruptive technologies, since it provides a pathway to combine technologies and related knowledge (Karimi and Walter, 2015; Teece, 2018). This research builds on finding the relationship between business models and disruptive technologies. Besides, the impact of social factors on the development of new technological systems (socio-material elements) needs to be accessed, which ultimately influences the development of new business models.

Disruptive technologies refer to those technologies which inevitably alter the way organisations operate. In recent years, the utilisation of disruptive technologies has been increasing rapidly to develop state-of-the-art products and services. Disruptive technologies can be directly related to disruptive innovations; in some cases, they are termed interchangeably. Christensen, Raynor and McDonald (2015); Kylliäinen (2019) describe disruptive innovation as an innovation related to a product, a service, a concept, or a process that either disrupts a current market or creates an entirely new market. Usually, signs of disruption appear when new entrants with fewer resources offer a kind of value, typically superior at a lower price, that challenges incumbents. Initially, entrants target overlooked sectors in the low-end market and gradually move to the upmarket, offering value that attracts incumbents' mainstream customers. This value can be a form of new technology, a new business model, or a combination of both. Once this innovation reaches existing markets and the conventional value drivers in the established market significantly change, the disruption has occurred (Christensen, Raynor and McDonald, 2015; Larson, 2016; Kylliäinen, 2019a).

Besides disruption, disruptive innovation brings several opportunities to enterprises if anticipated timely and effectively. Disruption from disruptive innovations causes an impact like the steam power had on the first industrial revolution and, of course, similar to the other industrial revolutions. The history of industrial revolutions reflects how technology and resources led to these innovations and caused social, economic, and cultural transformations. There is another dimension to this cause. In addition to the technology, social factors were equally accountable for these innovations. Aunger, (2010) described technology as a system that allows "*interaction with artefacts in particular contexts of engagement*". Any new development of technological systems results from the social influence on technologies or resources, such as knowledge, intentions, or willingness to improve existing practices (Karl E Weick, 1990; Moore and Benbasat, 1991; W J Orlikowski and Gash, 1994; Hirschheim, Klein and Lyytinen, 1996). Although each period has shaped the world in different ways by introducing various events of innovations and using different resources, the purpose has only been a continuous improvement in the existing practices. These improvements are made by and for social welfare.

Certainly, all these developments were made to improve socio-economic practices. At the same time, many social factors influence these innovations (Kylliäinen, 2019), such as industrial challenges, time-consuming working customs, knowledge & experience of experts, and most importantly, the available resources. For each revolutionary invention, the used resources and technologies were available from the beginning and the practical arrangements of those technologies and resources made the design of respective systems successful and caused the 'disruption' (Schwab, 2016; Buchanan, 2019). This 'effective arrangement of technologies and resources' is now referred to as a business model (Johnson, Christensen and Kagermann, 2008; Grimsley, 2013).

Undeniably, the industrial revolutions brought unpredictable and unprecedented transformations of socio-economic life. These revolutions did not just occur unexpectedly. On the contrary, there have been several trials and persistent signs of progress for each invention. For example, steam-based energy was introduced several decades before its successful use (Nuvolari, Verspagen and von Tunzelmann, 2011). Likewise, the light bulb was begun to use practically after several years it was first invented. Similarly, supercomputers were developed far earlier than they came into effect and later reached the widespread use of household computers (Schwab, 2017). All these evolutions not only replaced the existing systems but transformed them steadily and eventually disrupted the previous systems.

Another interesting fact is that, as we developed through all these eras of advancements, the timeline of each occurring revolution has decreased. For instance, in the first two industrial revolutions, the transformation of systems occurred slowly throughout several decades. Markets had to make progressive moves to accept and respond to those transformations. The timeline was shortened during the third industrial revolution, and numerous new developments were made within a few years. Even then, only a gradual level of planning was enough to gain a foothold in the market and stay sustained (Schwab, 2017).

Now, we have reached far beyond, towards the fourth industrial revolution. This period is a fast-paced era of automation and digitalisation where technologies are evolving at exponential rates and surprising us every day. So-called disruptive technologies such as cloud computing, big data, cyber-physical systems, robotics, artificial intelligence, and many others; provide us with endless opportunities and are transforming modern trade like never before. Besides, the markets are moving far faster than a business can adapt to such changes (Schwab, 2016, 2017). Therefore, the organisations require an advanced level of planning (in terms of innovative business models) to deal with this dynamic change in technology.

1.3 Research Problems and Motivation

Undoubtedly, organisations are becoming more competitive with the commercial use of disruptive technologies. This is also because some businesses are investing in implementing new technological solutions based on disruptive technology (or in some cases more than one disruptive technology). The use of these technological combinations depends on the business requirements. On one side, cloud computing offers on-demand computing and storage capacities (Marston et al., 2011). On the other hand, HPC (high power computing) offers high computation power and parallel processing to execute complex calculations at high speed (Morgan, 2019). Next, fog computing provides fast and real-time data analytics, where data can be integrated through dynamic IoT devices and if needed stores the data at the edge of the cloud systems. Then, big data offers to handle a large volume of unstructured data which further can be integrated through other computing capabilities. By employing these powerful technologies, the right information can be delivered to the right people at the right time in the right location, driving the business towards success.

Despite having enormous benefits of disruptive technologies, some businesses do not receive satisfactory results and collapse in their business processes (Bower and Christensen, 1995; Christensen and Bower, 1996). *"One of the most consistent patterns in business is the failure of leading companies to stay at the top of their industries when technologies or markets change. The pattern of failure has been especially striking in the computer industry"* (Bower and Christensen, 1995). The primary reason is that the business analysts or experts misinterpret the adoption of disruptive technologies by aiming mainly at technological development to satisfy their customer needs rather than giving importance to adapting to those new technologies (Schiavi and Behr, 2018).

Besides, disruption occurs not only from disruptive technologies but also from disruptive business models (Worlock, 2007) with new value drivers (Hwang and Christensen, 2008; Chesbrough, 2010; Zott et al., 2011; Christensen, 2013; Christensen et al., 2015; Cozzolino et al., 2018; Schiavi and Behr, 2018). Organisations have a choice to get either disrupted while ignoring the market change or to be sustained by continuously adjusting their business models (Bagley, 2014). Disruptive technologies are ambiguous, dynamically changing and becoming unpredictable. These technologies influence instabilities in markets & competition, communication processes, firms' capabilities (Sinofsky, 2014; Schiavi and Behr, 2018; Baden-Fuller and Teece, 2020) and eventually affect the firms as a whole. Therefore, the business arrangements that use disruptive technologies require continual business planning, management, structuring and ordering to stay in the competition.

Another reason for the failure is caused by ignorance of entanglement between social and technical factors (socio-material factors) while commercialising new technology. There is a fundamental entanglement in social and material (technology), and this perspective should specifically be considered in the event of technological changes happening in an organisation (Weick, 1990; Orlikowski, 1992, 2007; Orlikowski and Gash, 1994; Roux, 2003; Khosrow-Pour, 2005). Socio-material factors influence new technological arrangements or service provisions based on these arrangements. Consequently, the dynamics of this socio-material affect the business models devised for delivering value using these commercialised disruptive technologies.

In other words, the dynamic nature of technologies causes the development of new technological systems and, accordingly, new organisational structures; these organisational structures affect commercialisation with a success or failure as an impact of the execution of new technological arrangements. This continuous change in technological and organisational arrangements is a significant concern for many organisations. Therefore, it is crucial to measure the impact and usefulness of any newly initiated technological arrangements on the business before implementing any commercial solutions using disruptive technologies. There is a necessity to identify all the factors that influence the use of technological solutions as well as the factors impacting the usage of new business models while adopting these technological systems based on disruptive technologies.

It is further evaluated that there is a close association between disruptive technology, the social construction of technological development and business model development; nevertheless, the conceptualisation addressing the business model change in the context of both disruptive technology and socio-material influence on technological development has not been developed explicitly (Worlock, 2007; Schiavi and Behr, 2018; Cubero et al., 2021). Besides, an innovative element of dynamic capability (as an element of disruption dimension) in business model development has been embraced by various authors recently (Eisenhardt and Martin, 2000; Daniel and Wilson, 2003; Helfat et al., 2007; Teece, 2007, 2009, 2012, 2014, 2018, 2022; Wang and Ahmed, 2007; Helfat and Peteraf, 2009; Danneels, 2011; Helfat and Winter, 2011; Achtenhagen, Melin and Naldi, 2013; Wang et al., 2015; Laaksonen and Peltoniemi, 2018; Salvato and Vassolo, 2018; Baden-Fuller and Teece, 2020; Hunt and Madhavaram, 2020; Lin et al., 2020; Schmidt and Scaringella, 2020; Wang and Photchanachan, 2021).

Since the term dynamic capability is recently getting so much attention in the context of disruptive technologies, disruptive innovation, and business model change, it is still required to be conceptualised in the framework of business model change as a result of disruptive innovation (technologies). Although (Teece et al., 1997; Danneels, 2011; Wang, Senaratne and Rafiq, 2015; Teece, 2018; Cruz-Sanchez, Sarmiento-Muñoz and Dominguez, 2020; Lin et al., 2020) suggested frameworks that show an association between dynamic capabilities and business models to stay competitive in an uncertain market environment. Those frameworks are either not fully evaluated, not empirically studied, or both, in terms of conceptual modelling of business analysis. This research, therefore, explores all close relationships between business model and disruptive technologies to create an intended framework to develop disruptive business models, where the term disruptive business models refer to the development of business models for technology organisations that offer high-end solution exploiting disruptive technologies.

1.4 Research Questions

Even though the utilisation of disruptive technologies and innovative business models is growing faster (Baden-Fuller and Morgan, 2010; Teece, 2010; Baden-Fuller and Haefliger, 2013; Schiavi and Behr, 2018), there are not many studies that suggest a methodology to develop business models, particularly for organisations that sell high-tech products and services based on disruptive technologies. This research proposes a framework which supports the creation of personalised business models for the commercial use of disruptive technologies. In order to construct this framework, a profound analysis of all the possible influential factors in developing business models is required. In addition, there is a need to evaluate the relationship between social, technical, and business aspects in creating a business model. Accordingly, a list of research questions is presented below for the successful completion of the research project:

(1) What is the relationship between disruptive technologies and organisations' business models?

   a) Which socio-material factors influence the development of new technological solutions employing disruptive technologies?
   b) How are these disruptive technologies and related technological arrangements affecting today's businesses and entail the development of new business models?

(2) Which methods and approaches can be used to construct the planned framework?

(3) Which business model methodology is suitable for organisations that make commercial use of disruptive technology as the main value to their customers?

(4) How to test and validate the effectiveness of the designed framework once prepared?

To answer these questions, and to establish preliminary objectives, the literature (chapter 3) on disruptive technologies, socio-material and business models is explored. Besides, the qualitative research method (chapter 2) is used to collect and analyse qualitative data to meet the research objectives. This ultimately leads to filling the gaps (table 3.1, figure 3.8, §4.5, §5.3, figure 5.4) in existing studies and the successful completion of this project.

1.5 Research Aim & Objectives

Disruptive technologies are constantly evolving and, in a way, disrupting businesses with the dynamic changes they bring to the market. To avoid being part of the disruption and stay sustained, organisations must keep updating their business models. This research investigates how a new business model development methodology can be created to support the introduction of disruptive technologies. Therefore, this project aims to build a conceptual framework and an associated methodology to develop business models for the commercial use of disruptive technologies.

The following objectives are set to achieve the aim and successful completion of this research:

Objective 1 - To identify various real-world business case studies to understand the role of socio-material elements in developing cutting-edge technologies and, to identify their consequences on the organisations' business models.

Objective 2 - To identify new business elements for the methodology to develop customised business models for organisations that exploit disruptive technologies in their primary process of delivering value (as a service).

a) To analyse an effective business model development methodology by conducting an explicit set of similarities & differences among existing methodologies (which are most relevant) using a comprehensive approach.
b) To evaluate new elements of business model development methodology tailored specifically for businesses that adopt new technological solutions using disruptive technology.

Objective 3 - To conduct an empirical investigation on selective business use-cases, using their commercial requirements to decompose all related social and technical (socio-material) and business components.

a) To identify the main factors that influence the introduction of new technological arrangements in an organisation.
b) To assess socio-material elements to be acquired as new business model elements and their effectiveness in the organisation while utilising new technological systems based on disruptive technologies.

Objective 4 - To create a novel framework and a related methodology which is effective for developing business models to support the introduction of disruptive technology in organisations.

a) To extend an existing ontological framework (Osterwalder's Business Model Ontology) with the new business model elements deriving from the results of empirical analysis.
b) To design a new business model development methodology complementing the new business model ontology.

Objective 5 - To validate the effectiveness of the new business model development methodology through a use-case analysis of all the components of the new methodology.

1.6 Research Context & Domains

In the past two decades, there have several studies been conducted on business models, business model innovation, business model development methodologies etc., in different contexts. This research focuses on developing the business model methodology for organisations that sell technological products/services based on disruptive technology. To achieve this research goal, the project builds on two unified perspectives. First, there is a need for continuous change in business models while organisations make new technological arrangements for the commercial use of disruptive technologies. This is because disruptive technologies are very dynamic, and organisations must use dynamic business models to adapt to those changes as and when necessary. Besides technology becomes disruptive by creating “disruption” either through innovative products or processes or changing business models. Since the association of “disruptive technology”, “new technological products” and “business models” is needed to be evaluated, this research covers the domains of all these concepts. Second, the development of new technological systems and new business models are the result of intertwined social and technical factors. Therefore, the next domain covered in this research is “sociomateriality”. Since the project aims to construct a framework and a related methodology to develop business models for the commercial use of disruptive technologies, it adopts an ontological framework and creates a business model tool as a methodology. Thus, the research includes the domains of “ontology” and “business model development methodology”, see Figure 1.1.

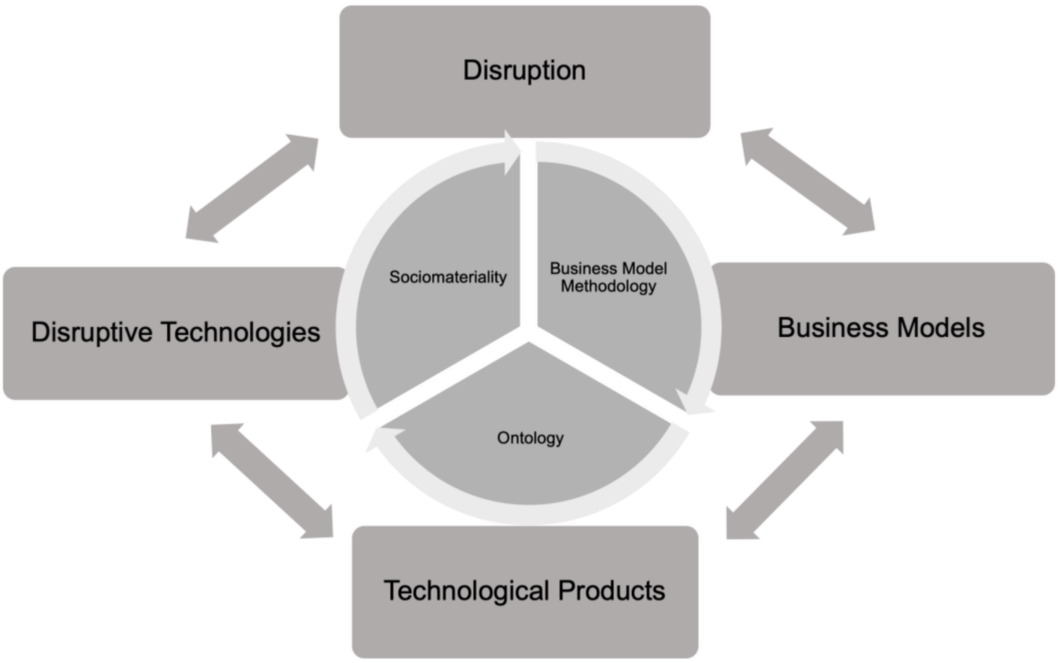


Figure 1.1 Research Domain

1.6.1 Research Design

The research design revolves around two perspectives. It presents the association between disruptive technology and business models; as well as represents the entanglement of sociomateriality influencing technological change considering the threat of disruption and their effect on the business model change.

Perspective 1: A business ecosystem is extremely influenced by technological change. It is challenging for a business to reframe its technological systems with a sudden change in circumstances. It might not even be possible without amending the organisational structure (Gilbert and Bower, 2002). Hence, it is not only a matter of introducing new technology in an organisation but at the same time preserving all the features it already offers to its customers. This is often prepared through business models.

Furthermore, adopting any new technological system is a cumbersome task. When an organisation sets up a business solution using any technology that inevitably affects the existing business procedures and techniques, since it involves many business activities and processes; an appropriate structure is required to manage those successfully. A business model is proved to be very useful in preserving those business activities while deploying any information systems. Generally, every enterprise directly or indirectly uses a business model to run the basic business value system. But with the advancements in the current systems, it is crucial to monitor the change in the market, new technical solutions, new processes, and interactions of systems. A business model outlines the purpose of the technology, an organisation adopts. Schiavi and Behr (2018) depicted that the connection between disruptive technologies and business models is steadily a significant concern. Disruptive technologies prompt the development of new business models; new business models influence commercialisation and effective execution of new technological solutions.

Perspective 2: There is a constitutive entanglement of the social and technical aspects in the development of a new technological product/service which affect the organisational structure as well as the firm’s business models. Undeniably, technology improves how an organisation operates and eases the interaction among employees; however, technological performance also depends on employees’ skills, efforts, and experience. On one side, organisations invest in new technology to develop new technological products/services or make improvements in existing products, services, processes, working environment, etc. On the other side, a technological product is a product created by human agents (an employee) using the application of knowledge. It is a two-way evolvement and needs to be captured carefully while developing new business models corresponding to the newly integrated technological arrangements using disruptive technologies.

Besides, (Wajcman and MacKenzie, 1999) demonstrated that in an organisation, the technological change appears not only for technical causes but for several other reasons including social causes. Though this change occurs due to the complexity of technological factors (either for improving the firms' performance or responding to the disruption), it certainly happens for the related contingency in social factors. Making a technological change in a particular societal setting requires reference to a set of social conditions, relevant training, re-organisation, and renewal of the business models to support that change. Therefore, this research follows a thorough analysis of socio-material factors along with the business factors for the development of the projected ontological framework along with the methodology to develop business models for organisations that develop high-end products employing disruptive technologies.

Figure 1.1 outlines the interdisciplinary domains that are considered for this research. The research begins the analysis from the existing business model research along with other domains to create a conceptual framework to develop business models for organisations that utilise disruptive technologies for commercial use (I call it *"disruptive business models"*). Then it carries out a systematic comparison among the most relevant business model methodologies to evaluate major business elements for the projected framework. Subsequently, it conducts an empirical analysis to confirm/extend the elements of the initial conceptual framework. Finally, based on the resulted elements of the framework, the research creates a final framework adopting an ontological approach and creates a business model methodology showcasing the usability of the framework. **Error! Reference source not found.** summarises the research design and planning.

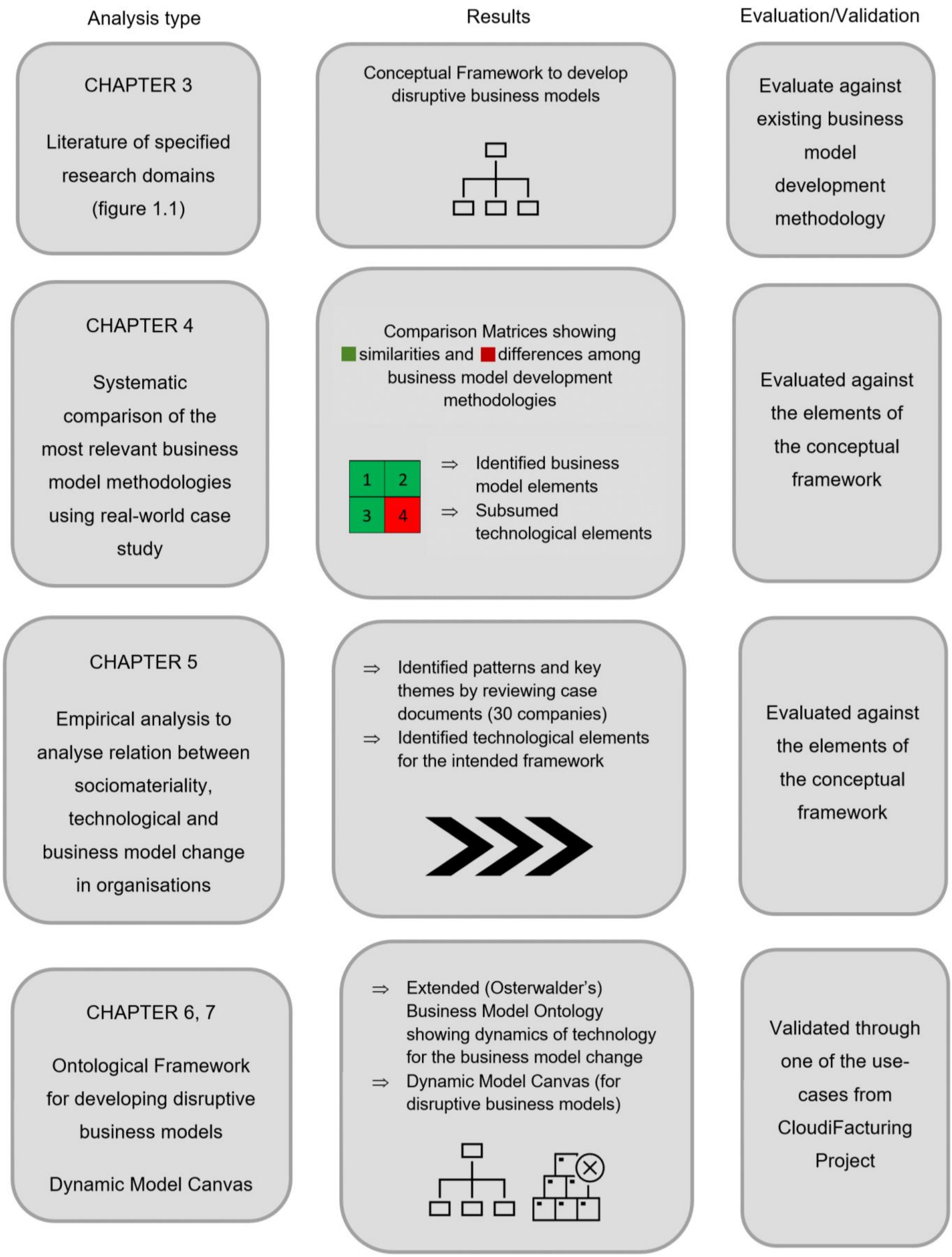


Figure 1.2 Research Designs

1.6.2 Cloud Computing as Disruptive Technology

Although the utilisation of disruptive technologies is evolving rapidly, the literature on disruptive technologies is still fragmented. Nevertheless, cloud computing holds a rich literature as compared to other disruptive technologies. With its massive offerings, cloud computing is believed to be one of the “high-value elements for achieving resilience and guaranteeing business continuity”, that transforms the way organisations operate with its simple and convenient solutions (Morgan and Conboy, 2013). It allows companies to use remote servers or storage hosted on the internet to access, process, manage, share, and store critical data with tremendous speed and accuracy. Organisations do not require any installation to their local systems; instead, they are driven by external or third-party systems. Various organisations are saving huge money by migrating to the cloud as they do not require to invest in expensive infrastructure or resources but can consume all essential services remotely on a subscription basis or per usage. Another significant feature is that cloud computing allows users and businesses to access information globally anywhere and anytime.

It is further explored that cloud computing is considerably influencing the European markets (European Commission) and global markets (Getov, 2012; ReportLinker, 2021) by providing immense advantages through enhanced productivity, efficiency, cost-cutting, and competitiveness (Ogunlolu and Rajanen, 2019). Cloud offers incredibly powerful tools and resources that benefit firms, especially small to medium-sized manufacturing & engineering companies (Salim et al., 2015; Brintha et al., 2021), to run their simulation services where thousands of systems can be processed at once. In addition, they do not require to buy any physical systems and can still provide speedy products/services to their customers. Besides, Cloud computing is a link that is also being used to enhance its related services which comprise of other disruptive technologies such as fog computing, IoT application, AI applications, big data, and data analytics. Therefore, the adoption of cloud technology (products/service provisions) is significantly increasing.

Despite including several advantages and convenient solutions, enterprises are facing severe issues (Salim et al., 2015; Rayome, 2019); and are unable to use the full potential of cloud technology, specifically small to medium-sized enterprises (SMEs). It has also been illustrated that nearly 70% of firms globally are shifting their core business functions to the cloud, and about 47% have shown concerns about disruption in their business operations (Rayome, 2019).

The primary reason is that the successful development and commercialisation of cloud-based solutions require critical planning. In addition to these innovative solutions, organisations must re-examine their business models also. Thus, it is crucial to have a well-established business plan to manage cloud-based solutions, even if a business is employing a single cloud solution. In the event of preparing a wide-ranging cloud-based business, developing an effective business model is an obligation. Further, Onggo and Selviaridis (2017) highlighted the importance of innovative business models when deploying solutions based on cloud computing. They believed that it is essential for an organisation that offers cloud-based solutions to their customers, to include business plans while preparing technological strategies. They comprehend those technological tactics assist to examine new technical requirements of a business; likewise, reproducing business components provide insight into all business processes and conditions for the implementation.

Therefore, this study focuses on cloud-based business models, predominately based on the availability of literature as well as data. The research gains access to around 26 significant business use-cases comprising data from 75 companies, that are mainly centred to create cutting-edge cloud applications as a value offered to customers (Objective 1). The companies that develop and sell technological products utilising disruptive technologies are Independent Software Vendors (ISVs), and their target customers are mainly Manufacturing SMEs (referred to as end-users in the use-cases). These use-cases details are provided in chapter 2. Due to the data availability, it is considered to direct the study towards developing a methodology to design a business model for the creation of cloud-based solutions explicitly for manufacturing and engineering SMEs. Nevertheless, the research develops an ontological framework, which is effective to present components' relationships in a generic manner. Therefore, the framework and methodology can be used while developing business models for commercialising solutions based on other disruptive technologies.

1.7 Research Contributions

The study proposes an ontological framework to develop business models for organisations that introduce new technological arrangements for the commercial use of disruptive technologies. While achieving the main goal, the research creates three main contributions that are listed below.

- Firstly, the research conducts a systematic comparison of the five most relevant business model methodologies (chapter 4) by using business model elements of two actual business use cases that offer high-tech products/services (simulation solution) utilising cloud/HPC resources. Thirteen large tables are created comparing business elements of these five business model methodologies, one by one with each other by mapping business elements of the above-mentioned use cases (objective 2a). The comparison results show that those business model development methodologies provide the same level of static analysis of business elements for organisations, and they do not explicitly contain the technological aspects. This comparison analysis uncovers that; (i) it is essential to decompose all possible technological elements to the granularity level and show the fundamental relationship between elements of the business model and dynamic disruptive technology (objective 2b), (ii) there is a need to adopt an ontological approach to extend the existing (and the most popular) business model ontology (developed by Alexander Osterwalder) to develop a new business model ontology that contains technological factors along with the business factors.

- As a second contribution, it evaluates and defines the exact social and technological elements needed to create a new business model ontology by conducting an empirical analysis on seven business use-cases (Objective 3b) that involve the development of high-tech products/services (simulation and analytics solution) utilising cloud/HPC resources (chapter 5). In some cases, some other technologies are also used such as Big Data, Artificial intelligence, Solar technology etc., combined with cloud/HPC tools. These decomposed technological elements such as ‘Technology Type’, ‘Technology Infrastructure’, ‘Technology Platform’, and ‘Technology Network’; are needed to create a new business model methodology (objective 3b). Besides, the driving forces (Socio-material and disruption elements) are also evaluated in this analysis such as 'Market & Competitive Forces', 'Low Performance', 'Disruptive Innovation', 'Dynamic Knowledge' etc (objective 3a).

- By enclosing the above-evaluated elements in a framework, the project reaches its final contribution and accomplishes its proposed goal. It extends an Osterwalder's business model ontology (objective 4a) and develops a new ontological framework (that represents the higher-level relationship of business model elements and disruptive technology elements) along with an accompanying methodology (objective 4b) (chapter 6) to create business models for organisations that introduce technological solutions as their main value using disruptive technologies (e.g., software vendors).

1.8 Thesis Structure

The thesis is structured into seven chapters and is described below.

Chapter 1 presents an introduction to the research. It provides background and motivations for conducting this research on business modelling for utilising disruptive technology. The chapter also outlines the research questions, aim, objectives and overall design to successfully complete the research. It also specifies a summary of the research's main contributions.

Chapter 2 gives an outline of approaches and methods used to conduct this research along with the justification for effectively achieving the research outcomes.

Chapter 3 provides a detailed review of the literature concerning disruptive technologies, sociomateriality and business models. An initial conceptual framework is developed through the early relationship established by examining previous related studies.

Chapter 4 creates a systematic comparison of five important business model development methodologies using 2 use-cases, to identify major business model elements for the intended framework to develop business models for organisations that offers high-end products utilising disruptive technologies.

Chapter 5 conducts an empirical analysis to identify technological elements and their intertwining social elements that impact business model design. The chapter identifies key concepts by showing similar patterns and major themes found in 7 use-cases.

Chapter 6 delivers an ontological framework showing the relationship between social, technological concepts, and business model elements that support the development of disruptive business models.

Chapter 7 describe a methodology derived through the ontological framework that works as a tool along with logical questions regarding business analysis, represented as flow charts and to be used by business experts.

Chapter 8 provides a summary of the findings and makes concluding remarks.

Chapter 2 Research Methods & Approach

Research Methods are the systematic ways to collect, interpret, arrange, and measure information or data related to a research project, which then contributes to reaching the final goal of the research. This chapter describes the research methods choices and approaches used in conducting the research and meeting the proposed aim of developing a novel framework and methodology to create business models for organisations that design and sell technological solutions based on disruptive technologies.

2.1 Research Methods Choices

This research focuses on the development of business models for firms that design and develop cutting-edge technological solutions (such as simulation, but not limited to) exploiting disruptive technologies (such as cloud technology, but not limited to) for business uses. Thus, this research revolves around multiple domains that make the research discipline very complex and consequently make different choices in answering research questions and achieving its ultimate goal.

This research is developed based on a qualitative research method with multiple cases as a suitable case study research strategy. To acquire a deep understanding of the phenomenon (in my case "factors influencing business model change"), I conducted two types of analysis, methodical analysis, and empirical analysis. For methodical analysis, I compare elements of existing business model methodologies (literature as a secondary data), applying real business elements of two use cases (primary data) from the CloudSME project (§2.2.3.1).

For empirical analysis, I choose purposive sampling and analyse selected cases by providing an interpretive paradigm and pragmatic approach following abductive reasoning. Using the main primary data source, I carry out document analysis which provides an immense value in case study research. Although I take participant observations (as a primary data) while being part of the "CloudiFacturing" (§2.2.3.2) project (from where documents are accessed), it is applicable to make only document analysis as a stand-alone method (Bowen, 2009). Figure 2.1 provides a view of all the corresponding research methods used in this study. More details on each method along with the rationale for selecting these research methods, are provided in the next section (§2.2).

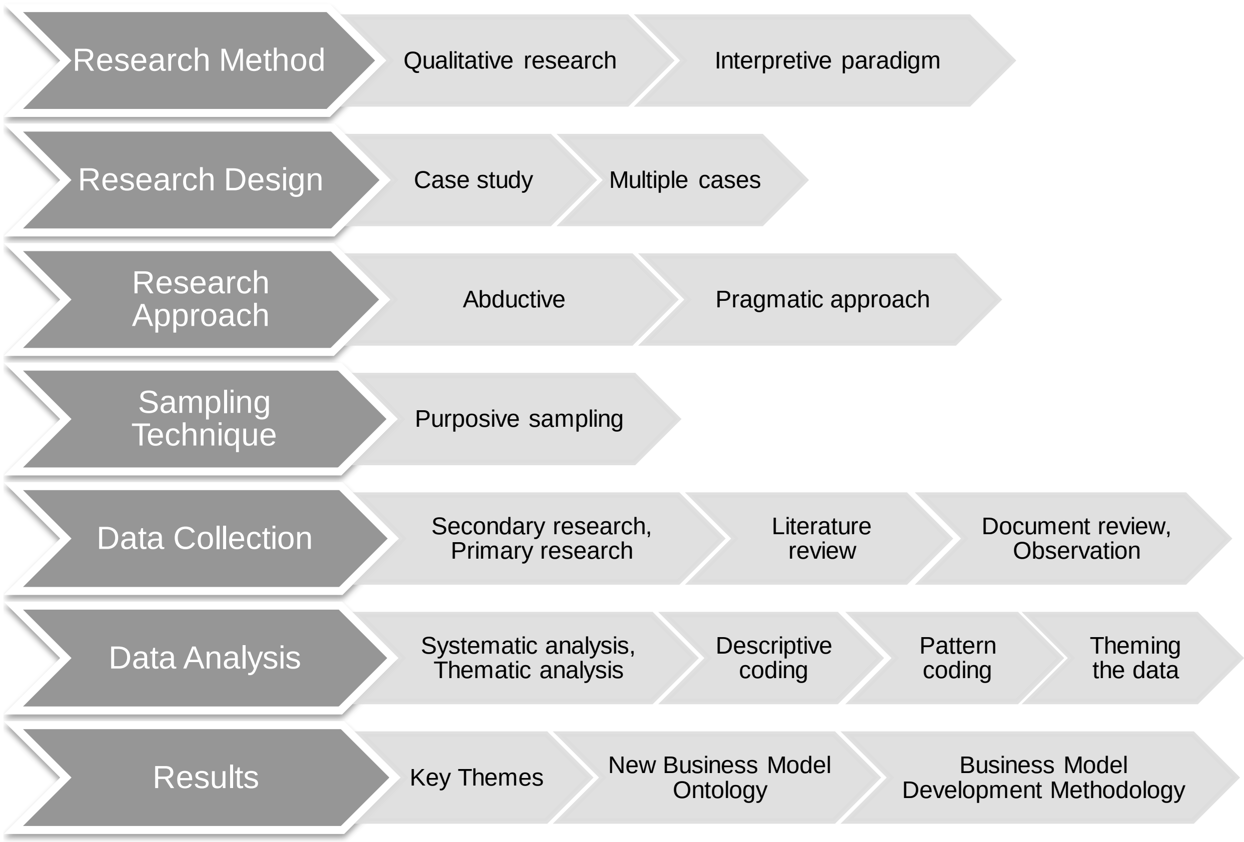


Figure 2.1 Research Methods Choices

As explained earlier, the data analysis is carried out in two parts, using two different projects and their documents for each analysis. First, a systematic analysis (or methodical comparison of business model methodologies) is carried out using business elements of two use-cases from the project titled “CloudSME” (§2.2.3.1). The CloudSME project prepares its business planning using the “Business Model Canvas” (Osterwalder et al., 2010). Those business model elements are executed in other key business development methodologies named the “Generic Busines Model” (Hedman and Kalling 2003), V4 Concept of Business Model (Al-Debei and Fitzgerald 2010), Business Model Engineering Approach (Seidenstricker et al., 2017) and Lean Canvas

Model (Maurya, 2012) to identify key business model elements for the proposed business model methodology. Thirteen large tables are created showing similarities and differences among business elements of these methodologies. Besides no ultimate difference is noted, nevertheless, it is concluded that these methodologies are not effective for firms that utilise disruptive technologies for commercial use. It reflects that the technological perception is subsumed with other business model elements and has not been given due consideration. The vibrant technological elements are needed to be decomposed along with their influence on business model change. Therefore, another analysis is necessary to show the relationship between disruptive technology and business model elements in the creation of the projected business model.

To begin with the second analysis, first and foremost, the study creates an initial conceptual framework derived from the literature (§3.5). Secondly, it performs a thematic analysis based on the elements of the conceptual framework using project documents titled "CloudiFacturing" project (§2.2.3.2). The project documents include information about Independent Software Vendors (ISVs), Manufacturing SMEs (end-users), Resources Providers, Competence Centres, and Digital Innovation Hubs. The analysis is carried out by coding the data abductively (going back and forth from theory to data) using descriptive coding and pattern coding. Then, themes are generated out of the identified similar patterns of the relationships of categories, that can be used to refine the initial framework's categories. Thereafter, these identified categories and their relevant elements are used to extend Osterwalder's business model ontology by adding the concept of disruptive technologies and their influence on business model creation. Finally, the elements of the ontological framework are used to create a new business model methodology for organisations that offers value to their customers based on disruptive technologies.

2.2 The rationale of the Research Methods used

Since this research focuses on identifying how the relationship between social and technological factors influences the development of new technological products and how this new development then instigates a business model change in the organisation, the research follows a qualitative research method.

2.2.1 Qualitative Research Method

Qualitative research assists in examining detailed experiences of people by using a certain set of research techniques such as in-depth interviews, semi-structured interviews, observations, focus group discussions, and document analysis. The qualitative study is particularly suitable to explain and understand issues, social interaction among people, describe how people behave, how organisations operate etc (Hennink et al., 2011; Hammarberg et al., 2016). Besides, (Miles et al., 2020) outlined those qualitative studies allow researchers to go beyond the initial conceptions and build new understandings and interrelationships of concepts. Thus, qualitative research fits to determine the factors that influence the development of new technological products using disruptive technology, which then explicitly cause the development of new business models.

2.2.2 Interpretive Paradigm

Interpretive studies are generally significant for conducting in-depth case studies as well as taking participant observations, especially if the context is related to human intervention with technological systems (sociomaterial). (Walsham, 2002) outlined that *“interpretive case studies, if carried out and written up carefully, can make a valuable contribution to both IS theory and practice.”* It is explained in the previous chapter that this study examines sociomaterial factors that influence the development of new technological systems and their magnitude effect on organisations’ business models.

The interpretive paradigm also fits in the ontological view of study and allows the researcher to understand the concept, and find shared meanings, and reasonings in the research context (Walsham, 2002). Since the research proposed to develop an ontological framework, it is necessary to build a deep understanding of the context, to define its meaning in the form of a planned framework and methodology to develop disruptive business models. Therefore, the interpretive paradigm is aligned with this research to understand the context through the case study/empirical analysis and participant observations.

2.2.3 Qualitative Case Study

There are several different methodologies and techniques to conduct qualitative research ranging from the well-established types such as grounded theory, phenomenology, ethnography, case study, and content analysis to more progressive kinds such as narrative inquiry, poetic inquiry, ethnodrama, and autoethnography (Miles et al., 2020). Besides, a case study is the only unit of investigation. The choice of data collection and data analysis also depends on the choice of research methodology used or to answer the types of research questions (Miles et al., 2020). The case study strategy is more commonly used to answer *"how"* and *"why"* questions (Yin, 2018).

A case study is an empirical investigation, mainly conducted to get an in-depth understanding of a contemporary phenomenon (the case) within its real-world context, particularly if the boundaries between the phenomenon and context may be unclear and requires multiple sources of evidence (Yin, 2018). In other words, the case study research design is favoured when there is little or no control over the events, and there is a need to study a contemporary fact (or facts). Besides the case study provides a substantial ability to deal with different types of evidence – documents, interviews, observations, artefacts etc. Further, the case study research includes both *"a single case study"* and *"multiple case studies"* (Yin, 2018).

The case study is expected to be one of the acceptable options for conducting qualitative research. Since the case study allows one to conduct an empirical and in-depth investigation of any contemporary phenomena within some specific context – such as examining individual life cycles, group exercises, business practices, organisational performance etc., (Yin, 2018), the case study design is precisely suitable for this research. Besides, in case-study research, the study samples are typically selected purposively (Mills et al., 2013).

While the research concentrates on finding the factors affecting technological change and business model change in an organisation, the research selected some specific real-world use-cases (from the CloudiFacturing Project, see §2.2.3.2), that share some similar characteristics in terms of technological development and commercial use of disruptive technology. Therefore, through evaluation of these use-cases, causal factors for technological change and business model change can be found and understood well. This research follows a multiple-case design, where data analysis is conducted in two parts.

2.2.3.1 Case Study Analysis – I

The first analysis is carried out to compare 5 business development methodologies using the real-world data from the documents of “CloudSME” project. For this analysis, business elements of 2 use-cases are implemented into each business model development methodology to find the common/uncommon elements that can be used to create a new business model development methodology tailored for the organisations that produce commercial solutions based on disruptive technologies (organisations such as Software Vendors). 13 large tables are created (chapter 4) by systematically comparing these 5 business model development methodologies with each other through the data (business elements) obtained from the use-cases. For the above-mentioned comparison, I only focus on the business requirement plan (of both use-cases), team involvement and their roles in the project. A brief summary of both the use cases is provided below.

Use-Case 1 – CloudSME (The project of Cloud-based Simulation platform for Manufacturing and Engineering – www.cloudsme-project.eu/):

This research obtained an access to the CloudSME project. This is a successfully completed European Commission’s Seventh Framework Programme, ‘FP7 funded – Factories of the Future’. The CloudSME has now established as a business named CloudSME UG (www.cloudsme.eu/).

Project Overview:

CloudSME delivers a specific technological solution that targets mainly small-to-medium manufacturing & engineering segments in the European market. The aim of the CloudSME project is to build a cloud-based, one-stop-shop solution that supports manufacturing and engineering SMEs in providing a scalable platform for smaller or larger scale simulations, enabling the wider take-up of simulation technologies, as well as significantly lowering the cost of infrastructure and maintenance. The CloudSME Simulation Platform offers end-user SMEs to utilise tailored simulation applications in the form of Software-as-a-Service (SaaS) based provision. Besides, it provides access to a Platform-as-a-Service (PaaS) solution to simulation software service providers and consulting companies allowing them to quickly assemble custom simulation solutions in the cloud for their clients. The project consortium includes 17 experienced partners, incorporating 12 SMEs, from cloud hardware and platform providers to simulation software providers, the end-users and technology integrators. Today, the CloudSME Simulation Platform has been dramatically changing the way in which manufacturing/engineering SMEs consume simulation solutions and providing new business opportunities to end-user SMEs, as well as to simulation software and cloud service providers. In order to reach its targeted end-users, especially, manufacturing and engineering SMEs, the company prepares the below offerings (source - the project of CloudSME):

1. A targeted (specialised) simulation one-stop-shop to the manufacturing and engineering market segments.
2. Support services for simulation software vendors to extend their products with seamless cloud access through CloudSME platform (i.e cloud execution through CloudSME platform and marketing in traditional ways).
3. Arrange a directory or general-purpose one-stop-shop (like a shopping mall) for all manufacturing and engineering SMEs.

Project Stakeholders and their Roles:

As explained earlier that the main focus of CloudSME project is to develop a cloud-based simulation platform as a one-stop-shop simulation solution for end-users, mainly from the manufacturing and engineering industry. Additionally, the platform also provides access to the cloud-based and other distributed computing infrastructures such as infrastructure related to the grid, HPC cluster, and desktop grid. The platform supports end-users by significantly reducing the operational time and investment, yet efficiently reaching their business processes. To develop such a platform, the project involves experienced and skilled players from all levels of the cloud-based provisions. Figure 2.2 and Table 2.1 provides information of the project’s key stakeholders and their roles.

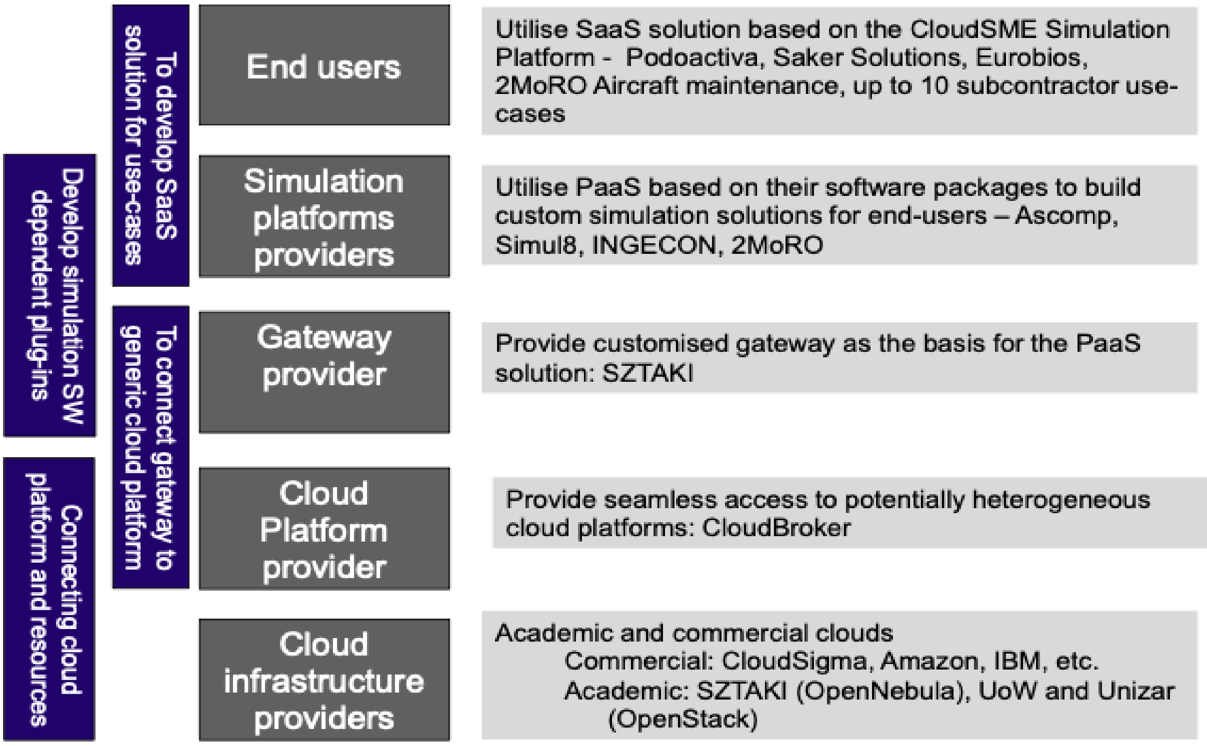


Figure 2.2 Key Stakeholders involved in the CloudSME project

(Source: The project of CloudSME – www.cloudsme-project.eu/)

	Partners	Role
1	CloudBroker (AppCenter, CloudBroker Platform)	Product Framework
2	SZTAKI (WS-PGRADE gUSE)	
3	UoW	Support Service
4	ScaleTools	
5	SZTAKI	
6	Bifi	
7	UBRUN	
8	Sander Werbung	Marketing and Sales
9	BiFi	Dissemination
10	ASCOMP (Multi-Physics One-Stop-Shop)	Simulation software one-stop-shops
11	Podoactiva (Insole Design One-Stop-Shop)	
12	Ingecon (Insole Validation One-Stop-Shop)	
13	Simul8	
14	Saker Solutions (Brewery One-Stop-Shop, Tools Manufacturing, One-Stop-Shop)	
15	Open Call new project partners One-Stop-Shops	
16	Other Software Vendors (contacted through CloudSME initiative)	
17	CloudSigma	Infrastructure Provider

Table 2.1 CloudSME project partners and their roles

(The project of CloudSME – www.cloudsme-project.eu/)

With the support of expert partners, the CloudSME sets-up 5 specialised one-stop-shops

- Multi-physics simulation one-stop-shop for fluid dynamic engineers;
- Podiatrist and insole designer one-stop-shop;
- Brewer process optimisation one-stop-shop;
- Tools manufacturer optimisation simulation one-stop-shop;
- UAV simulation one-stop-shop.

Along with the capabilities offered to the end-user manufacturing and engineering SMEs, the platform (specifically with the help of the infrastructure provider) offers a scalable infrastructure for seamless access to cloud/ HPC tools and resources to any simulation software vendor. All relevant APIs are made available for advanced integration for commercial and operational functionality. Above all, CloudSME provides services to simulation software vendors to arrange, deploy and set up one-stop-shops for their simulation software.

Since I am comparing business model methodologies for this part of the analysis, only business aspects of the CloudSME project documents are captured. These business perspectives are used as significant business elements, presented through 5 key business model development methodologies, and compared thoroughly in chapter 4. Now CloudSME is established as a commercial start-up with the name CloudSME UG (www.cloudsme.eu/) incorporated knowledge and expertise acquired from the project and serving manufacturing & engineering SME's.

Use-Case 2 – Ingecon/ Podoactiva - Insole Design One-Stop-Shop (One of the partners with CloudSME project):

This use-case describes the insole validation and design organised for Ingecon / Podoactiva. The CloudSME project supports the development of Cloud-based 3D Scan Insole designs. Other software applications including simulation is commercialised by Ingecon. Ingecon is a simulation software vendor and migrates their applications to the CloudSME platform. My research focuses on developing a business model development methodology for software vendors and therefore I choose another use case to compare the business model development methodologies further by using business elements of one of the simulation software vendors. Besides, another comparison validates the comparison results from the first use case. Since Ingecon develops a cloud-based insole simulation application for safety shoes for the customers of Podoactiva, the business model presented in the project for this use case focuses more on Podoctiva's (end-user) business elements.

Podoactiva is a Spanish biotechnology-based company specialised in podiatry and biomechanics, strives to use innovative technology to diagnose, design and manufacture personalised treatments in the form of orthotic insoles to improve the quality of people's lives through improvement of their walk (www.podoactiva.com/en). Podoactiva has operated as a partner with CloudSME project (The cloudSME project – www.cloudsme-project.eu/). Podoactiva develops a system named 3D Scan Sport Podoactiva®. It is a simulation software for the treatment and design of tailored insoles from a virtual mould of the foot for sports or for people having foot problems. The CloudSME project collaborated with Podoactiva specially to establish a portal through which scans can be uploaded to the cloud-based software which then verifies the scanned images to construct the design of personalized insoles.

Pododactiva validates this functionality with their ERP. When a podiatrist or hospital uses Podoactiva ERP to upload the scanned images of a patient's feet, they use a controlled button to validate the scan. Using a cloud access through Cloudbroker platform, the validation can be launched seamlessly. The overall concept is shown in below figure 2.3.

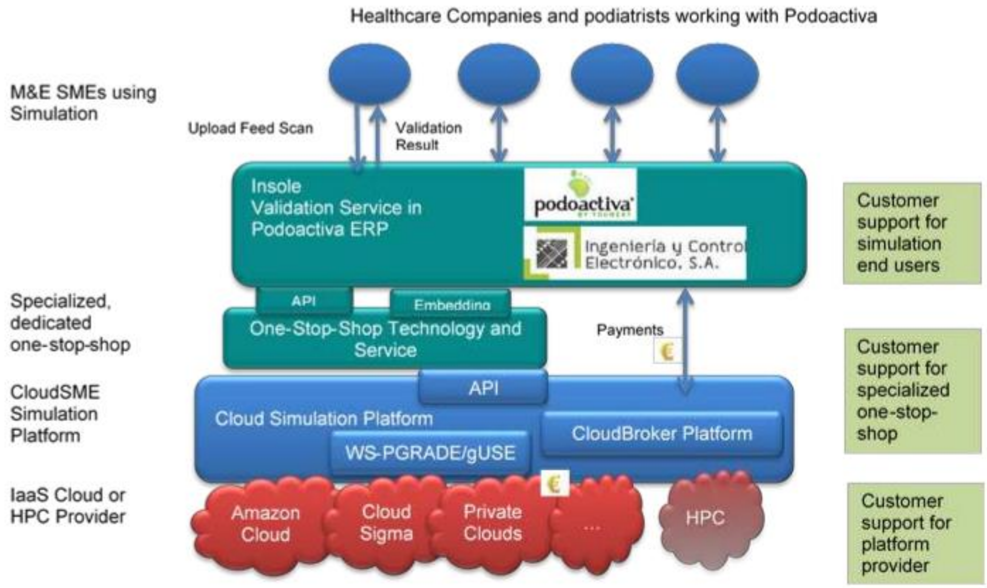


Figure 2.3 Concept of Insole validation for Podoactiva's customers
(Source: The CloudSME project – www.cloudsme-project.eu/)

As explained earlier, the business elements of Ingecon/ Podoactiva use-case have been used to compare elements of all five business model development methodologies, specifically to identify if similar comparison results are obtained. Further details on the business elements of the use-case, that are being used to create comparisons among business model methodologies, are provided in the chapter 4.

The business requirements analysis and business planning in both the use cases are evaluated in the project based on Osterwalder's methodology, i.e., 'business model canvas'. Also, business model canvas (BMC) is one of the five identified business model development methodologies. I used the exact business elements presented in the use-cases (through Osterwalder's BMC) and implemented those in the other four business model methodologies to create a comparison among each methodology. Some of the business components of the other four business model development methodologies are different from BMC. Those elements are uncovered through BMC in the project, nevertheless, they are analysed outside the business model analysis created in the project (for e.g., market analysis).

Although the comparison results do not lead to the development of the intended disruptive business model at this stage, the exercise is found to be very useful in analysing the general similarities and differences among those methodologies.

Besides, it is also evaluated that these business model methodologies are static in nature and do not display the dynamics of the technology. Although the analysis outlines similar static results, it assists in identifying that the technological factors are submerged in other business model elements (e.g., infrastructure that generally represents resources like software, hardware, and similar IT applications). There is, therefore, a need to decompose technological factors (representing disruptive technology and disruption) for the planned framework and business model development methodology.

Further, it is considered that an ontological approach is appropriate to create the proposed framework to develop customised business models for the organisations that make commercial use of disruptive technologies. Since ontology allows one to represent fundamental relationships of concepts (Hennig, 2008), the representation of the relationship between business and technological factors can be shown in the intended ontological framework (chapter 6). Alexander Osterwalder (Business Model Canvas) and Mutaz Al-Debei (V^4 concept business model) also represented their business logics through Ontology. I consider adopting an ontological approach by extending the business model ontology developed by Alexander Osterwalder. The reasons why I choose Osterwalder’s ontology is provided (in chapter 3). Also, there is no specific methodology to create/extend an ontology. Ontology shows the existence of the concepts and their fundamental relationship with each other. Similarly, an empirical analysis allows one to obtain, study, and interpret real-world data. Thus, I opt to conduct another case-study research to analyse the relationship between business, technological, and social aspects and understand their influence on each other and organisations’ business models.

2.2.3.2 Case Study Analysis – II

The first analysis of comparing five major business model development methodologies helps to identify that there is a need for breaking down the technological elements. Therefore, the second analysis is directed from the first analysis, to analyse the precise technological elements and their influence on the development of new business models. For this purpose, primarily, fundamental literature of technology is studied. This study helped me to understand the technology and its constituent elements (social elements) that influence the development of new technological systems. These newly introduced systems then affect organisation structure and inevitably bring change to the business models. In order to identify these patterns of changes, an empirical study is conducted by reviewing documents of the “CloudiFacturing” Project. For this analysis, the empirical data contains information on 7 use-cases comprising 30 individual companies that provide samples of 7 Independent Software Vendors (ISVs), 8 Manufacturing companies (end-users), 5 companies that operate as Digital Innovation Hubs (DIHs), 2 Resource Providers (RPs), and 8 Competence Centres.

Figure 2.4 CloudiFacturing Marketplace for Digital Engineering
(Source: The CloudiFacturing Consortium – www.cloudifacturing.eu/marketplace/)

Project Overview:

The CloudiFacturing Consortium – www.cloudifacturing.eu/:

CloudiFacturing (Cloudification of production engineering for predictive Digital Manufacturing) is a successfully completed project supported by European Union Horizon 2020 research and innovation programme. The concept of the CloudiFacturing project is to support manufacturing SMEs by offering an integrated network, both from the technological and from the business viewpoints, that leads European innovation in this area and operates an open, collaborative, and self-sustaining *‘Digital Marketplace’* (see Figure 2.4). This digital marketplace provides manufacturing related Cloud/HPC support; by providing ICT-enabled solutions, including cloudified Computer-aided tools (CAx), simulation and visual analytics software for big factory data running on flexible Cloud and HPC resources, as well as training and consultancy services to facilitate the adoption of the advanced technology.

The mission of CloudiFacturing is to optimise production processes and producibility using Cloud/HPC-based simulation and modelling, leveraging online factory data and advanced data analytics. In order to achieve this objective and to establish its technical results on a critical mass of manufacturing companies (especially SMEs), the project runs approximately 21 application experiments in 3 waves (phases). Each wave of experiments has around 7 end-user companies (small to medium manufacturing companies that require cloud-based simulation solutions) and 7 independent software vendors (ISVs) companies (that develop cloud-based simulation solutions for their end-users). Furthermore, several other project partners are involved in the collaboration and their specific roles include Digital Innovation Hub (DIH), Competence Centre (CC) and the Resource Provider (RP).

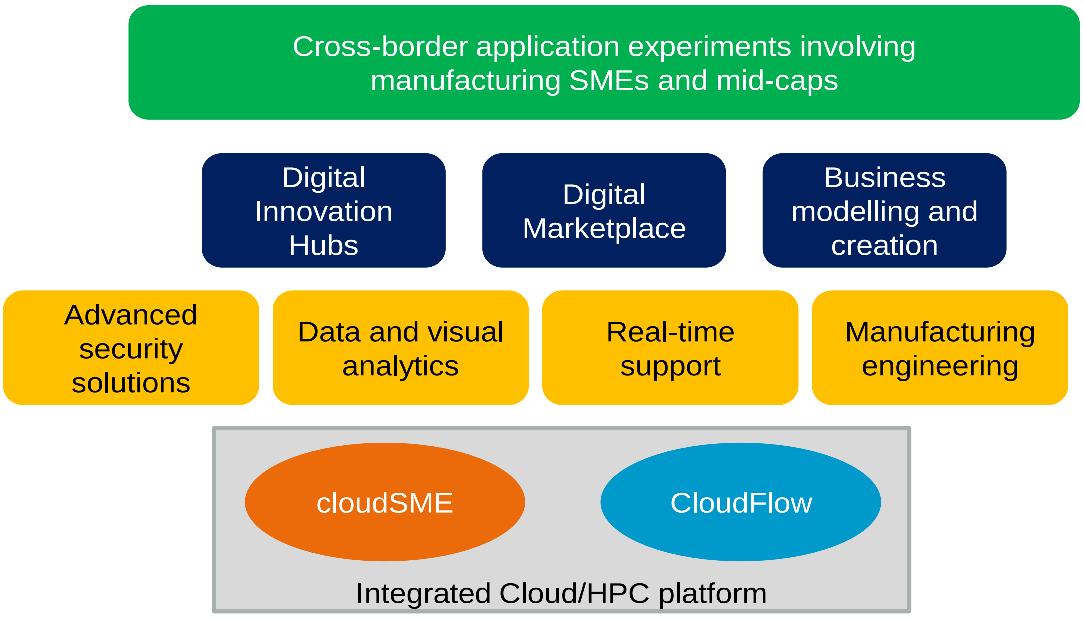


Figure 2.5 Mission of CloudiFacturing

(Source: The CloudiFacturing Consortium – www.cloudifacturing.eu/)

As described above, the CloudiFacturing project runs 21 experiments in 3 waves, my research analysis is conducted based on the review of the first wave of experiments. In this first phase of experiments (7 experiments, which I call 7 use cases), 8 end-user companies (manufacturing SMEs) and 7 ISV companies get access to the CloudiFacturing platform. All these 8 end-user companies are different in terms of their offerings, production processes, requirements, etc. Likewise, all 7 ISV companies deliver distinct technical offerings and expertise. The CloudiFacturing platform gives them access not only to use cloud/HPC-based resources but also to receive support specifically to develop or tailor their technological solutions to be executed on the platform. Several other stakeholders support the experiments with different roles and positions, which are explained below.

Roles of Partners in the Project:

Each experiment is supported by a well-defined project team involving several partners. Each partner has a specific role within the team as explained below and accordingly contributed to the analysis, design, or implementation of the individual experiment.

- **End-user (Manufacturing SMEs)** – Manufacturing SMEs act as end-users in the project. They aim to improve their manufacturing processes using Cloud or HPC-based solutions via the CloudiFacturing project, i.e., these are the companies where the experiment's results are utilised. In the first wave of experiments, 8 manufacturing companies are involved in the project as end-users and choose to optimise their manufacturing activities.

- **Independent Software Vendor (ISV)** – ISVs are the companies that offer their simulation or analytics applications to the experiments that are to be cloudified during the project. Specifically, 1 ISV has participated in each use-case as per their expertise, i.e., a total of 7 ISVs participated in the first wave of experiments.

- **Digital Innovation Hub (DIH)** – DIHs act as the vital outreach channels for promoting and showcasing experiment results in potential SMEs (small to medium enterprises) in their network. Apart from this, DIHs also play a central role in supporting the experiments when developing the solution, coordinating the activities of involved partners in experiments, and resolving issues by acting as a liaison and broker. In this case study, a total of 5 DIHs are involved who support different use-cases according to their expertise.

- **Competence Centre (CC)** – These are the organisations with necessary expertise and know-how in the technologies involved in developing the CloudiFacturing solutions. They work along with the experiment partners and develop horizontal technology; to achieve the technical goals of the project and implement vertical adaptation, which supports the individual experiments providing a basis for technologically successful experiment execution. They also support experiment partners in technical issues. The project is supported by 10 Competence Centres, where one or more dedicated Competence Centres are involved in each use case. Two special partners also provide their support as CC by offering their expertise from the previous successful European projects of CloudSME and CloudFlow.

- **Cloud/HPC Resource Provider** – They are the special partner organisations that provide relevant infrastructure, i.e., all required hardware and software platforms on the cloud/HPC resources to create respective solutions for the experiments. The project is supported by 2 more companies who act as resource providers in each of the experiments. Below table 2.2 describes the involvement of partners in each use case. Since the company names remain confidential, the table shows individual companies anonymously.

Use cases (Experiments)	End-user Companies (Manufacturing SME's)	Independent software Vendors (ISVs)	Digital Innovation Hubs (DIHs)	Resource Providers (RPs)	Competence Centres (CCs)
Use case 1 Optimising design and production of electric drives	Manufacturer 1	ISV 1	DIH 1	RP 1	CC 1, CC 2, CC 3, CC 4
Use case 2 Cloud-based modelling for improving resin infusion process	Manufacturer 2	ISV 2	DIH 2	RP 2	CC 4, CC 5
Use case 3 Improving quality control & maintenance using big data analytics	Manufacturer 3	ISV 3	DIH 3	RP 1	CC 1, CC 2, CC 4, CC 6, CC 7
Use case 4 Numerical modelling and simulation of heat-treating processes	Manufacturer 4, Manufacturer 5	ISV 4	DIH 4	RP 2	CC 4, CC 8
Use case 5 Optimising solar panel production	Manufacturer 6	ISV 5	DIH 5	RP 2	CC 4, CC 5
Use case 6 Optimising efficiency of truck components manufacturing processes by data analytics	Manufacturer 7	ISV 6	DIH 3	RP 1, RP 2	CC 1, CC 2, CC 6, CC 7
Use case 7 Simulating and improving food packaging	Manufacturer 8	ISV 7	DIH 1	RP 1	CC 1, CC 2, CC 6

Table 2.2 CloudiFacturing project team, their roles and involvement in each use case

In addition to the roles defined above, all experiments are supported by two specialised competence centres (as explained earlier) during the specification of business and technical requirements. The experiments are supported through the collection of all business requirements analysis, business modelling, financial analysis, technical & usability requirements, and assessment of implemented solution from an end-user's perspective (The CloudiFacturing Consortium – www.cloudifacturing.eu/).

The project document contains rich information about each organisation's technical, business and usability requirements, the design and implementation of the planned cloud/HPC-based solutions utilising the CloudiFacturing solution at varying levels. Correspondingly, the possible impacts of the experiments are also accessible in the document. The primary focus of this empirical analysis is to identify the interrelationship of social and technical factors and their influence on the development of new technological solutions, and how this new development causes the development of new business models. Therefore, the analysis is conducted based on the work undertaken and the progress made within the project concerning the business and technical requirements, design, and implementation, as well as the outcomes of the experiments.

It has been perceived that the contents of the document have been written by several authors of different companies involved in the project. Those authors are mainly international, whose first language is not English. This creates incoherence in the document and makes the analysis very challenging. The business analysis has been completed by a specific team, who used the lean canvas model methodology to derive the business models for each use-case. The lean canvas model is one of the five identified business model development methodologies in our study (section §), which therefore makes the analysis very interesting.

2.2.4 Observations

Observations are a useful technique used for closely *"observing and understanding the dynamics and interactions of the phenomenon under investigation"* (Moura and Bispo, 2020, pp. 360). It varies from participant observations to non-participant observations. It is considered to be an effective method to sense, feel, watch and be around people or objects (Moura and Bispo, 2020).

As explained above that, I conducted an empirical analysis using a case study strategy. I also carried out participant observations with the same organisations that I obtained documents from and reviewed them as my use cases. I joined the CloudiFacturing (CFG) project (§2.2.3.2) as a 'Research Associate' on a 12-week contract (between 01.07.2019 – 20.09.19) through the University of Westminster (Leader of the CFG Project). I worked a few weeks extra to finalise the work I was given. My main role was to assist a team (competence centre specified for arranging business modelling, technical and financial requirements) and contribute to the development of the business model for the digital marketplace (that was under development and part of the CFG features). I got access to various documents (related to the project), project meeting notes, and a platform to observe different companies' perceptions. Besides, I was actively involved in the project and attended major project meetings during my time at CFG. Since the companies involved in the project were located in diverse geographical areas, the meetings took place as online conferences. Although the meetings were organised to discuss the business model of the CFG digital marketplace during my time at CFG, a careful discussion was observed during the first wave of the experiments (CloudiFacturing, no date). I have attached a document in Appendix B, that briefly explains the direct notes I took while attending meetings, and that also mainly highlights contents that are directly relevant to my study.

2.2.5 Other Research Methods

This section presents the data collection, data analysis, and research approach together. The following paragraphs represent the methods as shown in figure 2.1.

2.2.5.1 Data Collection

Secondary Research:

The research also conducts a secondary research (as a data collection) method to review the related literature and examine the literature on disruptive technologies, socio-material influence in system development, various business model development methodologies and frameworks to conceptualise business model elements.

Various scholars and practitioners such as Christensen et al. (2015), Manyika et al. (2013), Ekekwe and Islam (2016) and others embraced disruption, disruptive technology, and other similar subject matters in their research widely. This research further reviews the literature of disruptive technologies to evaluate the impact of new, emerging, and dynamic technologies toward recent businesses. A sociomaterial view of the technology development and management is also reviewed (chapter 3).

Moreover, this research explores existing different business model development methodologies with the aim of developing an initial conceptual model that can guide in creating an intended framework and methodology to build disruptive business models. Various researchers suggested different methodologies to develop business models with respect to diverse business types and requirements. This research thoroughly explored and identified five business model methodologies (chapters 3 and 4), particularly relevant to this research; that is, Generic Business Model (Hedman and Kalling, 2003a), Business Model Canvas (Osterwalder and Pigneur, 2010), V4 Concept Business Model (Al-Debei and Avison, 2010), Business Model Engineering Approach (Seidenstricker et al., 2017), and Lean Canvas Model (Maurya, 2012a).

Additionally, this research also collected data by reviewing project documents of two actual case studies (real business cases) that are described in section §2.2.3. The research uses business components of the five mentioned business model methodologies and mapped business elements of respective business cases to create a methodical comparison between those methodologies (chapter 4).

Primary Research:

Apart from the secondary data, the research analysis is also made on primary data. Primary research is about accessing first-hand data (or raw data) that has not been interpreted or evaluated by any other source before. The primary research addresses certain research questions using qualitative or quantitative methods such as interviews, observations, or analysis of language (Hewson, 2006; Jupp, 2006). This research collected primary data by making active observations (§2.2.4) on the members of organisations that are considered as use cases for empirical analysis.

For this research, the primary data has been very useful in creating thematic analysis. The research applied qualitative coding to the project documents and validated them through observations. Therefore, the data analysis is conducted abductively (going back and forth from primary to secondary data) to identify similar patterns and emerging themes out of those patterns (§2.2.5.2).

2.2.5.2 Qualitative Data Analysis

Qualitative data signifies non-numeric data such as transcripts, notes, audio and video recordings, text documents or images. Qualitative analysts focus on analysing language rather than numbers to interpret the information (Jupp, 2006). Qualitative research can be conducted through several approaches such as *content analysis, framework analysis, narrative analysis, thematic analysis, grounded theory, case study and phenomenology* (Saldaña, 2011). Although each method in qualitative research has its own significance, the research background, context, and available resources influence the use of the specific method. The main findings of this research are carried out using thematic analysis, which then contributes to forming a conceptual model as a planned framework.

A qualitative study includes various steps and is an iterative process of data analysis, depending upon the method of data analysis. Since this research conducts thematic analysis by reviewing the project's documents and data collected through observations, it creates qualitative codes. The number of steps this research uses to analyse the data are explained below:

Data Condensation – developing and applying codes:

Data condensation is a process of selecting, simplifying, transforming, and abstracting rich data. The process of data condensation actually starts before the data has been collected in the form of research questions, conceptual framework, and the research designs. Generating codes, creating categories, developing themes, or writing summaries, all are the process of data condensation (Miles, et al., 2020).

Code (also known as qualitative code) refers to *"a 'word' or short 'phrase' that has been symbolised a summative, salient, essence-capturing and/or evocative attribute for a portion of language-based or visual data"* (Saldaña, 2013). Gibbs (2007) described qualitative code as, "*coding is, how you define what the data you are analysing is about".*

In other words, a qualitative coding is a process to identify similar patterns, classify concepts and forming associations among those concepts from a section of collected text/ video/ image/ audio to analyse. The coding links that analysis to the research's central idea or other related data. All codes are to be assigned important titles. The coding can be created manually or using a software for qualitative data analysis such as NVivo. NVivo has been designed for qualitative researchers to conduct a deep level of analysis of a rich text-based and/or multimedia data. This research has used NVivo software to analyse the project document.

Identify themes, patterns, and relationships:

There are no universally acceptable methods which can be used to analyse data. The researcher itself plays an important role by using its own analytical and critical thinking skills in qualitative data analysis. However, there are some techniques which can be applied to detect common patterns, themes, and interrelationship of concepts. Some of those techniques are as below:

- Word and phrase recurrences
- Examining the missing information
- Comparisons of primary and secondary data
- Metaphors and analogues

Data Display:

Another flow of analysis activity is data display. A display is a structured and condensed assembly of information that helps researchers to understand what is happening and what needs to be done. Based on those understandings, the researcher can make analytical reflections or take further actions. The organised data can be displayed in the form of matrices, graphs, and networks (Miles, et al., 2020).

Drawing and verifying conclusions:

This final flow of activity allows the researcher to interpret data (§2.2) and draw conclusions based on identified patterns, themes, assertions, and causal flows. These conclusions can be elusive at first, and with later refinements, they can become more explicit and meaningful. Conclusions can also be verified as the analyst proceeds.

2.3 Summary

This chapter addresses the number of methods used to carry out effective research. The chapter provides a brief discussion of the research methods choices, approach, and design, along with the justification and importance of those methods for this research. The chapter highlights the significance of using qualitative research and its associated methods to understand the interrelationships of two or more concepts. It further explains the importance of a case study strategy for the empirical investigation to get a comprehensive view of a phenomenon. For this research, the phenomenon is the interrelated elements of social, technical, and business that influence the change of business model within an organisation. Simultaneously, it justifies how these research methods are effective for conceptualising the high-level relationships among concepts. Finally, the relationship of concepts is demonstrated through an ontological framework as an intended framework to develop disruptive business models. The next chapter provides an overview of existing literature on business modelling in the context of technological change and its consequences on business model change.

Chapter 3 Literature Review

3.1 Overview

This chapter accumulates comprehensive knowledge about the entire subject matter related to the research domains. Several previous studies are explored to understand the notion of disruptive technologies, the concept of business models and their influence on modern businesses. Further, various business model development methodologies are reviewed to understand the arrangements of the business practices in the event of introducing new technological solutions built on disruptive technologies. Moreover, different fundamental papers are examined to apprehend the constitution of social and technological (socio-material) factors influencing the development of new technological systems. The chapter also provides insight into how the dynamic interaction among these factors (socio-material and new technological arrangements) may create disruption, and then cause the development of new business models. Consequently, a conceptual framework is prepared from the dynamics of interdependencies of the social, technical, and business model elements. Finally, it is considered to represent the association of the social, technical, and business elements by adopting an ontological approach.

3.2 What is Disruptive Technology?

To begin with, in the development of disruptive business models to manage the commercial use of disruptive technologies, it is important to understand both the concepts, i.e., disruptive technologies and business models. There is an ultimate relationship between disruptive technology and business model, which is presented visibly in this chapter. The concept of disruptive technology has gained so much attention in recent years and various scholar has provided different views on it. Disruptive technologies are those technologies that bring a constant flow of change in the markets and industries (Christensen, 1997; Ekekwe and Islam, 2012) in terms of technological change (Boucher et al., 2020), business model change (Christensen, 1997, 2013; Hwang and Christensen, 2008; Mark W Johnson, Christensen and Kagermann, 2008; Boucher et al., 2020), innovation, and may influence disruption (Manyika et al., 2013; Boucher et al., 2020). These technologies create new or improved technological products and, in the process of introducing those products, they completely displace the existing products, and consequently leave a greater impact on existing industrial processes and the markets.

Professor Clayton M. Christensen from the Harvard Business School devised the term “disruptive technology” in his book ‘The Innovator’s Dilemma’. He explained that new technology has two categories, sustaining and disruptive. Sustaining technology is a progressive advancement to an already established technology. Disruptive technology, on the other hand, needs improvements; it often has operational problems (because it is new), appears to hold limited use, and may not yet have a proven applied application (Kassel, 2017). These two categories are further explained in section (§ 3.1.2).

According to Ekekwe and Islam (2012), innovations from disruptive technologies offer new opportunities through the provision of higher-valued products and services. They form new or unexpected markets and reshape the established ones by anticipating the customers’ perceptions, of their demands, and eventually meeting them. This change then enables shift across industries and subsequently impacts the competitive landscape through the development of new business models. This is feasible by applying a new set of standards, which, with time, gets improved to the stage they can overtake established markets (pp. 1-11).

In addition to this, Manyika et al. (2013) also described that disruptive technology improves products or services in such a way that markets neither expect nor demand but turns out to be well recognised as the optimum choice of a consumer. Therefore, it is clear that with the use of disruptive technologies, new systems can be developed which bring innovation and creates a new market, and a new value network and, in the process, disrupts the existing ones.

3.2.1 History of Disruptive Technologies

Before the early 17th century, the primary sources of power available to industries were the power of wind, water, and animate energy. In 1698, Thomas Savery invented the steam engine, which was very useful; however, many refinements were made gradually. In 1712, Thomas Newcomen introduced the improved steam engine to pump water out of mines (The Second Industrial Revolution: Timeline & Inventions, 2014). After that, several further improvements were made by several experts throughout the century. The use of steam power was exceptional and continued to be used in most industrial purposes until the late 19th century. Steam power did not only replace other sources of energy but transformed them and resulted in improved and efficient products.

While the first industrial revolution brought significant growth in railways, mining, and textiles industries, the second industrial revolution empowered the growth of electricity, gas, and petroleum. The use of electrical energy wholly reformed the way individuals lived forever before. In 1809, Sir Humphry Davy invented the light bulb. Eventually, after continuous modifications by other inventors, in 1879, Thomas Edison and Joseph Swan upgraded the design of the light bulb (Buchanan, 2019). Edison's conception of the light bulb worked effectively, which was practical, economical, and safe. Therefore, with the continuous refinements, by the early 20th century, steam power (which was exceptional) was replaced by electrical and fuel-based products and wired communication sources by wireless telecommunication with the invention of the radio (The Second Industrial Revolution: Timeline & Inventions, 2014). This period further led to the development of mass production, automobiles, air transport and others.

Subsequently, the dawn of the third industrial revolution started since the late 20th century, and carried forth the sources of nuclear energy and technological developments. Many other significant advancements were made continuously and promptly through the rise of electronics, computers, and the most efficient development 'the internet' (Pouspourika, 2019). All these revolutions witnessed how our old lives were disrupted and offered us more comfortable lives each time.

Immediately following the third industrial revolution, the trend of using the internet has become an essential part of our everyday lives. The extensive use of the internet ultimately has brought forward the fourth industrial revolution, which is happening now. Although some people do not agree with the fact that the fourth industrial revolution is proceeding, amazing new developments are surprising us every day. So, forth cloud and distributed computing, renewable energy, robotics and virtual computing, internet of things (IoT), big data analytics, artificial intelligence, cyber-physical systems, and many other (ongoing) developments have been introduced and known as so-called disruptive technologies. While these technologies are highly significant and hold the potential to thoroughly transform the quality of life we are living with the introduction of automatic and intelligent systems, these new technologies are also disrupting our businesses (Vandenberg, 2019).

Since it has been examined through the three historical industrial revolutions, the disruption does not happen at once. The formation of new technical systems took a while to completely displace the existing systems with continuous planning and improvements in those newly introduced systems using the same available resources. Today, many businesses are struggling to realise that the adoption of advanced technology requires an advanced level of planning (Grimsley, 2013). It is also critical to understand that disruptive technology is not an invention of new technology. Instead, it is using the latest technologies that are already present in the market but changing the processes of business and arranging the technological systems by introducing comparative business models to design an innovative product or service.

Further, it has also been noticed that the time frame of each revolution has decreased over time (see figure 3.1); for example, the first revolutionary period was longer than the second revolutionary period. Moreover, many different advancements were made rapidly during the period of the third revolution as compared to the other two revolutions.

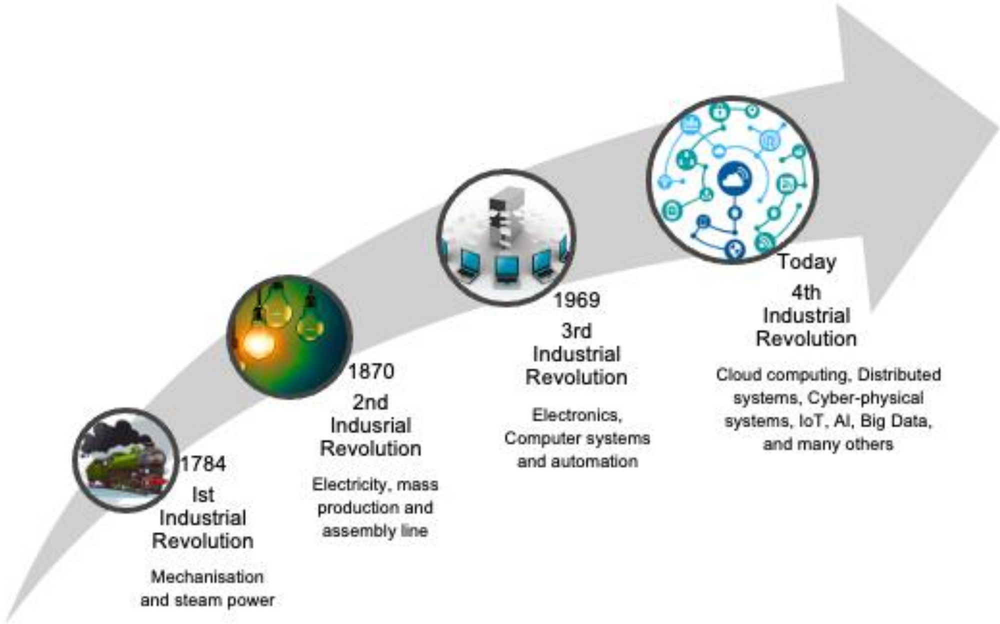


Figure 3.1 Time frame between the four industrial revolutions

The fourth revolutionary changes are appearing even closer. Presently, technologies and markets are evolving far faster than a business can adapt to such changes. In order to achieve proficiency, a business should disrupt itself before the technology disrupts it (Martins, 2018). Therefore, a business needs to look for any inevitable variances in the organisational structure while introducing new technical systems utilising new technologies; and to plan continuous monitoring to improve those processes while any changes are occurring, this is generally arranged through the business models.

3.2.2 Types of Disruptive Technologies

Disruptive technology framework involves two types of innovation; sustaining innovations and disruptive innovations. These both are differentiated based on technological performance and market segmentation.

Sustaining Innovation: Sustaining innovation comes from customer's expectations in the established market and by creating products that satisfy their needs for the future. In other words, under sustaining innovations; technologies are developed to help firms sustain and generate their growth in existing markets to ensure better performance, market growth and dominance. Sustaining innovation is incremental or radical, which does not lead towards any revolutionary change instead focuses on improving the performance of established products or services. This innovation is highly successful in large scale industries for their commercialised products simply as they have more financial resources, more customers and possess the capacity to push the innovation into the market (Ekekwe and Islam 2016).

Disruptive Innovation: Professor Clayton M. Christensen (Christensen, 2017; Christensen et al., 2015) depicted that *"disruption"* refers to a process, in which a smaller company with fewer resources can effectively challenge well-established incumbent businesses., as the established organisation concentrates on improving products and services for its most demanding customers. Further they prioritise the needs of some segments and overlook the needs of others. Companies that proved to become disruptive, as they target those overlooked segments, gaining a foothold by delivering high-suitable performance at a competitively lower price.

Additionally, disruptive innovations are the innovations that make products and services more accessible and affordable to a much larger population. This innovation is something that transforms an existing marketplace by introducing simplicity, convenience, accessibility and affordability to a similar product or service that is complex and expensive. Initially, disruptive innovation is produced at the point that may appear unattractive to incumbents; however, sooner or later, the new product or service gets entirely adapted to the industry (Christensen, 2017; Christensen, 2013).

On the whole, companies who follow "sustaining innovations" by chasing to fulfil needs of their most sophisticated customers at the top of the market to achieve the greatest profitability, are actually leaving the opportunity to other entrant companies to commence "disruptive innovations"; starting at the bottom end of the market and moving towards upmarket or tapping a new market that incumbent had failed to notice. Here is when the incumbent's mainstream customers start adopting the entrants' offerings in volume as their demands get accomplished while having their prevailing convenience (Christensen, 2017).

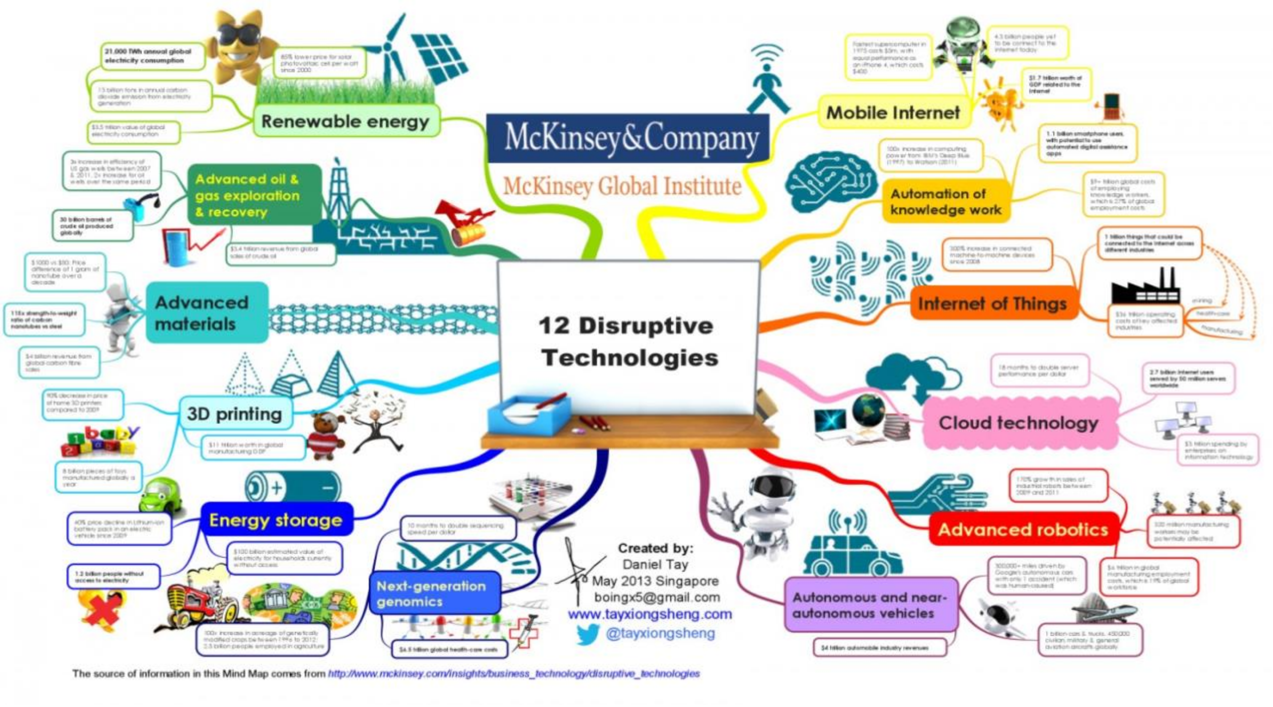


Figure 3.2 Disruptive Technologies (Tay, 2013)

There are many examples of emerging technologies that could become disruptive and produce new valued business models. Proceedings points will be covering a few of those emerging technologies.

3.2.3 Is Technology Disruptive?

As stated earlier (§ 3.1.1) that new technologies which are not fully established, create uncertainties and only appeal to the restricted audience for the development of new innovative products, that then eventually disrupt current business routines are known as 'disruptive technologies' (Christensen, 1997; Kylliäinen, 2019; Piplad, 2020). In other words, a disruptive technology is the one that introduces an unexpected change, improvement or new product and displaces the existing one (Kulkarni, 1988; Kassel, 2017). (Danneels, 2004) defined *"a disruptive technology is a technology that changes the bases of competition by changing the performance metrics along which firms compete."* In addition to technology, business models also play an important role to create disruption. The 'business model' dimension is discussed in section (§3.4).

There is another dimension to what makes a technology disruptive. There is no doubt that disruptive technologies are transforming the quality of life we are living, and the way organisations operate today, how they are affecting the way we communicate, study, work, etc. Though new products are created using new technologies, they are created for the human cause, and at the same time created by the human. These expressions directly link to societal representations. Therefore, to understand this social and technical link, the research has explored the fundamental literature on technology. These studies provide the impression that it is not only the technology that causes disruption, but there are also constitutional social factors that shape the technology to make a technological product to perform certain actions, and if those actions are routinised; a technology becomes disrupted. This view of interconnected factors of technology and social has given less attention in IS and management research, especially in the context of business models.

Previous studies related to social sciences, show the entanglements between the social and technology, which is termed socio-materiality, emphasis the relationships among humans and technological products as a constitutive intertwining (Fenwick, 2010; Leonardi, 2012; Scott and Orlikowski, 2014). Further some argued that the entanglements of socio-materiality influence the development of new technological systems and then impact on organisational change in the context of structural arrangements (Orlikowski, 2000; Orlikowski, 2007; Parmiggiani and Mikalsen, 2013), knowledge (Orlikowski, 1992; Orlikowski, 2009; Fenwick, 2010; Hattinger, 2016), competitive influences (Orlikowski, 1992; Orlikowski, 2009; Svahn, 2009), communication arrangements (Orlikowski, 1992; Orlikowski, 2009), business strategies, organisational culture, etc., (Orlikowski, 1992).

Weick (1990) presented a view of technology as a form of knowledge and the technical system as a subset of that knowledge by presenting a definition by Berniker (1987), *"technology refers to body of knowledge about that means by which we work on the world, our arts, and our methods. Essentially, it is knowledge about the cause-and-effect relations of our actions… Technology is the knowledge that can be studied, codified, and taught to others".* Whereas a technical system is *"a specific combination of machines, equipment and methods used to produce some valued outcome… Every technical system embodies a technology. A technical system is a combination of machines, equipment and methods used to produce some valued outcomes. It derives from a large body of knowledge which provides the basis for design decisions"* (Berniker (1987), cited by Weick, 1990).

If technology is knowledge, then can knowledge be disruptive? To answer this, it is important to understand that unmaterialised knowledge cannot be disruptive; however, considering Christensen's definition, when technology (and knowledge) gets materialised into a technological product and disrupt the existing product then it becomes disruptive.

3.2.4 'Taken-for-granted' Socio-material Aspects During Technological and Organisational Change

A technological change is an improvement in the 'art' of developing (technological) products and/or processes. A technological product is an application of knowledge, created and shaped by human to improve the old practices, lifestyles, and society; while a technological process is a function to develop and improve products and services. Technological change not only brings new opportunities in an organisation by creating new technological products or processes but also creates new markets and changes in societal context.

Although new technologies offer exceptional transformation to organisational context, it happens in an unprecedented way (Weick, 1990). A specific technological product or process based on a particular technology is appealed to be highly efficient to one organisation; but the same product is proven to be not very successful in another organisation (Soh, Kien and Tay-Yap, 2000; Martinsons, 2004). This is due to the disagreement in beliefs of organisations or cultural differences. It is very important to measure societal and cultural contexts in the event of introducing a new technological product to an organisation. Several experts agreed on the fact that the relationship between society and technology is complex. A new technological launch prompts a range of social reactions, that cannot be predicted, as a result of differences in individual opinion. Likewise, no single societal situation can cause to produce a determinable technological response (Orlikowski, 2009; Buchanan, 2019; Olatunji, 2022). As a fact, different responses that come from the social and the technological change, shape each other and must be planned together.

A number of theories from social sciences acclaim the constitutive entanglement of the social and the material (artefacts as a technical perspective) in everyday life (Orlikowski, 1992, 2007; Orlikowski and Gash, 1994; Scott and Orlikowski, 2014) yet have been ignored or 'taken for granted', especially in information system development and organisational research. Particularly in the case of new technologies, business experts or developers should abandon these perspectives where technology is treated as a black box, and social affairs (human actions) are getting separated from technology (Orlikowski, 2007; Orlikowski, 2009). The research, therefore, seeks to understand this entanglement of socio-material aspects and undertake relevant concepts to show their institutional properties for the development of new technical systems and subsequent new designs of business models.

(Karl E Weick, 1990) also illustrated that "Material artefact arrange sensemaking process in motion, sensemaking is controlled by actions, actions themselves are constrained by artefacts, and sensemaking attempts to identify conditions developed by the technology." He further highlighted in his research that new technologies are equivoque and therefore are difficult to understand by some business analysts, while designing technological systems based on new ambiguous technologies. He specifically highlighted that because these technologies are complex and unpredictable, they make a very little sense but sometimes many different types of sense. Other than Weick; Orlikowski and Gash (1994), Hirschheim, et. al. (1996), Davidson (2002), Davidson and Pai (2004) have also justified the importance of sense-making in new technologies and organisational changes related to that technology. It has been examined that these technologies not only require time and experience to understand but also need measuring their impact by identifying the connection of these technologies with society, organisations, and other important concepts.

Moreover, Weick (1990), Moore (1991), Orlikowski and Gash (1994), Hirschheim, et. al. (1996) emphasised the fact that the social factors such as different understandings and values of technology (of different actors in an organisation) are significant to influence the development and use of a new technical system and consequently to understand the organisational change. This research build on examining this entanglement of socio-material factors (social and technical factors) for the development of new technical systems and organisational change. Weick further described that "mental representation and micro-level processes (understanding rapid variations in processes) are critical to understanding the organisational impact of new technologies." Orlikowski & Gash (1994) highlighted that "technologies are the social artefacts, their material form embody their sponsors' and developer's objectives, values, interests and knowledge of the technology”. Whilst Hirschheim, et. al. (1996) defined ‘technical systems that manipulates, stores, and disseminates symbols (representations) which have an impact on socially organised human behaviour’.

Similarly, Weick highlighted that newer technologies are dual. They not only engage autonomous, invisible processes that are actually making sense but also invite equally autonomous, invisible imagined processes that are mentally illuminating in individual’s mind. These combined processes of stochastic events and continuous events develop cognitive emotional complexity and operators mistake at individual level. Therefore, he suggested that cognition and micro-level processes are critical to understand the impact of new technologies. Likewise, Orlikowski (1992) covers two main aspects of new technology to understand its structural arrangement; (i) duality of technology – which she meant that the technology is created and improved by human actions, yet it is also used by humans to undertake some actions. (ii) technology is interpretively flexible – which express the interaction of technology and organizations as a meaning of the different actors and their socio-historical perspectives involved in its development and use. Thus, it is significant to understand and model the social influence for developing or using technological systems which then influence the changes in organisational structure including busiensss models.

Furthermore, Moore (1991) stressed that while adopting a new information systems, primary focus of manager should be assembling the perception of user’s (rather than the perception of innovation itself) and how user’s perceptions impact the use of information systems. Similarly, Orlikowski & Gash (1994) argued that understanding people perspectives towards technology is substantial to understand their interaction with it. To interact with technology, people need to make sense of it; and in this process of sense-making, they develop specific knowledge, assumptions, and expectations of technology, which as a consequence derive to shape some actions towards it. These perspectives then become routinised and treated as ‘taken-for-granted’ mental and behavioural habits. Nonetheless, these perspectives are very significant to reflect on; Orlikowski & Gash (1994), therefore introduced two perspectives of frames; users’ frames and system designers’ frames which are also detailed in the below section (§3.2.5).

3.2.5 Importance of Re/conceptualising in New Technology

As described in previous section that new technologies are ambiguous and make various kinds of sense and therefore cannot be framed in 'one unified paradigm' instead require various kinds of concepts, therefore require a continuous structuring and on-going sense-making in technologies and organisations (Karl E Weick, 1990; Orlikowski, 2009). The theories of social cognitive research reflect on the importance of mental models. These intellectual models are exceptionally sense-making devices, particularly required during the process of technical and organisational change.

Various scholars have described a framework differently. Some have described a framework as an important step of implementation and some view this as a model based on research and practical experiences such as theoretical frameworks and conceptual models (Meyers, Durlak and Wandersman, 2012). Some researchers view a framework as a paradigm; where a paradigm refers to a fundamental set of constant assumptions held by an individual which guide their work agenda and the framework (Grant and Giddings, 2002; Rogers, 2016; Kovács-Kószó, 2020; Matthew B Miles, Huberman and Saldaña, 2020) consists of categories or paradigms for interpreting and relating different concepts (Robson, 2018).

While Miles and Huberman (1994) define a framework *"as a graphical or narrative demonstration of key factors, variables or concepts to represent the phenomenon of implementation."* (Roux, 2003) outlines a framework as a representation that *"provides a coherent analytic process for studying empirical data to explain the complexity of technological change."* Besides, a framework can be viewed as an ontological hierarchy (Hirschheim, et. al., 1996). They described a framework as a process of the conceptual development of a model base and/or a taxonomy, which can be used to map or relate the concepts with each other to reach an outcome. Meyers et al. (2012) added to describe the term framework as information that focuses on the *''how-to''* execution such as sources that present details of the specific procedures and strategies believed to be important for quality implementation.

The framework for modelling concepts is also viewed in social sciences research, where the terms referred to as "frames", "conceptualising" or "re-conceptualising" a idea. Weick (1990) suggested the importance of revising the concepts of new technology. He stressed that previously introduced (cause-and-effect) technologies were physical, deterministic, and mechanised, thus the focus was on the concepts related to structure, analysis, static complexity, and behaviour control. Currently, the technologies begin to be more stochastic, continuous, and abstracted and sometimes create problems of failure in business when making technological arrangements based on these technologies. The managers and designers work on their psychological models but never be able to understand the cause of the problem as it involves so many views.

To signify similar view, Orlikowski (1992) suggested a theoretical model to understand the relationship and interaction of technologies and the organisations. The author presented earlier views of technologies; which either have a deterministic impact on organisational properties by providing insight on how technology is used or have a strategic perspective of technology to be dynamic and have human involvement by providing insight to how technology is developed. She argued that both these previous views of technology are incomplete and one-sided, therefore she proposed a reconstruction of the concepts of technology where notions of technology and its roles in the organisations can be fundamentally re-examined. She used concept from Giddens' 'theory of structuration' to analyse interaction of technology in organisation during its development and use (nature and role of technology in the organisation) and referred the model as 'structurational model of technology'.

She highlighted two major aspects of technology; duality of technology and interpretive flexibility of technology. Both of these aspects have been masked by the time-space discontinuity in different periods of interaction between the technology and the organisation. This dual view of technology shows that the technology is developed by human and institutionalised in structure. It also reflects technology as a product of knowledge, material, interest and conditions. Another view of technology as being interpretively flexible shows flexibility in how people design, use and interpret technology; and flexibility is a meaning of the material components of the artefacts, the institutional context of technology development and use, the knowledge, power and interest of human agency (developers and users). Consequently, the components of 'structurational model of technology' proposed by Orlikowski (1992) are comprised with (i) human agents (designers, users and decision-makers), (ii) technology (material artefacts intervening task execution), (iii) institutional properties of organisations

(organisational contexts; structural arrangements, business strategies, expertise, culture, procedures, ideology, knowledge, competitive forces etc.)

Equivalently, Orlikowski & Gash (1994) introduced technological frames to represent the impact of different interpretations of 'system developers' and 'users' on using a 'newly introduced technical system' (an artefact) in an organisation. This approach is useful to examine the congruence/ incongruence underlying assumptions, expectations and knowledge that people have about technology. They further argued that these technological frames presents an effective analytical perspective for predicting actions and meanings that are not easily obtained through other theoretical concepts. (NB: frames refer to assumption, expectations and knowledge of people). They identified three domains relevant to the adoption of newly introduced technical system; 'nature of technology', 'technology strategy' and 'technology in use' to evaluate different perceptions of 'designers' and 'users' on using a groupware system (Orlikowski & Gash, 1994).

Likewise, Hirschheim, et. al. (1996) also proposed a conceptual framework which is useful to interpret and relate key results from different intellectual structures (based on different domains and orientations) of developers for the development of information systems. Their main focus is to gain insight on different behaviour and viewpoints of actors involved in the development and use of technical systems. In order to capture wide range of intellectual structures of information research development, Hirschheim et. al. (1996) first reviewed the viewpoint presented by Banville & Landry (1989) of information systems development research as 'fragmented adhocracy' while analysing general problems and relevant solutions of developing technical systems. They also implied that unifying paradigm of information system development is not effective, where one paradigmatic view for the technical development or use is dominant than the other and there is a requirement of a framework which includes different angles. Here, the researchers used theory of Habermas to consider the concepts of 'orientation'. Orientations are the consistent set of attitudes, assumptions, intentions, and beliefs of developers which they build during the process of technological change (Habermas, 1984, Habermas, 1987; cited by Hirschheim, et. al. 1996).

Moullin et al., 2015 proposes a generic implementation framework to illustrate the core concepts of implementation. They claimed that they formed this framework by using many former frameworks and so it is not completely new however is very efficient to ensure chosen models, frameworks, theories, innovation and/or other relative variables cover the basic implementation concepts. This research follows an ontological approach to create a projected framework to develop disruptive business models. Disruptive business models refer to the business models that are specifically designed for organisations that offers cutting-edge solutions/services based on disruptive technologies to their customers.

3.3 What is Business Model?

The concept of a business model became prominent just after the initiation of internet technologies during 1990's. Since that time, various researchers and business experts have brought out this concept through academics and other publications (Zott et al. 2011). The business models are integral part of modern enterprises since it covers a firm's internal and/or external strategic requirement analysis necessary, that is an organisation's mission, objectives, strategies, and tactics. In other words, an effective business model is important to execute an effective business plan (Muehlhausen, 2013).

There is no specific definition of a business model. In general, a business model is a profit formula for acquiring customers, servicing them, and making money as a result. It is a structure of regulations to manage relative business operations. Nevertheless, several scholars considered and presented business models according to their own perceptions. *"Business modelling is the managerial equivalent of the scientific method; you start with a hypothesis, which you then test in action and revise when necessary"* – (Magretta, 2002). Besides, (Hedman and Kalling, 2003b) described the business model conception *"as a relation between information system and strategy"* of a firm. They reviewed multiple pieces of literature and concluded that it is highly significant to comprehend how Information Systems enhance business strategies, offer competence as well as the importance of sustainable advantage for a business.

Further, Osterwalder et al. (2010) stated that "A business model describes the rationale of how an organisation creates, delivers and captures value." In words of Zott and Amit (2010), a business model refers to as 'the content, the structure, and the governance of transactions designed to create value through the exploitation of business opportunities.’ Besides, (Al-Debei, 2010) defined a business model as *“an abstract representation of an organization, be it conceptual, textual, and/or graphical, of all core interrelated architectural, co-operational, and financial arrangements designed and developed by an organization presently and in the future, as well as all core products and/or services the organization offers, or will offer, based on these arrangements that are needed to achieve its strategic goals and objectives”.* The business model is also termed as a plan, a statement, a conceptual tool, a model, a framework, a description (Baden-Fuller and Morgan, 2010), an architecture, a representation, a structural template, a methodology, and a pattern (Peric, Durkin and Vitezic, 2017).

The literature on business models underlines the importance of constructing a business model, particularly in the field of research in e-commerce, technology management and strategy management (Zott et al., 2011). Foss and Saebi (2017) expressed the view that the business model is widely considered as the structural design of the value creation, value delivery and value capturing mechanism of an organisation (Teece, 2010; Baden-Fuller et al., 2017). Further (Foss and Saebi, 2017) argued for the literature on the business model and explained that the business models are developed (1) to understand the value drivers of the business, and (2) as they are considered to play a significant role in boosting a firm’s performance, (3) as they are the potential unit of innovation.

A well suitable business model allows an organisation to address scenarios other than evaluating its main offering to capture value. Kesting and Günzel-Jensen (2015) justified that Google made a successful leader in business as it realised the full potential of its business model by offering main services (search engine) at no cost and making a profit through other opportunities that by Google AdWords. Therefore, it is essential to create or change a business model at such time to increase the set of resources for the business’s growth (Kesting and Günzel-Jensen, 2015).

3.3.1 Business Model Aligned with Factors of Disruption

In addition to the factors mentioned above, the factors of disruption also influence firms to change their business models. *“These days it is no longer good enough to build a company to last; it is about building a company to ignite change. The power of positive* *destruction reveals how to start a new business, disrupt an industry, and adapt to changing environments by leveraging technology and a new mindset"* (Merrin and Adler, 2016), and business models (Schiavi and Behr, 2018). It is crucial for a business, specifically firms that commercialise disruptive technology, to timely look for new market trends and competition dynamisms, and, accordingly, change their business models (Evans, 2003).

3.3.1.1 Competition forces

Competition forces are the network of competition in the new market. It describes the new and potentially disruptive trends present in the market and does not necessarily represent organisations' competitors. These trends can be new potentially disruptive technologies or potentially disruptive business models. For example, Merrin and Adler (2016) described how a company can positively disrupt its own business model by borrowing insights from other companies and improving its existing practices. The author gave the illustration of a cement company, Cemex. Conventionally, Cemex's customers (such as construction companies) never received the exact amount of cement required for the construction. They bought either too much or too little amount than needed. If they bought too little then another delivery was required (which usually took a long wait time), or they required space to store the left-over material in case they bought too much. This was not too appealing for Cemex's customers. Cemex went on the edge of bankruptcy in the early 1990s. It perceived other organisations like Domino's, FedEx and the manufacturing industry. It implemented a "*just-in-time delivery mechanism*". By effectively using technology (satellites and similar software used by other organisations) and an efficient business model (concept of just-in-time delivery started by other organisations), Cemex provided the exact amount of cement as was required in a running project at that time. The customer did not have to buy the unnecessary quantity, they did not have to store excess material, and they did not have to wait for long or delayed deliveries. By changing the game, Cemex became one of the world's largest cement producers and was known for being *"masters of innovation, technology, and strategic vision"* (pp.13).

3.3.1.2 Dynamic Capabilities

Dynamic capabilities reflect the firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments. They require an understanding of the nature of knowledge and competence as strategic assets (Teece, 2009). In the age of disruption with a highly uncertain environment, a firm must be aligned with internal and external resources, which are often done with dynamic capabilities. Dynamic capabilities play an important role in a firm's performance in response to the disruption (Helfat and Winter, 2011; Karimi and Walter, 2015; Teece, 2018). Besides, dynamic capabilities and business models are also interdependent. Designing and revising business models is a key element of dynamic capabilities for seizing new opportunities (Teece, 2007, 2018; Karimi and Walter, 2015). A firm with robust dynamic capabilities may become more efficient in aligning (with speed) its resources and other competencies, including its business models in response to customers' needs and changing markets (Teece, 2018).

Dynamic capabilities include three stages - absorption, adaptation, and innovation. Absorption refers to the absorbing external capacities and integrates of them into internal capacities, adaptability underlines the condition of matching the firm's internal competencies with the external environment, and finally, innovation ability suggests the way firms rely on innovation to attain competitive advantages (Lin et al., 2020).

Uber has applied dynamic capabilities and changed the way how taxi industry works by establishing new markets and making innovative strategic choices using advanced technologies, new activities, and methods. While the mobile app can be considered the use of technology artefact as an established platform, new activities, or methods are kind of innovative strategic choices, such as Uber drivers using their own cars and the company does not require to invest in cars. Uber's strategy turned out to be effective while integrating different resources including advanced algorithms, the partnership with the map and tracking applications for effective journey planning.

3.3.2 Business Model as a Business Model Development Methodology

The term business model has been used widely signifying different meanings. It has been used as a business strategy, as a revenue model (Mutaz and Avison, 2010; Osterwalder and Pigneur, 2010; R Amit and Zott, 2012), as a theoretical model, as a conceptual model or tool (Hedman and Kalling 2003; Osterwalder and Pigneur 2010), etc. There are many different definitions of business models and a few of them are presented above in section 3.3. Some related those methodologies with strategies, and some linked those through Information systems (Hedman and Kalling 2003; Mutaz and Avison 2010; Baden-Fuller and Haefliger 2013). This research focuses on the methodology (which can be termed as a conceptual model/ tool/ methodology) to develop a business model mainly for technical organisation such as independent software vendors (ISVs) who runs multi-sided business models but is not limited to ISVs use. The methodology can be used explicitly for developing disruptive business models. In this section, I briefly describe four identified business model methodologies are explained in the below paragraphs.

3.3.2.1 Generic Business Model:

The value and the components of the business model diverge according to the use of different technologies and types of businesses. Hedman and Kalling (2003) described as which components to be included in a business model in general so that managers and researchers understand the interdependencies of information systems and business. They represented a generic business model using concepts of strategic theory and models of strategy-related research on information system (Hedman and Kalling 2003)

Porter and Millar (1985) explained that the use of information systems could improve value chain activities to gain competitive advantage through low cost or differentiation. However, Hedman and Kalling (2003) believed that technology does not improve business performance in actual. The business performance can be enhanced if any technology executed smartly, fit with other resources, and attained effectively. Moreover, it must be understood, used and fixed within the organisation in a unique way. Any improvements in value chain activities must be materialised by an offering that increases customer-perceived quality and/or reduces cost. All these factors and their causal inter-relations need to be understood for any specific business model. The methodology proposed by Hedman and Kalling (2003) contains below seven elements and the fundamental relationship between have been shown in the figure 3.3.

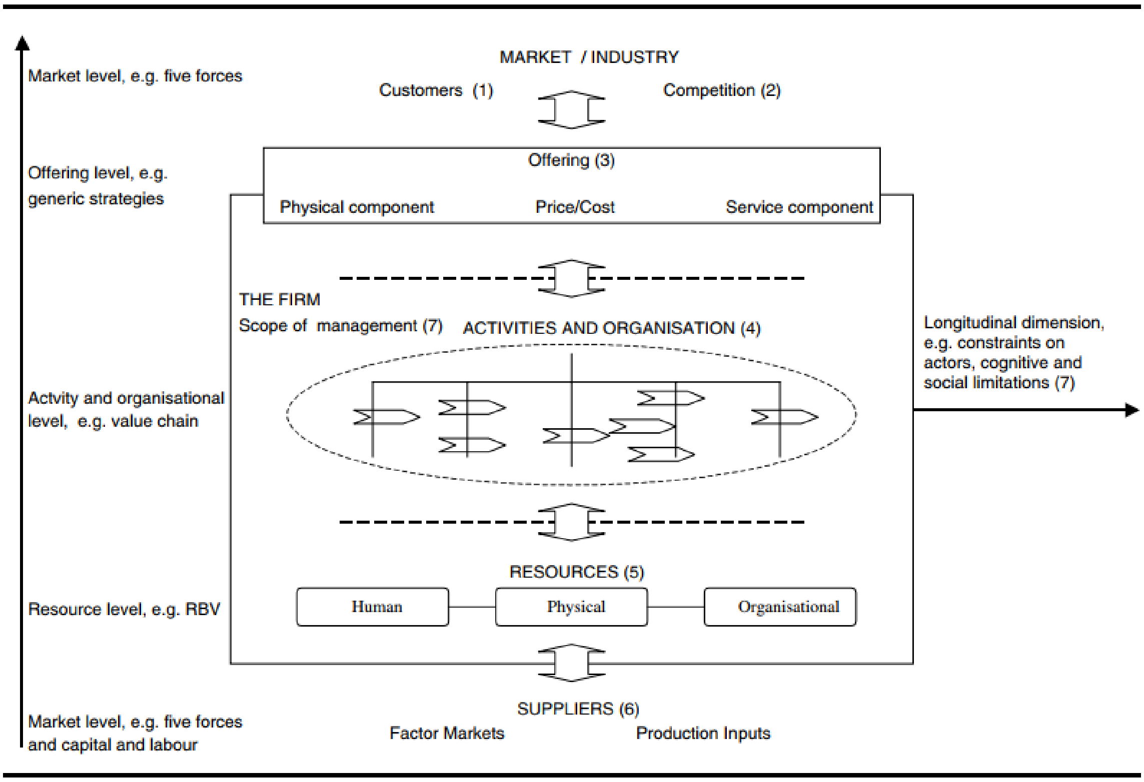


Figure 3.3 Generic Business Model (Hedman and Kalling, 2003b)

The methodology imposes generic yet significant business model elements, i.e., Customer, Competition, Offering, Activities and Organisation, Resources, Suppliers (Factor Market), Longitudinal Dimension. The generic business model has been reviewed in a few recent research. This model covers relevant business aspects employing any technology. The authors suggested testing this methodology with different technologies to understand its impact on different businesses (Hedman and Kalling, 2003). Therefore, in order to understand the business model concept in general, this methodology has been utilised for further analysis.

3.3.2.2 Business Model Canvas:

Osterwalder et al. (2010) proposed a business model canvas, a logical tool that shows how an organisation works and which main functions are included in a business. This methodology illustrated logic of how a business makes money through 9 building blocks covering 4 core areas of business (strategies, operations, finances and markets) shown in figure 3.4.

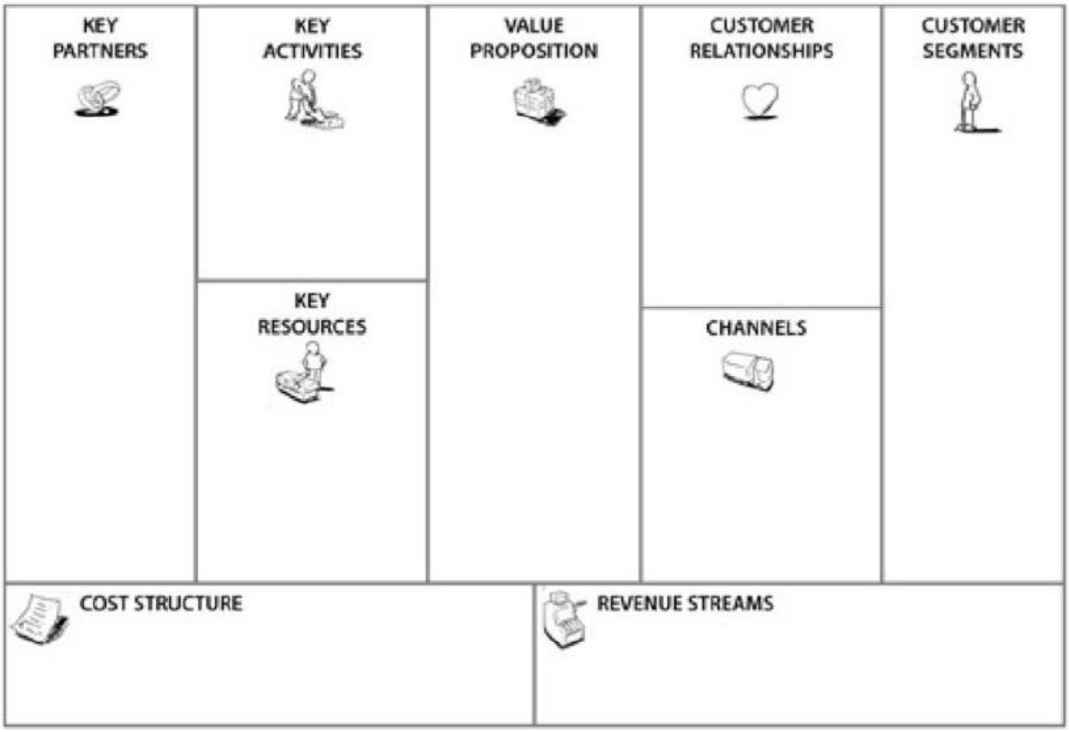


Figure 3.4 Business Model Canvas (Osterwalder and Pigneur, 2010)

The business model canvas is comprised with business elements of Value Proposition, Customer Segments, Customer Relationships, Channels, Key Resources, Key Activities, Key Partners, Cost Structure and Revenue Streams.

This tool allows an enterprise in general to understand, design and implement the described methodology or manipulate with the existing one to create new strategic conventions. The author claims that this concept has been already successfully applied and tested in various organisations worldwide such as IBM, Ericsson, Deloitte and many more. Business model canvas tool is also available as a mobile application.

The research has examined the exclusive use of this methodology in businesses world-wide, therefore it is significant to include this methodology in the analysis.

3.3.2.3 The V4 Concept of Business Model:

Al-debei and Avison (2010) claimed that the business model is an essential tool of management in digital business. They have shown business model as an intermediate layer between business strategies and technology implementation processes. The research further described that, *“making the business model more explicit helps digital organizations assess the value of intangibles in their businesses since the information provided by the business model, mobilizes knowledge capital that supports organizational strategic decision making. Further, this mobilized knowledge signifies an organizational asset that enables a digital business to achieve sustainable competitive advantage in its market.”*

Moreover, they represented the V4 concept of business model as a complete ontological structure of business model showing the 4 main dimensions: Value Proposition, Value Network, Value Architecture and Value Finance. In their research, they also described the modelling principles of business model concept. Fig 3.5 shows a basic structure of the V4 concept of Business Model methodology.

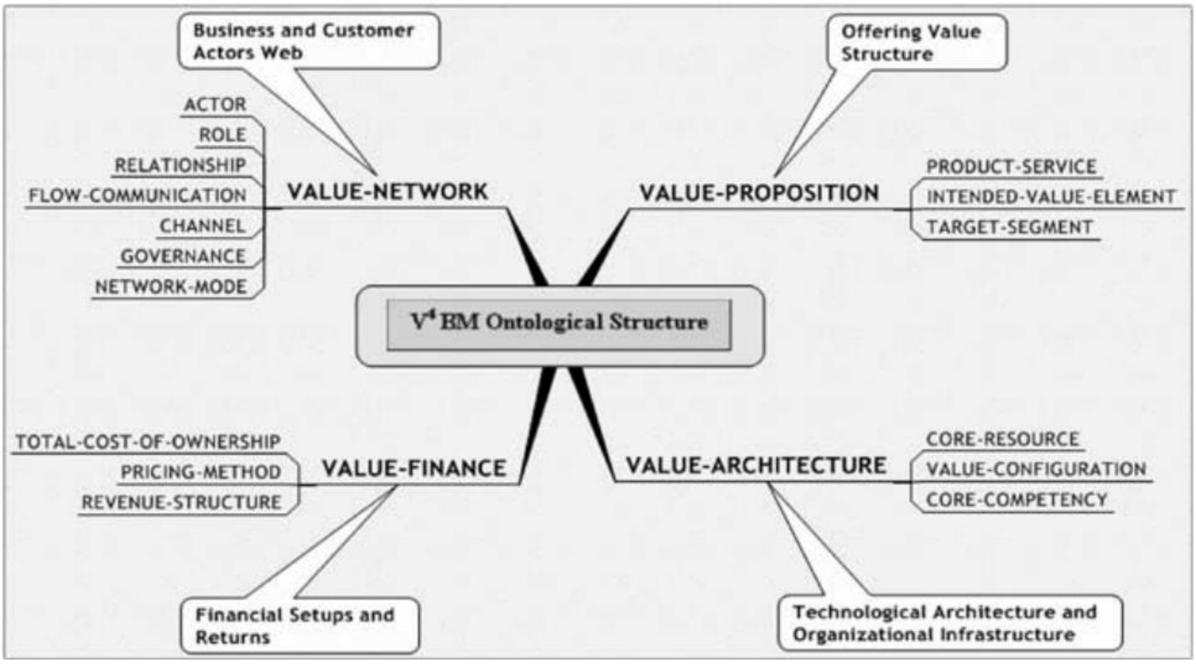


Figure 3.5 V^4 Cocept of Business Model (Mutaz and Avison, 2010)

They suggested that in order to succeed in a business, a well-designed business model, ensuring harmonisation among business processes, strategies and information systems is necessary. They further implied that the business models should be timely reviewed according to the changes occur in external environment. The research has opted this methodology for further evaluation because this methodology has been derived from the elements of both the methodologies, the generic business model and the business model canvas. This methodology is particularly useful as the authors has also applied an ontological approach for the development of the methodology.

3.3.2.4 Business Model Engineering Approach

Seidenstricker et al. (2017) proposed a business model engineering approach for distributed manufacturing systems (DMS). This study focused on to design and develop a new business model for engineering industries. This research recommended to first consider factor of 'theory of diffusion' in order to develop an innovative business model for DMS. These factors (relative advantage, compatibility, complexity, trialability, observability and perceived risks) are believed to be influential to understand whether an innovation is adopted or not. Further, this business model suggested following four elements to design a business model which are shown in figure 3.6 (Seidenstricker et al., 2017). They suggested business model dimensions including, Value Proposition, Revenue Model, Technologies, Competencies and Value Chain & Processes, Key Resources.

Seidenstricker et al., (2017) suggested that value proposition and revenue model should be adjusted closely and assessed in collaboration with customers and partners. Other two elements are useful to outline the offered values. These two elements include three level model helps to differentiate between the various activities required to ensure effectiveness within the network and each distributed production unit. The combination of these four elements provides an innovative business model.

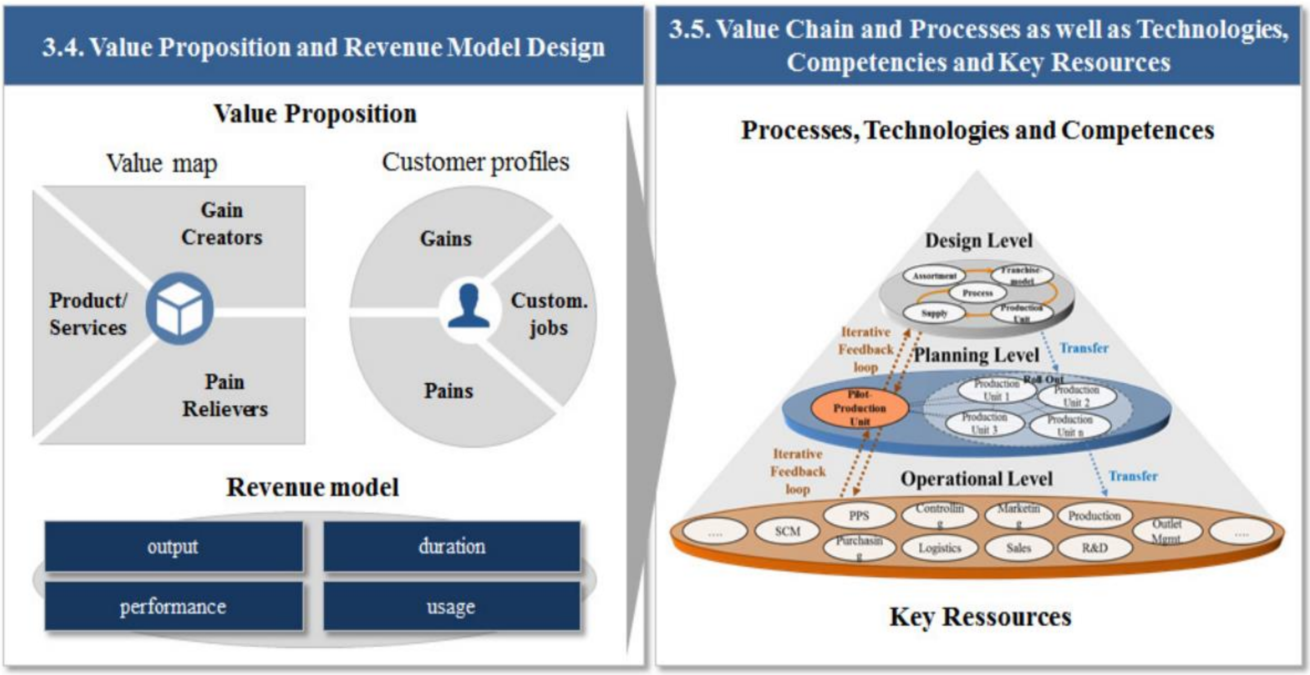


Figure 3.6 Business Model Engineering Approach (Seidenstricker, Rauch and Battistella, 2017)

Further, the author recommended applying and validating this proposed approach in future research activities through real case studies. This research follows the analysis of this methodology because the methodology is designed specifically for developing business models for manufacturing and engineering industries. This research has similar interest to develop a business model methodology for cloud-based businesses initiated for manufacturing and engineering SMEs. Besides, the structure of the business elements is unique and latest, this certainly provides some advanced level of insight for developing a business model.

3.3.2.5 Lean Canvas Model

Lean Canvas Model is an adaptation of Business Model Canvas, aiming to reach customer problems and proposed solutions with an actionable and entrepreneur-focused business plan. It mainly focuses on core business elements, and those are – problems, solutions, key metrics, and competitive advantages (Maurya, 2012). Maurya (2012) claimed that the Lean canvas approach makes canvas more actionable because it considers things which are most uncertain yet riskier and are missing in Business Model Canvas. Such factors include key problems, mainly in product development, a list of possible solutions to the problem and firm's unfair advantage.

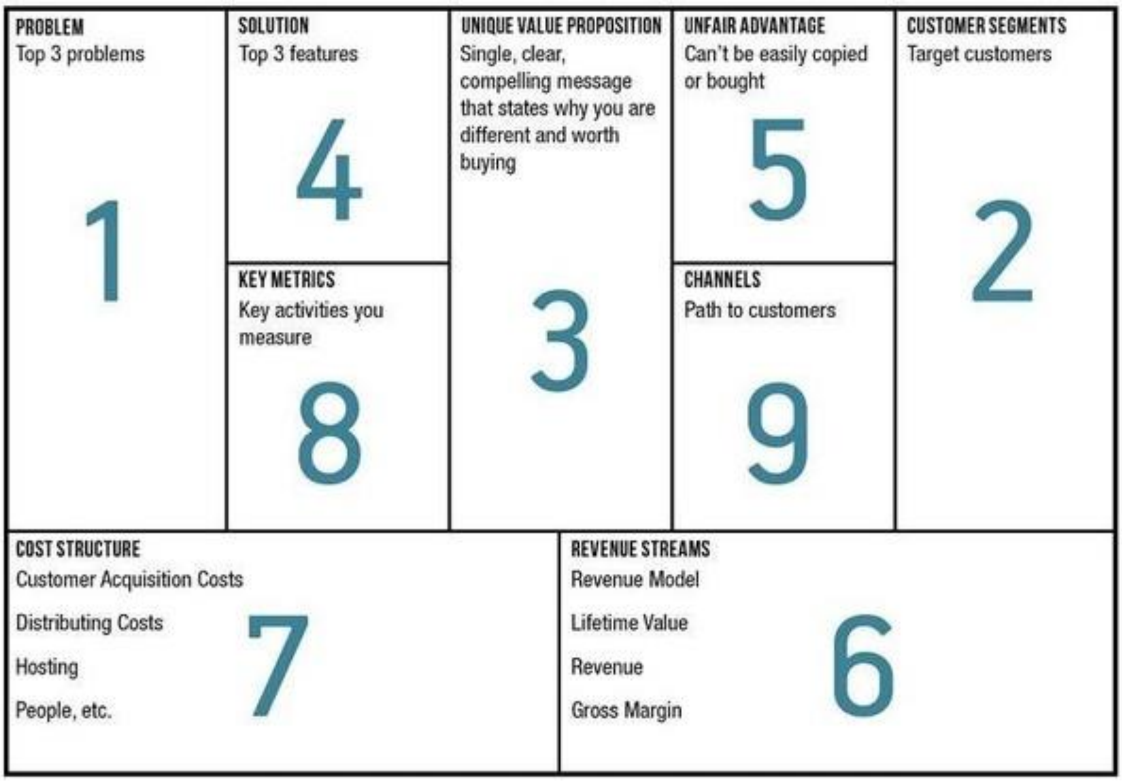


Figure 3.7 Lean Canvas Model (Maurya, 2012b)

Figure 3.7 shows the main business components; that includes in the canvas; Problem, Solution, Unique Value Proposition, Unfair Advantage, Customer Segments, Key Metrics, Channels, Cost Structures, Revenue Streams. Although the methodology is promising, this is introduced mainly for start-up companies.

3.3.2.6 Initial Conceptual Framework

A few more studies on business modelling and framework, in addition to the above-illustrated studies on business model methodologies, are evaluated to create an initial conceptual model for this research. As explained in chapter 1 (§1.3), there is a rich literature developed that shows the interconnection of business models and disruptive technologies. Nevertheless, this association is not being conceptualised, especially covering the external capabilities arrangement (dynamic capabilities) in the context of disruptive business models. Based on this connection between technology (also socio-technical) and new business model arrangement, as well as all other relevant elements shown in the table 3.1, I have created a conceptual framework (figure 3.8).

Model/Framework Name (Authors)	Type of Model/ Framework	Data Collection	Data Analysis	Model/Framework Elements	Business Type Covered as Case	Elements related to Disruption/ Technology
Dynamic Capabilities Framework (Teece, Pisano and Shuen, 1997)	Elements towards framework	Literature based	Comparing existing models, Evaluation based on empirical examples	Factors of Production, Resources, Organisational Routines, Core Competences, Dynamic Capabilities, Products, Markets and Strategic Capabilities, Processes, Positions & Paths	Examples include firms operating in rapidly changing technological environments	Dynamic Capabilities, Markets and Strategic Capabilities (Competitive force), Processes, Positions and Paths
Generic Busienss Model (Hedman and Kalling, 2003)	Conceptual model	Literature based	Theoretical foundation, Empirical examples	Customers, Competition, Offerings, Activities & Organisation, Resources, Suppliers (Factor Market Intersection), Longitudinal Dimension	General/ Manufacturing Companies	Competition, Longitudinal Dimension
Business Model Framework (Chesbrough 2007)	Cocemptual Framework	N/A	N/A	Articulate the value Proposition, Identify Market Segment, Structure of Value Chain (offerings, arranging assets aligned with suppliers and customers), Revenue generation Mechanism, Cost Structure, Identifying potential complementors and competitors, Formulating Competitive strategy	General/ 6 different types of BM explained through a single framework evaluating functions of BM	Identifying potential complementors and competitors, Competitive Strategy
Business Model Canvas (Osterwalder and Pigneur 2010)	Conceptual tool	Literature based, Interviews	Empirical validation following Design Science Research	Value Proposition, Customer Segments, Customer Relationships, Channels, Key Partners, Key Resources, Key Activities, Cost Structure, Revenue Streams	General	N/A
V4 Concept of Business Model (Al-Debei and Avison 2010)	Conceptual framework	Literature based, Interviews	Empirical validation following Design Science Research	Value Proposition (Product/Service), Target Segments), Value Network (Actor, Flow-Communication, Channel, Governance), Value Architecture (Resource, Value Configuration, Core Competency), Value Finance (Cost, Pricing Method, Revenue Structure)	Mainly for Mobile and Network Companies	Core Competency
Lean Canvas Model (Maurya 2012)	Conceptual tool	Adapted from Business Model Canvas	N/A	Problem, Solution, Key Metrics, Customer Segments, Unique Value proposition, Unfair Advantage, Channels, Cost Structures, Revenue Streams	General	Unfair Advantage
Business Model Innovation (Spieth and Schneider 2016)	Measurement index for business model change	Literature based, Interviews	Empirical validation	Target Customers, Positioning, Product and Service offering, Core Competencies & Resources, Internal Value Creation, External Value Creation, Distribution, Logic of Earnings, Logic of Costs	General/ also covers relationship of business model and Technological development	Positioning, Core Competency

Model/Framework Name (Authors)	Type of Model/ Framework	Data Collection	Data Analysis	Model/Framework Elements	Business Type Covered as Case	Elements related to Disruption/ Technology
Business Model Engineering Approach (Seidenstricker et al. 2017)	Conceptual framework Prototype	Literature based	Distributed Manufacturing Systems	Value Proposition (Value Map, Customers Profiles), Revenue Model, Value Chain and Processes, Technologies, Competencies and Key Resources	Manufacturing and Engineering Companies	Technologies, Competencies
Disruptive Business Model (Review) (Schiavi and Behr 2018)	Conceptual framework Prototype	Literature based	Literature review with content analysis	Unique Value Proposition, Reconfiguring existing models for Emerging Technologies and Innovation Processes (Resources, Processes, Value Network, Profit and Cost), or Creating new models (Lower Performance, Simplicity and Accessibility, Lower Cost, Lower Profit, Changed business structures)	Specific to firms deals with changing technologies and innovation processes	Reconfiguration of BM for emerging technologies and innovation Processes
Business Model in Dynamic Capabilities Framework (Teece 2018)	Conceptual framework	N/A	Empirical Examples included	Dynamic Capabilities Dimension in Business Model: Sense (Identify Opportunities related to Technology), Seize (Design and refine BM; Resources by anticipating Competition, Transform (Re-align structure by aligning existing capabilities and accessing new capabilities)	Examples include firms operating in uncertain environments of rapidly changing technologies	Dynamic Capability dimension

Table 3.1 A review on Business Model Concept

The initial conceptual framework (figure 3.8) is created as a skeleton for my final business model framework that includes a number of social, technical, and business elements, as well as the representations of their relationships. Overall, figure 3.8 includes the elements commonly found in the sections §3.2.5, §3.3.1, §3.3.2, and table 3.1. For this framework, I not only proposed conceptualising business elements, but I also integrated together the concepts of sociomaterialty, disruptive technologies, disruption, uncertain external forces, and changing business models.

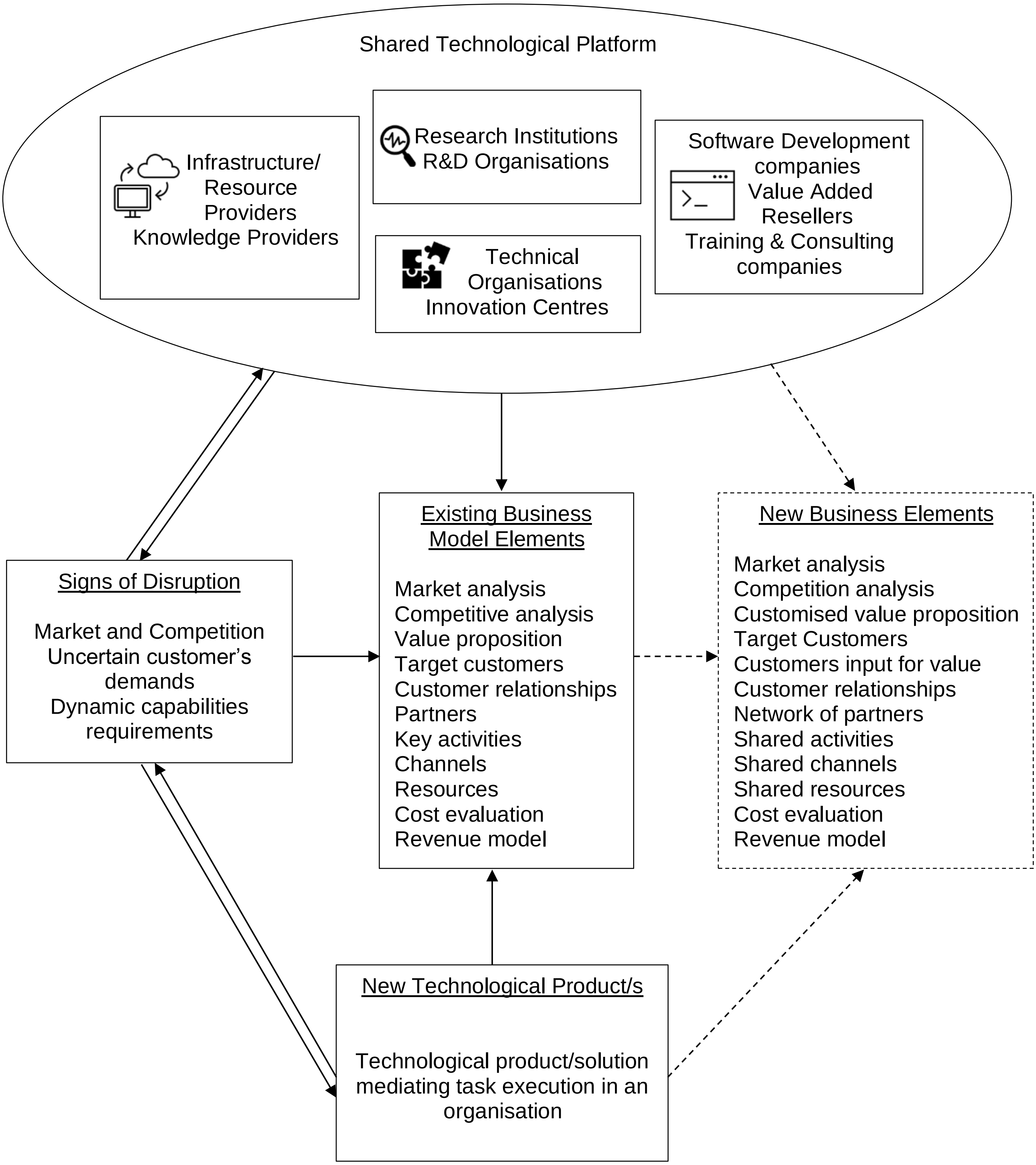
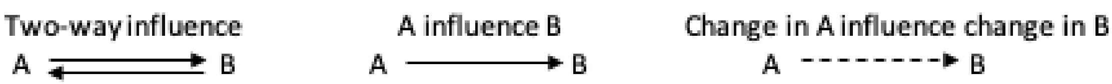


Figure 3.8 Conceptual Framework (derived from the literature)



The elements of my initial conceptual framework (figure 3.8) extend the view of sociomaterialty, especially covering the external capabilities arrangements corresponding to the necessary disruptive technologies (dynamic capabilities) in the context of disruptive business models. Presenting the outlook of globalisation, (Miles et al., 2010) suggested that emerging collaborative organisation designs, where several innovative organisations collaborate and participate in developing large-scale complex solutions for mutual gain, require collaboration in firms' business models (Miles et al., 2010; Wierzbiński & Surmacz, 2012). They suggested organisations may collaborate (*"multi-firm collaboration"* (Miles et al., 2010)) to help identify ways of generating joint economic gain. They may work together with a common focus on a particular technology or idea to produce innovation by sharing broadly distributed knowledge of individuals as well as organisations, using shared resources.

Since, the conceptual framework also holds a sociomaterial view that suggests that technological development is a continuous process. This view further reflects technology as a product of knowledge, material, interest, and condition. It presents the view that technology is developed by humans and institutionalised in structures. In other words, a developer (human) uses technology to develop a specific technological product for an organisation to meet its specific requirements, and it eventually gets routinised. These requirements could be related to their employees' requirements (human) or customers' demands (human). Technology is further perceived as being interpretively flexible, which implies variance in how people design, use and understand technology. This variance (flexibility) can be observed in terms of material components of the technological product, the institutional context of technology development and use, the knowledge, the power, and the interest of human agency (researchers, developers, designers, managers, or users) (Wanda J Orlikowski, 1992).

The corresponding impressions of social sciences implicate that the new technologies require ongoing development because they make little sense and sometimes make various types of sense (K E Weick, 1990; W J Orlikowski and Gash, 1994; Reynolds, 2015). For example, when an organisation adopts a technological system, various levels of employees make different sense of that product and sometimes do not understand its full potential. A technical expert of that organisation knows more about an introduced system than an administrator. Likewise, an administrator has a different perception of the same product than a customer. Nevertheless, over a period of time, that product becomes the culture (permanent arrangements) of that organisation and gets deep-rooted as the knowledge of employees as well as the customers. This view depicts the connection of “human agency” (or “Actors”) to “technology”, which produces “technological systems” for “organisations”; and then “organisations” use these systems to serve different “human agency”. This above framework shows this connection between “technology”, “human agency” and “organisation” in the context of business models and disruption.

The above conceptual framework also highlights other views on why organisations decide to make technology improvements or business model changes. Whilst (Baden-Fuller and Haefliger, 2013) described a two-way association of technology and business model. First, the use of specific technology in a way to generate profitability and improve organisation performance as a business model; and second, the development of a particular technological product as a business model decision of managers to satisfy customers’ demands. The management and IS-related studies suggest the fundamental link between technology and business models. However, the technological elements are not shown as a whole (Orlikowski and Scott, 2008) in the process of business model development (Osterwalder and Pigneur, 2010). There is no doubt that technological advancements bring innovation to an organisation but choosing the right business model is obviously more significant to reach such potential (Karimi and Walter, 2015). Finally, but importantly, my conceptual framework shows that the business model often requires changes responding to any little changes that occur in an organisation and, more specifically, related to the technology (Kavadias, Ladas and Loch, 2016).

Further studies that reflect on my framework are the studies that suggest changing environments through uncertain technologies, new competition forces and the requirement of dynamic capabilities. These changing technological environments influence organisations to change their business models as well as the way they deliver value to their customers. In the event of sensing disruption in the market, organisations make decisions to stay competitive and disrupt their own practices (Merrin and Adler, 2016). The organisations apply disruptive innovations by borrowing insights from other organisations/industries (Merrin and Adler, 2016), collaborate with partners, make other alliances to add dynamic capabilities (Eisenhardt and Martin, 2000; Teece, 2009, 2012; Salvato and Vassolo, 2018) responding to disruption, in terms of new knowledge, new resources and other competencies.

Similarly, several other studies suggested alignment of business model with respect to the disruptive technology (Hwang and Christensen, 2008; Veit et al., 2014; Ovans Andrea, 2015), or (Morris, Schindehutte and Allen, 2005; Teece, 2010; Zott, Raphael and Massa, 2011; Ghezzi, 2014) business model as a strategy, including disruptive innovation (Hwang and Christensen, 2008; Yovanof and Hazapis, 2008; Teece, 2010; Onggo and Selviaridis, 2017; Schiavi and Behr, 2018), however, no conceptualisation or methodology or tool has been provided. Further, few researchers suggest conducting an empirical analysis (Danneels, 2002; Daniel and Wilson, 2003; Teece, 2014; Seidenstricker, Rauch and Battistella, 2017; Baden-Fuller and Teece, 2020). Consequently, this research employs the perspective of dynamic technology which covers both sociomaterial factors and factors of disruption in the context of business model change.

3.4 Summary

This chapter covers an overview of the existing literature on disruptive technology and business model methodologies. Further, the chapter also provides a critical review of the sociomateriality perspective and factors of disruption that influence technological change and business model change in an organisation. It is also identified that this effect of dynamics (interrelated elements of social, technical, and disruption) has yet to be conceptualised in the settings of business modelling. Finally, I created an initial conceptual framework that shows the interdependent factors of social and technical (sociomaterial), and the factors of disruption that influence the development of the new technological product. Ultimately, all these changing effects of social and technical influence the change of business model. In the next chapter, I introduce a framework to compare different business model methodologies to identify all the relevant business model elements for this research.

Chapter 4 A Systematic Approach to Identifying a Suitable Methodology to Develop Disruptive Business Models

4.1 Overview

The previous research highlights the importance of exclusive business models for individual businesses corresponding to their business requirements. An applicable business model supports a firm to integrate technological solution/s efficiently and leaves a positive impact on business success, more importantly, if the solutions are based on disruptive technology. This research proposes to design a framework along with a methodology to develop business models for organisations that develop technological solutions using disruptive technology, initially as cloud technology. There are two reasons to converge on cloud-based business models; (i) I acquired access to European research projects that provide cloud provision to support organisations to develop cloud-based solutions and assist European Manufacturing SMEs, (ii) the literature on disruptive technologies is still evolving. Therefore, it is considered primarily to develop a methodology to create cloud-based business models to understand their adoption for commercial use, and how they impact the respective organisations.

This chapter provides an explicit view of a systematic comparison of five significant business model development (BMD) methodologies. This comparison is created by using original business elements of (i) a successfully completed European project named CloudSME, and (ii) CloudSME project partners – Ingecon/ Podoactiva (§2.2.3.1; use-case 1, use-case 2 respectively). These business model elements are mapped (by allocating a numeric value (≈1-63) to each element) to create comparison matrices for two BMD methodologies at a time. I have created 13 large comparison tables by comparing all BMD methodologies with each other. This analysis has helped to identify not only similarities and differences among these methodologies but insight into the next steps for further empirical analysis.

4.2 SWOT Analysis of Five Selected BMD Methodologies

Before conducting the methodical analysis, a SWOT analysis is carried out on all the five business model development methodologies. SWOT analysis aids to present the general strengths, weaknesses, opportunities, and threats of each BMD methodology, which is shown in table 4.1. This SWOT analysis also provides a concise view of the most prominent methodology among these five methodologies.

Business Models	Business Model Canvas	Generic Business Model	V^4 Concept of Business Model	Business Model Engineering Approach	Lean Canvas Model
Strengths	Simple & Straightforward Widely accepted & used Business logics are clearly defined through ontology concepts	Simple & Straightforward Covers a broad range of strategic analysis & environmental factors Created for business using information systems	Includes a full range of strategic analysis The coherent relationship among business model elements as created using an ontological approach Target users are telecom (niche) industry	Covers a broad range of strategic analysis It additionally includes a complete analysis of the value proposition and revenue model This methodology is also conducted for manufacturing SMEs	Introduced for start-up businesses Simple and easy to use Entrepreneur focused Competent to identify customer's problems
Weaknesses	Does not involve market, competition, and other essential strategic analysis	Outdated Only a general level of analysis could be created using this business model	Not too simple to implement Consists of a few unnecessary elements	Very complex to understand and implement Complexity leads to too many repetitions of business elements	Not much discrete from Business Model Canvas Omits main elements of managing communication and relationships in business
Opportunities	Various companies successfully implemented Could be useful for both new starters and existing businesses	The concept has been extensively used to create new business models, e.g., Business Model Canvas and V^4 Concept of Business Model	Competitive and market analysis can be done through this business model Further research has been carried out	A value proposition model can be defined within the business model	Companies have already started adopting Starts with the problems and eventually reach solutions
Threats	Modified business models have already started to be established in many industries	In some cases, lead to deceive of business logics and could cause difficulty in managing the business plan	Although well-established research, but not too recognised in business use	Not very recognised Could lead to complex planning and miss out on insightful evaluation	Similar to the Business Model Canvas, however, does not cover some important features. Some businesses may hesitate to use

Table 4.1 SWOT Analysis of Selected Five Business Model Methodology

Among these five business model methodologies, it is found that the business model canvas and the lean canvas model appear to have been accepted extensively. This SWOT analysis has helped to comprehend the effectiveness, practicality, and recognition of each BMD methodology.

4.3 Reflection on the Decision of Selecting Five BMD Methodologies

First and foremost, it is important to understand why I have made a choice precisely on the five business model methodologies; i.e., Generic Business Model (Hedman and Kalling, 2003b), Business Model Canvas (Osterwalder and Pigneur, 2010), V^4 Concept Business Model (Al-debei and Avison, 2010), Business Model Engineering Approach (Seidenstricker et al. 2017a), and Lean Canvas Model (Maurya, 2012b).

Although Headman and Kalling designed the generic business model for firms related to Information Systems, it provides basic logic of business elements that can be generalised to any organisation. It provides standard yet significant insight into the causal connections of IS to organisations represented through the business model elements. Therefore, the generic business model is significant for this comparison.

Furthermore, the business model canvas is one of the leading business model methodologies and is popular among business experts. It is also considered an important business model in the field of Information Systems. It gives a comprehensive view of business elements and their relative interactions. Also, the CloudSME project has used the business model canvas as a methodology to analyse its business elements. Moreover, the business model canvas is a tool derived from the Business Model Ontology developed by Alexander Osterwalder in his doctoral research project (Osterwalder, 2004). Since this research considers adopting an ontological approach to create a proposed framework, this methodology is highly relevant for the systematic comparison.

Next, V^4 concept business model is also claimed to be a methodology that is useful to develop IS-based business models. Similar to Osterwalder's Business Model Canvas, V^4 concept business model methodology is also created based on an ontological framework. In addition, the business model elements for its Unified Ontology are built on literature. I intend to use an abductive approach to identify business elements for the proposed framework, where I integrate major business elements, that are found from the literature and formed (verified/ extended) through my findings. Thus, the V^4 concept business model methodology also appears to be critical to consider for this comparison analysis.

Following this, the Business Model Engineering Approach is a methodology, designed for distributed manufacturing industries. It is effective to be contemplated in the systematic comparison analysis for two main reasons; (i) it is recently introduced prototype BMD methodology and the authors recommended testing to evaluate its effectiveness, (ii) the methodology has integrated a technology element within the methodology and thus reflects a close relevance.

Lastly but importantly, the lean canvas model is another dominant methodology that is being widely used. Although this methodology is derived from the business model canvas, it does not have applicability to Information Systems. Nevertheless, the methodology has been used broadly by technical companies too. The second case study (for empirical analysis chapter 5) used in this research, runs 21 experiments (use-cases). All these 21 use-cases have analysed their business model elements adopting lean canvas model. Since these use-cases involve the development and dissemination of cloud-based technological solutions, it becomes significantly important to involve lean canvas model in the comparison analysis.

4.4 Systematic Comparison of Business Model Methodologies

As explained earlier that the research created a systematic comparison of five major BMD methodologies to identify suitable methodology for the development of cloud-based business models. The comparison matrices are created using business elements of 2 real-world business use-cases CloudSME project and Injecon/ Podoactiva (§2.2.3.1; use-case 1, use-case 2, respectively). It is to emphasise that both the use-cases involved technological solutions (e.g., simulation) exploiting cloud-based tools and resources, and originally developed their business models based on the business model canvas. This is equally important to identify if the original business model they have developed (using business model canvas) is effective enough. The business model elements of these two use-cases are mapped (by assigning a numeric value (≈1-63) to each business element) to create comparison matrices for two BMD methodologies at a time. Therefore, the core business activities and requirements of these use-cases are used to evaluate the other four BMD methodologies.

4.4.1 Use-Case 1: Business Planning of CloudSME project (Cloud-based Simulation platform for Manufacturing and Engineering – www.cloudsme-project.eu/)

As stated in chapter 2 (§2.2.3.1) that, the CloudSME project was proposed to create a cloud-based, one-stop-shop solution to improve the major processes in manufacturing and engineering (M&E) SMEs and to deliver a scalable platform for small-scale or large-scale simulations, allowing the wider adoption of simulation technologies. The CloudSME simulation platform supports its end-user SMEs to consume personalised simulation applications in the form of Software-as-a-Service (SaaS) based provision. It also assists simulation software service providers and consulting companies by providing them Platform-as-a-Service (PaaS) solutions and enabling them to quickly assemble tailor-made simulation solutions in the cloud for their customers (source - the project of CloudSME).

The project has directly targeted simulation software vendors, simulation experts/ consultants and value-added resellers. The CloudSME has approached to its target users using the following ways (Source - the project of CloudSME):

- Targeting specific M&E market segments to offer targeted simulation one-stop-shops /general directories (like a shopping mall) as different sector has different requirement such as level of computational, number of users and budget etc.
- Supporting simulation software vendors to extend their products with extreme cloud-access (generally for cloud execution through CloudSME platform).
- Offering an overall one-stop-shop solution to all M&E SME’s.

In order to complete this project successfully, CloudSME derived a specific business model for the development, dissemination and marketing of their offered solutions. The CloudSME is found to be diverse in terms of its users (software vendors etc.) and their customers (manufacturing SMEs). Besides, CloudSME offers two types of customised cloud solutions i.e., SaaS and PaaS involving a number of different business requirements. Since all these considerations are essential to be accessed through suitable business planning, the project adopts Osterwalder's business model canvas as their strategic business tool to professionally classify all their core business activities. All these important business activities are shown in figure 4.1, i.e., through the business model canvas originally introduced by (Osterwalder and Pigneur, 2010).

Figure 4.1 Business Model Canvas (BMC) for CloudSME
(CloudSME, no date; Osterwalder and Pigneur, 2010)

Figure 4.1 shows the major 9 components of business model canvas. The yellow highlighted elements are the actual business activities which are analysed in the CloudSME project using the business model canvas. This research borrows these business activities of the project and maps them by assigning individual numbers so that the elements can be represented easily in the comparison matrices. The details of these mapped elements are provided below each matrix.

4.4.1.1 Comparing Business Model Canvas & Generic Business Model:

Table 4.2 portrays the comparison of the business model canvas (BMC) and the generic business model (GBM). The elements in columns imply the elements of BMC (which are the business activities analysed in CloudSME project) and the elements in rows represent the elements of GBM (including all covered or any uncovered business activities in BMC through CloudSME project or vice versa).

Green	Shows similar business activities that are covered in both business models
Red	Shows distinct business activities which are uncovered in BMC or GBM
Orange	Shows repetition of activities through distribution of components

MODELS	BUSINESS MODEL CANVAS (BMC)																
	Components/ Elements	Value Propositions				Customer Segments			Customer Relationships				Channels				
GENERIC BUSINESS MODEL	Customers					32	33	34									
GENERIC BUSINESS MODEL	Competitors																
GENERIC BUSINESS MODEL	Offerings	21	22	23	24												
GENERIC BUSINESS MODEL	Activities & Organisation												4	5	6	30	31
GENERIC BUSINESS MODEL	Resources																
GENERIC BUSINESS MODEL	Factor Market Interactions				**25**				26	27	28	29	4	5	6	30	31
GENERIC BUSINESS MODEL	Longtitudinal Dimension																
	Difference																

MODELS	BUSINESS MODEL CANVAS (BMC)														
	Components/ Elements	Key Partners							Key Activities						
GENERIC BUSINESS MODEL	Customers														
GENERIC BUSINESS MODEL	Competitors														
GENERIC BUSINESS MODEL	Offerings														
GENERIC BUSINESS MODEL	Activities & Organisation	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GENERIC BUSINESS MODEL	Resources														
GENERIC BUSINESS MODEL	Factor Market Interactions														
GENERIC BUSINESS MODEL	Longtitudinal Dimension														
	Difference														

MODELS	BUSINESS MODEL CANVAS (BMC)																			Difference	
	Components/ Elements	Key Resources						Cost Structure						Revenue Streams							
GENERIC BUSINESS MODEL	Customers																				
GENERIC BUSINESS MODEL	Competitors																			48	49
GENERIC BUSINESS MODEL	Offerings													41	42	43	44	45	46	47		
GENERIC BUSINESS MODEL	Activities & Organisation							35	36	37	38	39	40								50	51
GENERIC BUSINESS MODEL	Resources	15	16	17	18	19	20														
GENERIC BUSINESS MODEL	Factor Market Interactions																				
GENERIC BUSINESS MODEL	Longtitudinal Dimension																				52
	Difference																				

Table 4.2 Comparison Matrix for GBM & BMC

Values	Description	Values	Description
1	Technology core solution providers	14	Consulting and integration
2	Marketing core solution providers	15	Marketing
3	Cloud infrastructure providers	16	Finance, Legal and Administrative operations
4	Software vendors	17	Cloud Infrastructure
5	Experts and consultants	18	Cloud Management Platform
6	Value-added simulation software resellers	19	Maintenance & User Support Staff
7	Manufacturing & Engineering Associations and Organisations	20	HPC Infrastructure
8	Operation & Maintenance of the Platform	21	Capabilities for easy set-up of dedicated simulation One-Stop-Shops
9	Software vendors support	22	Series of dedicated simulation One-Stop-Shop for European M&E SMEs
10	End users support	23	General Purpose One-Stop-Shop for M&E SMEs
11	Software vendors, value added resellers, experts and consultants marketing	24	Dynamically linked Cloud & HPC Infrastructure
12	European M&E SMEs marketing	25	Expert Support Services (for End User Support, End User Simulation Consulting, Software Vendor Support for Setup, Operation and integration)
13	Channels (industry associations such as NAFEMS) marketing	26	Services through Software Vendors (One-Stop-Shops Operators, Integration Services, Consulting Services)

27	End user of simulation software vendors (indirect customers)	39	Infrastructure Provider resource charges
28	Relations with end user customers (direct)	40	Finance, administration, and legal costs
29	End user training and consulting services	41	Simulation usage
30	Industry Association	42	Insertion fees
31	Direct Online Channels	43	Membership fees
32	Series of specific M&E markets	44	Integration & consulting fees
33	European M&E SMEs	45	Simulation training fees
34	Simulation Software Vendors	46	End user support services
35	Service Operation (CloudSME one-stop-shop, Cloud platform, Workflow, and portal technology, Cloud & HPC infrastructure connectivity)	47	Software vendor support services
36	Marketing and Sales (towards software vendors, industry associations, Dissemination)	48	Market Analysis (Other competitors)
37	Customer Support (End User, Simulation software Vendors)	49	Competitive Analysis (Competitors - Using Manual approaches, Licensed based Simulation services, Simulation software vendor using SaaS, Marketplace oriented, General purpose SaaS Solution provider, Industry specific SaaS solution Provider)
38	Technology Maintenance	50	Technical Implementation
51	Manage and Monitor IPR's	52	Possible Constraints and Limitations

4.4.1.2 CloudSME Business Planning through the Generic Business Model (Distinct or Duplicate elements)

Table 4.2 shows the comparison between the Business Model Canvas (BMC) and Generic Business Model (GBM). The elements highlighted in red reflect differences of elements between both business model methodologies, i.e. those elements are not covered within the business model of the CloudSME project using business model canvas; however, they are found outside the business model through the additional analysis made on the project document. The contents highlighted in green show similar elements, and the activities in orange highlighted outline repetition of components, which may be accessed through more than one activity in both business model methodologies. In this section, I address details of distinct elements or the re-occurred elements, since similar elements are already highlighted through the project's business planning created through BMC (figure 4.1).

Competitors: The CloudSME business analysis is conducted using Osterwalder's BMC and did not evaluate notion of competition or competitors within the methodology. I identified from the project document that the competition analysis is carried out using Porter's five forces analysis (Porter, 1999), which provides business activities 48 and 49 (market analysis and competition analysis respectively). Nevertheless, these elements are explicitly evaluated in Generic Business Model.

Activities & Organisation: Using BMC, a wide range of organisational activities are evaluated, apart from activities 50 and 51 (technical implementation and Monitor IPR's). These two activities fit into GBM of Hedman and Kalling (2003) as these are part of the key activities in any organisation. Although BMC splits activities and organisations into various different parts specifically, these aspects are not outlined within the methodology.

Longitudinal Dimension: This element of GBM is useful to identify potential constraints and limitations (activity 52) within the business; however, it is also not identified as a business model element in the CloudSME project. This element however has been reflected in the project using PESTLE analysis and outside the business model analysis.

Therefore, it is apparent that these above essential elements have not been covered within the BMC. The generic business model, on the other hand, is a very general methodology which covers all the basic business aspects. However, the element 'Activities and Organisation' itself is multifaceted and can be complex to interpret in case of several business activities are required to be analysed.

Finally, the structure of the Generic Business Model has been shown through the following figure 4.2. The image has been created through the structure of the generic business model (see original figure 3.3, in chapter 3). The below figure highlights the distinct business elements as identified from the above comparison; where red coloured text shows the elements covered using GBM however, have been missed out in the analysis of CloudSME business plan.

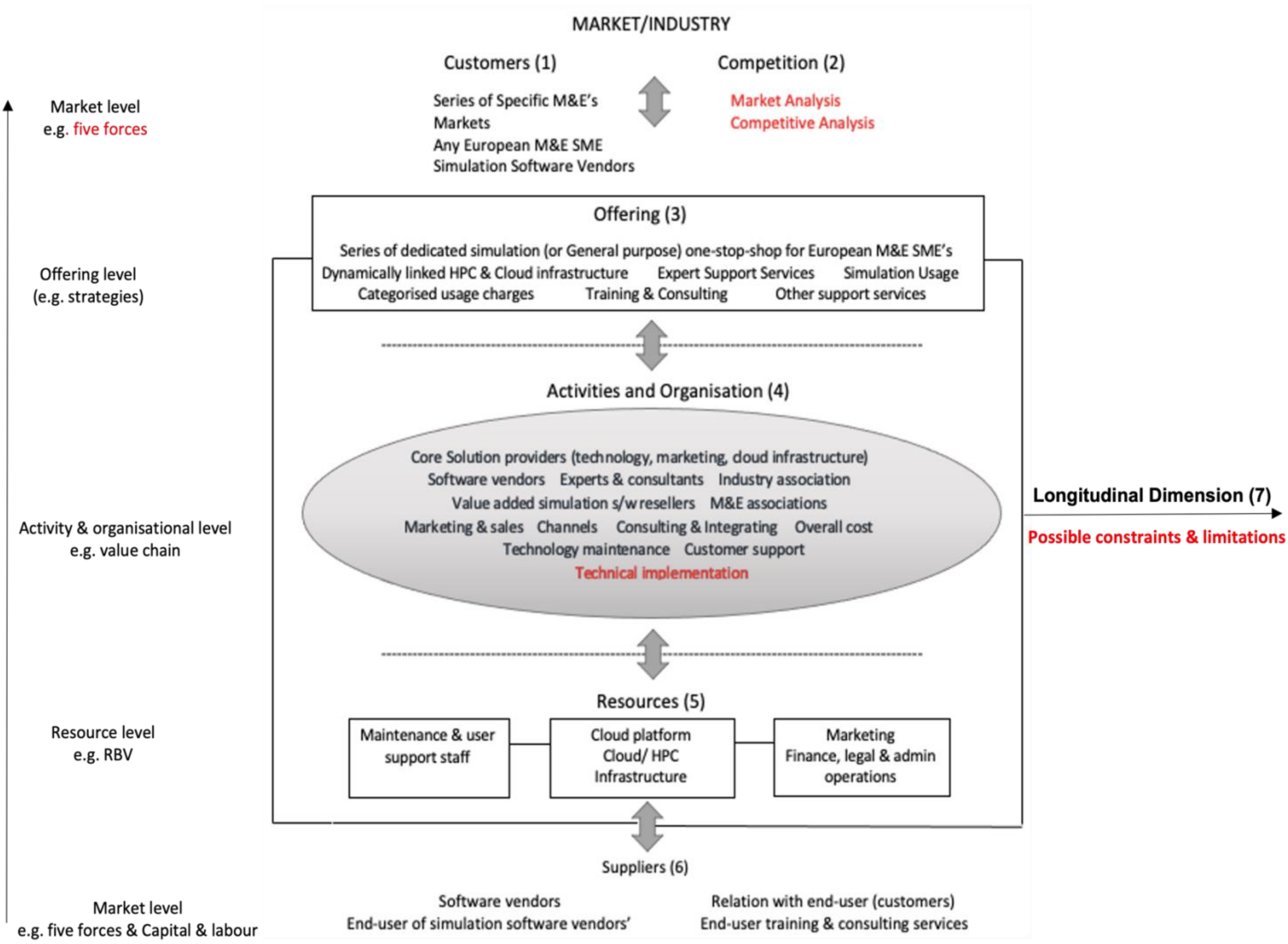


Figure 4.2 Generic Business Model through CloudSME business elements (Hedman and Kalling, 2003b)

4.4.1.3 Comparing Business Model Canvas & V4 Concept of Business Model

A second mapping matrix table is prepared to compare elements of BMC and V4 concept Business Model based on the business elements of CloudSME project. The business activities are mapped with numbers, and a detailed description of those mapped components is provided below in the matrix table. The table 4.3 shows the main differences and similarities of the business model elements of both the methodologies (as per the activities analysed in the project) (CloudSME, no date)

MODELS		BUSINESS MODEL CANVAS (BMC)									Difference
V^4 CONCEPT BUSINESS MODEL	COMPONENTS/ELEMENTS	Value Propositions	Customer Segments	Customer Relationships	Channels	Key Partners	Key Activities	Key Resources	Cost Structure	Revenue Streams	
Value Proposition	Products/ Services	23 24 25									
	Value Elements	21 22									
	Target Segments		32 33 34								
Value Network	Network Mode										55
	Actors					1 2 3 4 5 6 7					
	Roles						8 9 10 11 12 13 14				
	Relationship			26 27 28 29							
	Flow-Communications										3 4 5 27 28 33
	Channels				4 5 6 30 31						
	Governance										48
Value Architecture	Core Resources							15 16 17 18 19 20			
	Value Configuration										49 50 51 56
	Core Competencies										52
Value Finance	Total Cost of Ownership								35 36 37 38 39 40		
	Pricing Methods										53 54
	Revenue Structure									41 42 43 44 45 46 47	
Difference											

Table 4.3 Comparison Matrix for BMC and V^4 Concept Business Model

Values	Description	Values	Description
1	Technology core solution providers	3	Cloud infrastructure providers
2	Marketing core solution providers	4	Software vendors

5	Experts and consultants	18	Cloud Management Platform
6	Value added simulation software resellers	19	Maintenance & User Support Staff
7	Manufacturing & Engineering Associations and Organisations	20	HPC Infrastructure
8	Operation & Maintenance of the Platform	21	Capabilities for easy set-up of dedicated simulation One-Stop-Shops
9	Software vendors support	22	Series of dedicated simulation One-Stop-Shop for European M&E SMEs
10	End users support	23	General Purpose One-Stop-Shop for M&E SMEs
11	Software vendors, value added resellers, experts and consultants marketing	24	Dynamically linked Cloud & HPC Infrastructure
12	European M&E SMEs marketing	25	Services through Expert Support Services (for End User Support, End User Simulation Consulting, Software Vendor Support for Setup, Operation and integration)
13	Channels (industry associations such as NAFEMS) marketing	26	Software Vendors (One-Stop-Shops Operators, Integration Services, Consulting Services)
14	Consulting and integration	27	End user of simulation software vendors (indirect customers)
15	Marketing	28	Relations with end user customers (direct)
16	Finance, Legal and Administrative Operations	29	End user training and consulting services
17	Cloud Infrastructure	30	Industry Association

31	Direct Online Channels	44	Integration & consulting fees
32	Series of specific M&E markets	45	Simulation training fees
33	European M&E SMEs	46	End user support services
34	Simulation Software Vendors	47	Software vendor support services
35	Service Operation (CloudSME one-stop-shop, Cloud platform, Workflow and portal technology, Cloud & HPC infrastructure connectivity)	48	Project Partners & Management of CloudSME
36	Marketing and Sales (towards software vendors, industry associations, Dissemination)	49	Market Analysis
37	Customer Support (End User, Simulation software Vendors)	50	Technical Implementation
38	Technology Maintenance	51	Manage and Monitor IPR's
39	Infrastructure Provider resource charges	52	Development of Cloud based Simulation Services for M&E SME’s in Europe
40	Finance, administration and legal costs	53	Billing Options (Per Second/Minute/Hour/Day/Week/Month/Year/Per usage/Per Download)
41	Simulation usage	54	Subscription Option
42	Insertion fees	55	Closed (not accessible for everyone)
43	Membership fees	56	Competitive analysis

4.4.1.4 CloudSME case study through V^4 Concept Business Model

The matrix table 4.3 features divergence in both the methodologies. Although (Al-debei and Avison, 2010) adopted a few of their business elements of BMC and GBM collectively in their research and formed V^4 concept business model (V^4 BM), there are some business elements, which are not fully explicitly evaluated in the project using BMC. Nevertheless, those elements are analysed in the project outside of their business model. All the elements (distinctive from the BMC) of V4 concept business model are explained through the proceeding points:

Network Mode: While using V4 BM, the project might have considered activity 55 (closed access) explaining the network mode (under Value Network) of product/service it offers. But it is not severely important element to incorporate in every business. The consideration of this element depends on individual business.

Flow Communications: The project underlined the elements of 'value network' of V4 BM in a range of components of BMC methodology describing key activities, key partners, channels and others. However, this has not been assessed how and among whom the communication flows within the network. Elements 3, 4, 5, 27, 28 and 33 (represented as cloud infrastructure providers, software vendors, experts & consultants, end user of simulation software vendors, relations with end user and European manufacturing and engineering SME's respectively) are believed to be important segments of making value network in V4 BM. Although they all are covered in BMC however presented in a different way. Repetitive elements 3, 4 in both business models are also considered as key partners/ key actors respectively. Repetitive element 33 is measured as customer segment/ target segments in both methodologies.

Governance: Element 48 (project partners & management of CloudSME) represents as governance under the value network component of V4 BM. The governance of CloudSME has not been disclosed in the project as it is not an absolutely necessary consideration for this project however it could be an important element for other projects of charity organisation or a partnership business etc.

Value Configuration: The project has not been able to analyse significant elements directly like 49, 50, 51 and 56 (market analysis, technical implementation, manage & monitor IPR's and competitive analysis) within its business model using BMC, however used this configuration in the project with an independent analysis. These elements, however, can be analysed using V4 BM.

Core Competencies: The 'core competencies' is a valuable component which can be identified using V4 BM methodology. Element 52 (development of cloud-based simulation services for M&E SME's in Europe) is a unique value proposition of CloudSME and correlate with core competencies of V4 concept business model which is not detailed through its employed business model based on BMC.

Pricing Methods: The business financial elements 53 and 54 (billing options and subscription options) are evaluated in the project as an individual financial considerations and not within the business model methodology itself wherever it can be outlined inside the methodology by using V4 concept business model.

By this comparison, the research has found a few business activities which have not been detailed through the business model of CloudSME, however has someway identified through a few independent analysis within the project. On one hand, V4 BM methodology can be very useful in some cases. It is comprised with several sub-components which can be effective to evaluate several business activities and requirements within the business model.

On the other hand, it can also be unmanageable because it contains various components which construct analysis of some elements more than once; such as activities 3, 4, 5 have been represented as actors under 'value network' as well as they have been analysed in flow communication under 'value network'. Nonetheless this is not considered as a major concern as different actors may have different roles to play in a business.

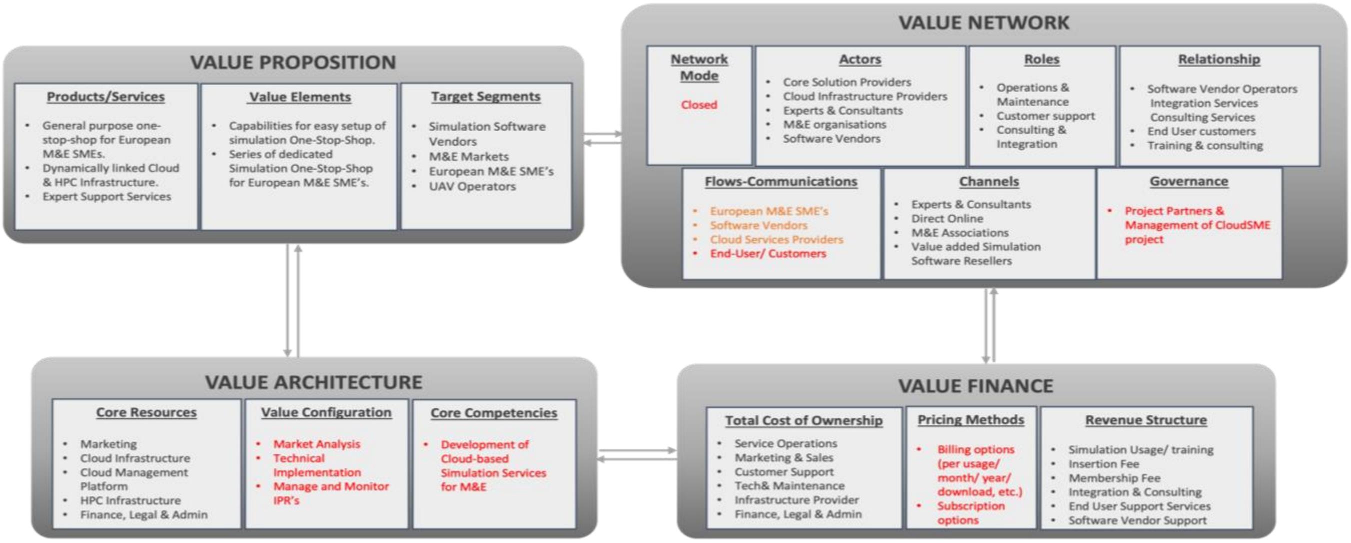


Figure 4.3 V^4 Concept Business Model through CloudSME business elements (Al-debei and Avison, 2010)

Conclusively, above Figure 4.3 shows these identified variations in both the methodologies by manipulating business attributes through the structure of V4 concept business model methodology based on the above analysed elements in CloudSME project. The differences and repeated elements can be depicted through the red and orange text, respectively.

4.4.1.5 Comparing Business Model Canvas & Business Model Engineering Approach

A similar matrix table 4.4 is created to carry out the main differences among Business Model Canvas and Business Model Engineering Approach (BMEA) based on CloudSME project (source - the project of CloudSME), which is shown below:

MODELS				BUSINESS MODEL CANVAS (BMC)																															Difference			
	Components/ Elements			Value Propositions		Customer Segments		Customer Relationships		Channels			Key Partners					Key Activities			Key Resources						Cost Structure			Revenue Streams								
Business Model Engineering Approach (BMEA)	Value Proposision	Customer Profiles	Customer Jobs			32	33																													58	59	60
			Pains															8	14							15	16	35	36	38									50	51
			Gains	24				27	28															17	18	20				41	42	43	44	45				
		Value Map	Product/ Services	25				26										9	10											46	47				52	55	56	57
			Gain Creators			34						6	1	2	3	6	7																					48
			Pain Relievers						29	4	5	30	4	5												19											53	54
	Revenue Model	Output																												41	42	43	44	45				
		Duration of Provision																																				54
		Performance Level																												46	47							
		Usage																																				53
	Value Chain and Processes	Design Level		23																																		52
		Planning Level		21	22																																50	51
		Operational Level																8																		55	56	61
	Technologies, Competencies and Key Resources	Technologies																									35									57	58	60
		Competencies																																			49	62
		Resources																				15	16	17	18	19	20											
Difference												31						11	12	13							37	39	40									

Table 4.4 Comparison Matrix for BMC and Business Model Engineering Approach

Values	Description	Values	Description
1	Technology core solution providers	7	Manufacturing & Engineering Associations and Organisations
2	Marketing core solution providers	8	Operation & Maintenance of the Platform
3	Cloud infrastructure providers	9	Software vendors support
4	Software vendors	10	End users support
5	Experts and consultants	11	Marketing for Software vendors, value added resellers, experts and consultants
6	Value added simulation software resellers	12	European M&E SMEs marketing

13	Channels (industry associations such as NAFEMS) marketing	27	End user of simulation software vendors (indirect customers)
14	Consulting and integration	28	Relations with end-user (direct customer)
15	Marketing	29	End user training and consulting services
16	Finance, Legal and Administrative Operations	30	Industry Association
17	Cloud Infrastructure	31	Direct Online Channels
18	Cloud Management Platform	32	Series of specific M&E markets
19	Maintenance & User Support Staff	33	European M&E SMEs
20	HPC Infrastructure	34	Simulation Software Vendors
21	Capabilities for easy set-up of dedicated simulation One-Stop-Shops	35	Service Operations (CloudSME one-stop-shop, Cloud platform, Workflow and portal technology, Cloud & HPC infrastructure connectivity)
22	Series of dedicated simulation One-Stop-Shop for European M&E SMEs	36	Marketing and Sales (towards software vendors, industry associations, Dissemination)
23	General Purpose One-Stop-Shop for M&E SMEs	37	Customer Support (End User, Simulation software Vendors)
24	Dynamically linked Cloud & HPC Infrastructure	38	Technology Maintenance
25	Expert Support Services (for End User Support, End User Simulation Consulting, Software Vendor Support for Setup, Operation and integration)	39	Infrastructure Provider resource charges
26	Services through Software Vendors (One-Stop-Shops Operators, Integration Services, Consulting Services)	40	Finance, administration and legal costs

41	Simulation usage	52	Development of Cloud based Simulation Services for M&E's
42	Insertion fees	53	Billing Options (Per second/ Minute/ Hour/ Day/ Week/ Month/ Year/ Per usage/ Download)
43	Membership fees	54	Subscription Option
44	Integration & consulting fees	55	Setting-up Simulation software
45	Simulation training fees	56	IaaS and PaaS optimized for simulations in the cloud
46	End user support services	57	Deploy simulation software and enable specialised one-stop-shop
47	Software vendor support services	58	Simulation solution for Cloud or HPC Infrastructure (Simulation Vendors Perspective)
48	Management of CloudSME	59	Design new factory Layout, Design new insole, Optimise UAV Operations, optimise design of a device & process to handle multiple moving fluids (M&E SME's perspective)
49	Market Analysis (Other competitors)	60	Enable software for the Cloud (Service Providers perspective)
50	Technical Implementation	61	Testing simulation solution and suggesting improvements
51	Manage and Monitor IPR's	62	Competitive Analysis (Competitors - Using Manual approaches, Licensed based Simulation services, Simulation software vendor using SaaS, Marketplace oriented, General purpose SaaS Solution provider, Industry-specific SaaS solution Provider)

4.4.1.6 CloudSME case study through Business Model Engineering Approach

Business Model Engineering Approach (BMEA) is an interesting methodology and binds many business factors within the business model. Although CloudSME project elected the most popular business model methodology that is BMC, this methodology does not cover a few business factors as indicated through GBM and V4 BM. For certain businesses, BMC has found to be very useful. However, the identified discrete elements of BMEA are also not easy to ignore, which may dominate other methodologies. CloudSME has carried out a few other analysis outside the applied business model such as value proposition model, competitors and financial analysis etc. The analysis of value proposition is done individually and is further divided in three different sectors. Conversely, BMEA actually comprises the value proposition analysis within the business model. The description of each identified differences of BMEA to BMC is described as below:

Value Proposition: BMEA incorporates value proposition analysis within the business model, therefore it makes a huge difference in overall business plan. It identifies customer profiles and value map that covers a large amount of building blocks of business model canvas within this part of model and the different elements identified in this section are customer jobs (activities 58, 59, 60), pains (activities 50, 51), products/ services (elements 52, 55, 56, 57), gain creators (component 48) and pain relievers (activities 53, 54). These are the elements identified in the project with a discrete analysis as a value proposition analysis of three different sectors. Using this analysis within the business model however makes the evaluation very composite.

Revenue Model: Revenue model of BMEA covers same business aspects as revenue stream of BMC and additionally include provision period (activity 54) and usage (element 53). These elements are identified under financial analysis of the project which has been summarised outside of the business model of CloudSME. Also, these elements are appeared in other analysis of value map under value proposition, which creates duplicity.

Value Chain and Processes: Value chain and process are described in business model canvas somewhat differently. Under BMEA, it comprises of three levels which are design, planning and operational level. A very few elements of 'value chain and processes' of BMEA are drawn within the business model of CloudSME. Elements 50, 51, 52, 55, 56 and 61 are signified in the project under the value proposition analysis which has been accessed separately.

Technologies, Competencies and Key Resources: These elements have also been defined in the CloudSME project within the Value Proposition analysis. Elements 57, 58, 60 (technologies) and 49, 62 (competencies) can be well-identified within the business model by using BMEA.

Finally, the business elements of CloudSME are being featured in the BMEA model structure (original fig 3.6, in chapter 3) showing the above evaluated differences from the table 4.4 which are shown in below fig 4.4 depicted in red font (also note the orange text reflects the duplicity of elements).

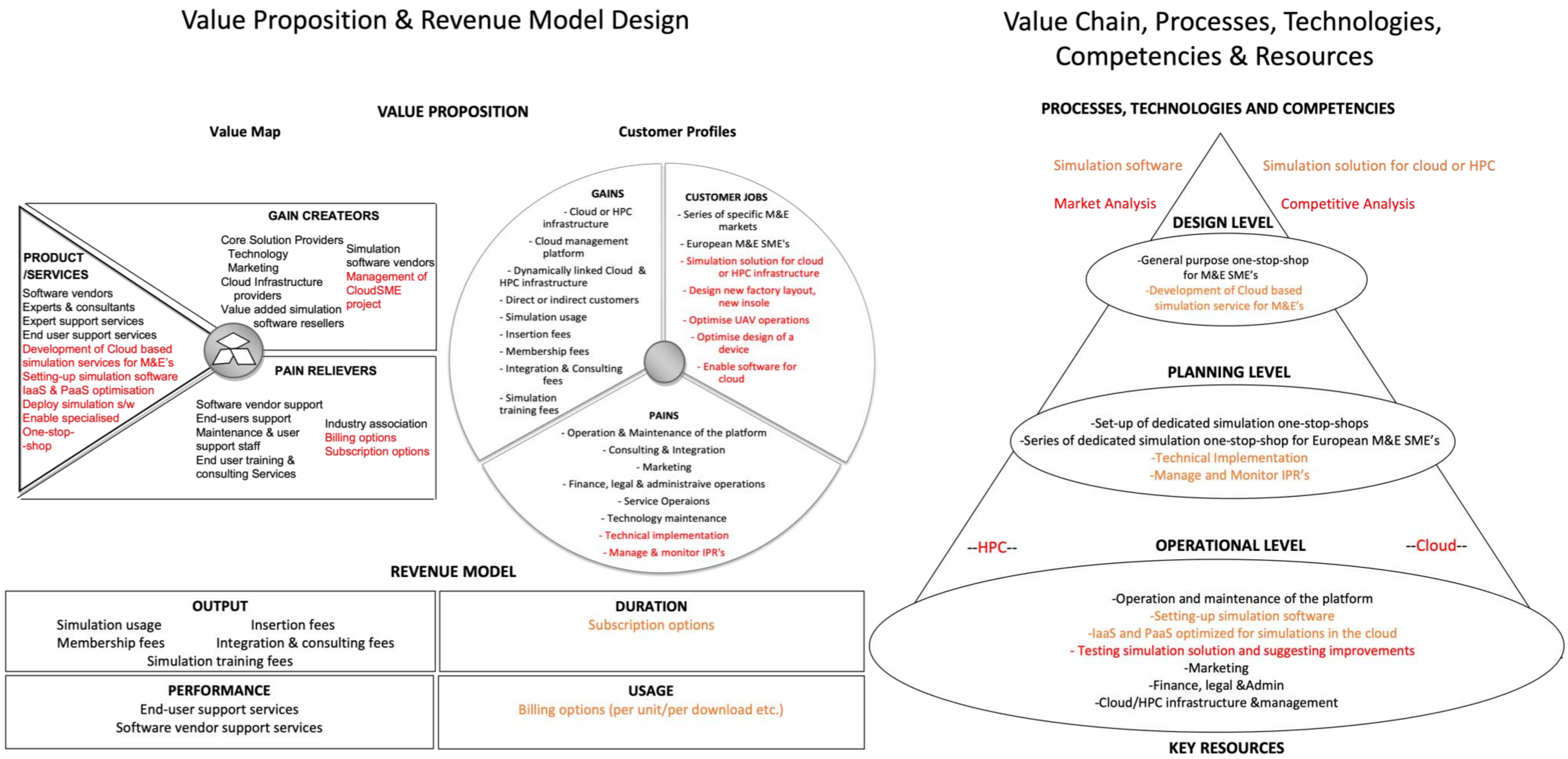


Figure 4.4 Business Model Engineering Approach through CloudSME business elements (Seidenstricker, Rauch and Battistella, 2017)

4.4.1.7 Unidentified business elements of the project using BMEA

Business Model Engineering Approach is one of the very recent methodologies introduced for the distributed manufacturing industries. It is examined earlier that CloudSME project has also been targeting manufacturing and engineering SME’s. All the business requirements of manufacturing industries can be easily defined using BMEA. However, there are some important business activities which are analysed in the CloudSME project using BMC but have not been identified by applying BMEA methodology.

Although BMEA is useful to identify a large number of business activities, it does not assess a few key elements such as it only identifies channels partially. Element 31 (direct online channels) have not been analysed anywhere. It is examined that the ‘channels’ section should be defined transparently, especially for manufacturing industries. One of the other main components ‘key activities’ of BMC, evaluates major roles and responsibilities, nevertheless has only been covered partly in BMEA. Other activities of marketing (elements 11, 12, 13) are evaluated using BMC however, cannot be considered using BMEA. Similarly, activities 37, 39, 40 are represented in BMC under the cost structure; however, BMEA does not classify those elements. Additionally, it is found that implementing this business model methodology may create complexity in the analysis, and it produces more duplicity of the requirement analysis than any other methodology creates.

4.4.1.8 Comparing Business Model Canvas & Lean Canvas Model

It is evaluated earlier that both the business model canvas and the lean canvas model (LCM) are the most accepted business model methodologies being used widely in businesses. Although LCM is the adaptation of BMS, it is going to be interesting to comprehend the difference between the two. Table 4.5 shows the comparison conducted between Business Model Canvas (BMC) and Lean Canvas Model (LCM) concluding CloudSME business elements (source - the project of CloudSME)

(green)	Shows similar business activities covered in both business models
(red)	Shows different business activities which are uncovered in BMC or Lean Canvas Model

MODELS	BUSINESS MODEL CANVAS (BMC)																																																	Differences	
LEAN CANAVS MODEL	Components/ Elements	Value Proposition			Customer Segments			Customer Relationships				Channels					Key Partners							Key Activities							Key Resources						Cost Structure						Revenue Streams								
	Problem																																																		48
	Solution																																																	49	50
	Unique Value Proposition	21	22	23																																															
	Unfair Advantage																																																	51	52
	Customer Segments				32	33	34																																												
	Key Metrics																							8	9	10	11	12	13	14																					
	Channels											4	5	6	30	31																																			
	Cost Structure																																				35	36	37	38	39	40									
	Revenue Streams																																										41	42	43	44	45	46	47		
Differences			24	25				26	27	28	29						1	2	3	4	5	6	7								15	16	17	18	19	20															

Table 4.5 Comparison Matrix for BMC and Lean Canvas Model

Values	Description	Values	Description
1	Technology core solution providers	12	European M&E SMEs marketing
2	Marketing core solution providers	13	Channels (industry associations such as NAFEMS) marketing
3	Cloud infrastructure providers	14	Consulting and integration
4	Software vendors	15	Marketing
5	Experts and consultants	16	Finance, Legal and Administrative operations
6	Value added simulation software resellers	17	Cloud Infrastructure
7	Manufacturing & Engineering Associations and Organisations	18	Cloud Management Platform
8	Operation & Maintenance of the Platform	19	Maintenance & User Support Staff
9	Software vendors support	20	HPC Infrastructure
10	End users support	21	Capabilities for easy set-up of dedicated simulation One-Stop-Shops
11	Software vendors, value added resellers, experts and consultants marketing	22	Series of dedicated simulation One-Stop-Shop for European M&E SMEs

23	General Purpose One-Stop-Shop for M&E SMEs	37	Customer Support (End User, Simulation software Vendors)
24	Dynamically linked Cloud & HPC Infrastructure	38	Technology Maintenance
25	Expert Support Services (for End User Support, End User Simulation Consulting, Software Vendor Support for Setup, Operation and integration)	39	Infrastructure Provider resource charges
26	Services through Software Vendors (One-Stop-Shops Operators, Integration Services, Consulting Services)	40	Finance, administration and legal costs
27	End user of simulation software vendors (indirect customers)	41	Simulation usage
28	Relations with end user customers (direct)	42	Insertion fees
29	End user training and consulting services	43	Membership fees
30	Industry Association	44	Integration & consulting fees
31	Direct Online Channels	45	Simulation training fees
32	Series of specific M&E markets	46	End user support services
33	European M&E SMEs	47	Software vendor support services
34	Simulation Software Vendors	48	Low simulation usage in Manufacturing & Engineering (M&E) SME's due to hardware prices, licensing costs and technical expertise
35	Service Operation (CloudSME one-stop-shop, Cloud platform, Workflow and portal technology, Cloud & HPC infrastructure connectivity)	49	To support end-user SME's to utilise customised simulation applications in the form of SaaS
36	Marketing and Sales (towards software vendors, industry associations, Dissemination)	50	Easy access to PaaS to assemble custom simulation solutions in the cloud for simulation software service providers and consulting companies

51	Experienced project partners	52	The platform to be built on existing technologies provided by project partners in previous European projects

4.4.1.9 CloudSME case study through the Lean Canvas Model

Lean canvas model (LCM) is also one of the leading business model methodologies. LCM is an adaptation of BMC and has been designed mainly for start-up businesses. The structure of LCM is as similar as BMC with a slightly different approach, and therefore, many distinct elements are discovered in both of these business model methodologies. It is examined that LCM consists of a few distinctive yet convincing components which have not been assessed in the project while using BMC. Description of those elements is as below:

Problem: Lean Canvas model focuses on entrepreneur’s gain by identifying customer’s issues which has not been measured in the CloudSME project with the use of the BMC., however it has been described as a general problem that project proposed to solve. According to LCM, element 48 “low simulation usage in manufacturing and engineering SME’s due to hardware prices, licensing costs, technical expertise” highlights a ‘problem’ of end-users. This element of customer’s problem is definitely considered to be a necessary element however each business explicitly defines a customer-focused problem or a gap as a first starting point; therefore, it cannot be argued to have this consideration within the business model.

Solution: This element is directly linked to the “problem” element. Every problem requires a “solution”. LCM business model allows businesses to plan a solution for each problem while developing business model. Through CloudSME evaluation, elements 49 and 50 are considered as solution, i.e., ‘to support end-user SME’s to utilise customised simulation’ and ‘easy access to PaaS to assemble custom simulation solutions’ respectively.

Unique Value Proposition: Although the element of unique value proposition in LCM is considered to be as same as value proposition of BMC in most cases, it is found that LCM emphasises on defining a single yet exceptional value proposition. This element has been well evaluated in the CloudSME project by exploiting BMC.

These are very similar however it has been highlighted in this comparison that for some cases, a single mission statement can be reflected as a unique value proposition.

Unfair Advantage: This is one of the core and influential element of LCM and should be considered in all types of businesses. It is absolutely crucial for a business to clearly define their uniqueness which cannot be copied by rivals easily. This evaluation is usually concluded through the competitive and the market analysis, which is not defined within the business model of CloudSME. However, market analysis and competitive analysis has been conducted outside their business model. Elements 51 and 52 (‘experienced partners’ and ‘the platform to be built with the help of previous projects’) are examined as the unfair advantage of CloudSME.

Following figure 4.5 shows the common structure of Lean Canvas Model where the elements used are examined through CloudSME project. The red coloured elements show the elements found in LCM which are missed out within the business plan of CloudSME using BMC.

<table>
<tr>
<td rowspan="2">PROBLEM
Low simulation usage in Manufacturing & Engineering (M&E) SME's due to:
- Hardware prices
- Licensing costs
- Technical expertise</td>
<td>SOLUTION
- To support end-user SME's to utilise customised simulation applications in the form of SaaS
- Easy access to PaaS to assemble custom simulation solutions in the Cloud for simulation software service providers and consulting companies</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION
To develop a general purpose one-stop-shop solutions and easy set-up of cloud-based simulation usage for European M&E SME's</td>
<td>UNFAIR ADVANTAGE
- Experienced partners
- The platform to be built on existing technologies provided by project partners in previous European projects</td>
<td rowspan="2">CUSTOMER SEGMENTS
• Series of specific M&E markets
- Tool Manufacturing
- Podiatrists
- Breweries
- Insole manufacturers
- Multi-physics engineering SME's
- UAV operators
- Open call use cases
- Use cases by further promotion
• Any European M&E SME
• Simulation software Vendors</td>
</tr>
<tr>
<td>KEY METRICS
- Operation and maintenance
- Software vendors support
- End users support
- Software vendors, VARs, experts & consultants marketing;
- European M&E SMEs marketing
- Channels (NAFEMS)
- Consulting and integration</td>
<td>CHANNELS
- Software vendors
- Experts and simulation consultants
- Value added simulation software reseller
- Industry associations
- Direct online channels</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
- Service operation (CloudSME one-stop-shop, Cloud platform, Workflow & portal technology, Cloud & HPC infrastructure connectivity)
- Marketing & sales (towards software vendors, Industry associations, Dissemination)
- Customer Support (End-user, Simulation software vendor)
- Technology Maintenance
- Infrastructure provider resource charges
- Finance, Administration & Legal</td>
<td colspan="2">REVENUE STREAMS
- Simulation usage
- Insertion fees
- Membership fees
- Integration & consulting fees;
- Simulation training fees;
- End user support services;
- Software vendor support services.</td>
</tr>
</table>

Figure 4.5 Lean Canvas Model through Cloud SME business elements (Maurya, 2012b)

4.4.1.10 Unidentified business elements of the project using the Lean Canvas Model

It can be perceived from the above comparison table 4.5 that several important business aspects have not been assessed within the business plan of the project, through the use of BMC. Parallelly, a large number of business elements which have not been discovered through the LCM which however are identified in the project using BMC, such as the elements 24, 25 of ‘value proposition’, 26, 27, 28 and 29 of ‘customer relationships’, 1, 2, 3, 4, 5, 6 and 7 of ‘key partners’ and lastly 15, 16, 17, 18, 19, 20 of ‘key resources’. These all are the key components which cannot not be ignored by businesses like CloudSME’s viewpoint. The author claims that ‘Lean Canvas Model’ (Maurya, A., 2012) is useful for start-ups, however, the methodology is lacking in some useful insights of business which can be gained with experience.

Finally, a few more comparison tables are created using the same business elements of CloudSME, which compare the remaining of the business model methodologies with each other; such as comparing GBM with V4 concept BM, GBM with BMEA, GBM with LCM and so on. Unlike the above comparison, the detailed analysis is not carried out for the remaining matrix created because the elements of business model are defined through CloudSME case study, are same. The idea here is to create cross comparison tables to analyse the difference between each of the remaining methodology with each other, and their distinct element. Also, the structure of the business components is already examined while comparing each methodology with BMC. Also, the differences can be easily viewed from the comparison tables as shown below reflecting major similarities and differences among each other.

	Shows similar business activities covered in both business models
	Shows different business activities which are uncovered in compared business model
	Shows similar activities in both business model but not covered in (actual) CloudSME project
	Shows repetition of activities through distribution of components

MODELS	GENERIC BUSINESS MODELS																																Difference	
V^4 CONCEPT BUSINESS MODEL	Componets/Elements		Customers			Competition		Offerings							Activities & Organisation							Resources						Factor Market Interactions				Longitudinal Dimension		
	Value Proposition	Products/ Services										23	24	25																				
		Value Elements											21	22																				
		Target Segments	32	33	34																													
	Value Network	Network Mode																																57
		Actors													1	2	3	4	5	6	7													
		Roles													8	9	10	11	12	13	14													
		Relationships																										26	27	28	29			
		Flow-Communications		33													3	4											27	28				
		Channels															4	5	6	30	31													
		Governance																																53
	Value Architecture	Core Resources																				15	16	17	18	19	20							
		Value Configuration				48	49								50	51																		
		Core Competencies													54																			
	Value Finance	Total Cost of Ownership														35	36	37	38	39	40													
		Pricing Methods																															55	56
		Revenue Structure						41	42	43	44	45	46	47																				
Differences																																52		

Table 4.6 Comparison Matrix for Generic Business Model and V^4 Concept Business Model

MODELS				GENERIC BUSINESS MODEL																										Differences		
BUSINESS MODEL ENINEERING APPROACH	Components/Elements			Customers		Competitors		Offerings						Activities & Organisation							Resources						Factor Market Interactions		Longitudinal Dimensions			
	Value Proposition	Customer Profiles	Customer Jobs	32	33																									60	61	62
			Pains											8	14	35	36	38	51	52					15	16						
			Gains					24	41	42	43	44	45											17	18	20	27	28				
		Value Map	Product/ Services					46	47	54	57	58	59						9	10							25	26				
			Gain Creators		34											1	2	3	6	7										48		
			Pain Relievers															4	5	30						19	29			55	56	
	Revenue Model	Output							41	42	43	44	45																			
		Durartion of Provision																													56	
		Performance Level										46	47																			
		Usage																													55	
	Value Chain and Processes	Design Level											23							54												
		Planning Level										21	22						51	52												
		Operational Level										57	58																53			63
	Technologies, Competencies and Key Resources	Technologies											59																		60	62
		Competencies				49	50																									
		Resources																			15	16	17	18	19	20						
Differences														11	12	13	31	37	39	40												

Table 4.7 Comparison Matrix for Generic Business Model and Business Model Engineering Approach

MODELS		GENERIC BUSINESS MODEL																																				Differences	
LEAN CANAVS MODEL	Components/ Elements	Customers			Competitors		Offerings							Activities & Organisation									Resources						Factor Market Interactions										Longitudinal Dimension		
	Problem																																						48
	Solution																																					49	50
	Unique Value Proposition										21	22	23																										
	Unfair Advantage																																					51	52
	Customer Segments	32	33	34																																			
	Key Metrics															8	9	10	11	12	13	14																	
	Channels																	4	5	6	30	31																	
	Cost Structure																35	36	37	38	39	40																	
	Revenue Streams						41	42	43	44	45	46	47																										
Differences					53	54							24	1	2	3	4	5	6	7	55	56	15	16	17	18	19	20	25	26	27	28	29	4	5	6	30	31	57		

Table 4.8 Comparison Matrix for Generic Business Model and Lean Canvas Model

MODEL	BUSINESS MODEL ENGINEERING APPROACH																		
	Components/Elements		Value Prposition						Revenue Model				Value Chain and Processes			Technologies, Competencices and Key Resources			Difference
			Customer Profile			Value Map													
			Customer Jobs	Pains	Gains	Product/ Services	Gain Creators	Pain Relievers	Output	Duration of Provision	Performance Level	Usage	Design Level	Planning Level	Operational Level	Technologies	Competencies	Resources	
V^4 CONCEPT BUSINESS MODEL	Value Proposition	Products/ Services			24	25 56 57 58							23						
		Value Elements												21 22					
		Target Segments	32 33				34												
	Value Network	Network Mode																	63
		Actors					1 2 3 6 7	4 5											11 12 13
		Roles		8 14		9 10													
		Relationships			27 28	26		29											
		Flow-Communications	33		27 28		3	4											
		Channels					6	4 5 30											31
		Governance					48												
	Value Architecture	Core Resources		15 16	17 18 20			19										15 16 17 18 19 20	
		Value Configuration		51 52										51 52			49 50		
		Core Competencies				53							53						
	Value Finance	Total Cost of Ownership		35 36 38															37 39 40
		Pricing Methods						54 55		55		54							
		Revenue Structure				46 47			41 42 43 44 45		46 47								
Difference			59 60 61												56 57 62	58 59 61			

Table 4.9 Comparison Matrix for V4 Concept BM & BMEA

All the above created tables show the core similarities and differences among the business components of all the five business model development methodologies. In order to validate if the parallel comparison results achieved, it has been considered to use a second business use-case with different business requirements. Therefore, another use-case of 'Ingecon/Podoactiva -Insole validation one-stop-shop' from the CloudSME project has been elected to make the similar comparison matrices. The details of the business along with requirement analysis has been discussed below.

4.4.2 Case Study 2: Background of Podoactiva (One of the partners in CloudSME project (source – the project of CloudSME, www.cloudsme-project.eu/)

Podoactiva is a biotechnology-based company specialised in podiatry and biomechanics, strives to use innovative technology to diagnose, design and manufacture personalised treatments in the form of orthotic insoles to improve the quality of people's lives through improvement of their gait.

Podoactiva has developed a system named 3D Scan Sport Podoactiva®. It is simulation software for the treatment and design of tailored insoles from a virtual mould of the foot for sports or for people having foot problems. It particularly collaborates with CloudSME project to use a cloud-based version of this simulation software to design insoles and simulate the interaction of feet and insoles. In turn, this design is loaded into a CNC machine to manufacture the insoles.

The CloudSME project has supported Podoactiva to establish a portal through which scans can be uploaded to the cloud-based software service, and then validated the scanned image to produce the design of customized insole. A business model using business model canvas for insole validation in the Podoactiva use case has also been described in the project. The following figure 4.6 shows the main elements that are being identified in the use case.

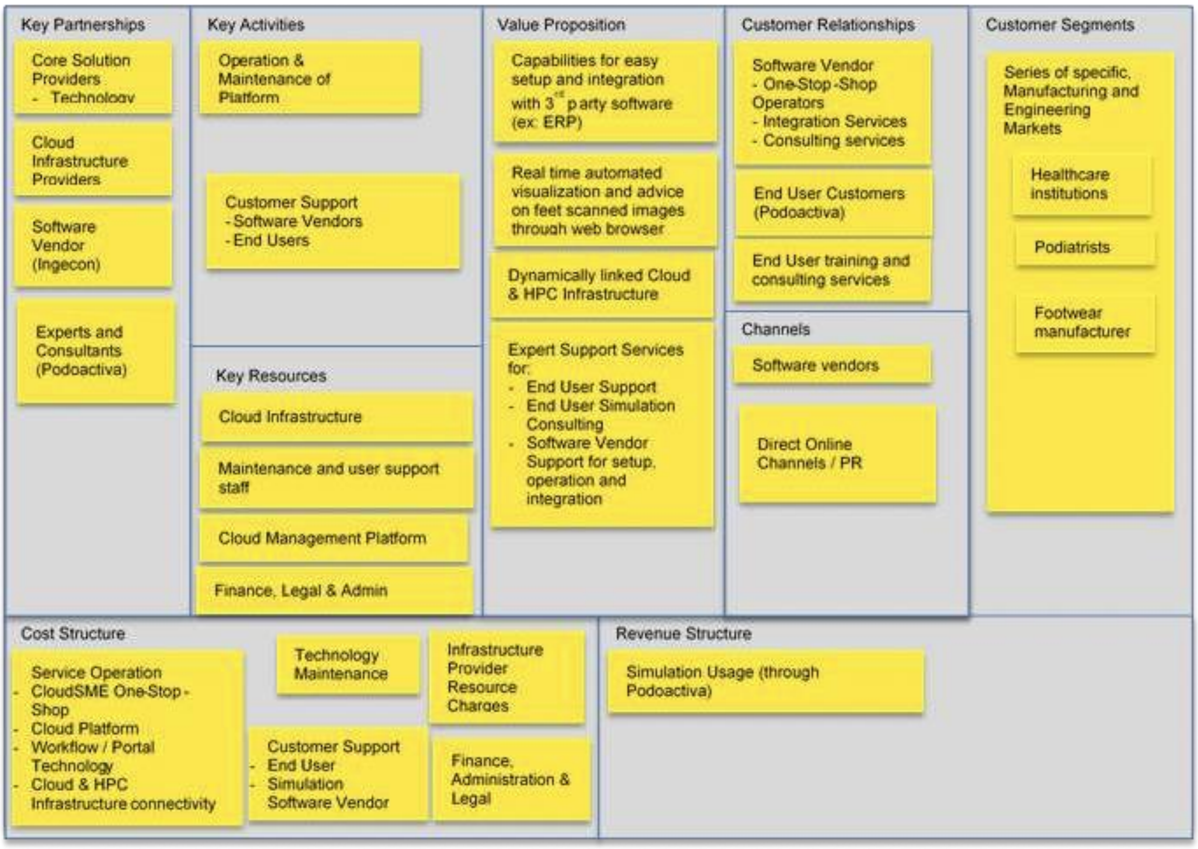


Figure 4.6 Business Model Canvas through Ingecon/Podoactiva Case Study (CloudSME, no date; Osterwalder and Pigneur, 2010)

4.4.2.1 Comparing Business Model Canvas and Generic Business Model through Ingecon/Podoactiva:

The business elements of Podoactiva are being used to create a few more comparison tables in order to confirm if the similar results are obtained (source - the project of CloudSME).

MODELS		BUSINESS MODEL CANVAS																										Difference	
GENERIC BUSIENSS MODEL	Components/Elements	Value Proposition			Customer Segments	Customer Relationships			Channels		Key Partners				Key Activities			Key Resources				Cost Structure					Revenue Streams		
	Customers				20																								
	Competitors																											27	28
	Offerings	12	13	14																							26		
	Activities & Organisation								3	19	1	2	3	4	5	6	7					21	22	23	24	25			
	Resources																	8	9	10	11								
	Factor Market Intraction/ Suppliers			15		16	17	18	3	19																			
	Longitudinal Dimension																												29
Difference																													

Table 4.10 Comparison Matrix for Generic Business Model & BMC through Podoactiva use case

Values	Description	Values	Description
1	Technology core solution providers	7	End users support
2	Cloud infrastructure providers	8	Cloud Infrastructure
3	Software vendors	9	Cloud Management Platform
4	Experts and consultants	10	Finance, legal & administrative operation
5	Preparation & maintenance of platform	11	Maintenance & User Support Staff
6	Software vendors support	12	Capabilities for easy set-up & integration of third-party software

13	Real-time automated visualisation & advice on feet scanned images	22	Technology maintenance
14	Dynamically linked Cloud & HPC infrastructure	23	Customer support (end user, simulation software vendors)
15	Expert support service for (end-user support, end-user simulation consulting, software vendor support for set-up, operations & integration)	24	Infrastructure provider resource charges
16	Relationships with software vendors (one-stop-shop operating, integration services, consulting services)	25	Finance, administration and legal cost
17	Relation with end user customers	26	Simulation usage through Podoactiva
18	End user training & consulting services	27	Market analysis
19	Direct online channels / PR	28	Competitive analysis
20	Series of specific manufacturing & engineering markets (Healthcare institutions, Podiatrists, Footwear manufacturers)	29	Possible constraints and limitations
21	Service operations (CloudSME one-stop-shop, Cloud platform, workflow and portal technology Cloud & HPC infrastructure connectivity)		

4.4.2.2 Podoactiva's business model elements through Generic Business Model

It has been discovered that the elements 27, 28 signifying 'market analysis' and 'competitive analysis' of GBM, is not analysed within the business model of Podoactiva use case. Apart from this, element 29 that is 'longitudinal dimension' found to be overlooked through the business model using BMC.

In the above comparison matrix table 4.10, only a few differences among BMC and GBM are discovered, perhaps a few business activities are detailed in this use-case. For this use-case, it is comprehended that Podoactiva is not a small industry, the business analyst of Podoactiva or Ingecon (since Injecon is technical analyst of Podoactiva for this project and responsible for integrating Podoactiva solution in cloud platform), however, have only considered total 29 business activities. It is perceived from the document review that the concept of disruptive technology is not clear to manufacturing companies. There is a possibility that due to lack of experience, the business analysis is not carried out explicitly. While Podoactiva lack the insight of some business aspects even using Business Model Canvas, the analyst of CloudSME, carried out analysis defining wide range of business elements. Nevertheless, the results of this overall comparison among these two methodologies are similar to some extent; which signifies that BMC does not contains analysis of 'market analysis', 'competititon analysis' and 'longitudinal dimension'.

4.4.2.3 Comparing BMC & V4 concept BM through Podoactiva:

Following matrix table 4.11 shows the similar and distinct business elements which are identified by comparing elements of V4 BM and the BMC (source - the project of CloudSME).

MODELS	BUSINESS MODEL CANVAS (BMC)																												Difference			
V^4 CONCEPT BUSINESS MODEL	Components/Elements		Value Proposition		Customer Segments	Customer Relationships			Channels			Key Partners				Key Activities			Key Resources				Cost Structure					Revenue Streams				
	Value Proposition	Products/ Services	14	15																												
		Value Elements	12	13																												
		Target Segments			20																											
	Value Network	Network Mode																														30
		Actors										1	2	3	4																	
		Roles														5	6	7														
		Relationships				16	17	18																								
		Flow-Communications																											3	4	32	33
		Channels							3	4	19																					
		Governance																														31
	Value Architecture	Core Resources																	8	9	10	11										
		Value Configuration																												27	28	29
		Core Competences																														34
	Value Finance	Total Cost of Ownership																					21	22	23	24	25					
		Pricing Methods																														
		Revenue Structure																										26				
Difference																																

Table 4.11 Comparison Matrix for V^4 Concept BM & BMC through Podoactiva use case

Values	Description	Values	Description
1	Technology core solution providers	8	Cloud Infrastructure
2	Cloud infrastructure providers	9	Cloud Management Platform
3	Software vendors	10	Finance, legal & administrative operation
4	Experts and consultants	11	Maintenance & User Support Staff
5	Preparation & maintenance of platform	12	Capabilities for easy set-up & integration of third-party software (e.g. ERP)
6	Software vendors support	13	Real-time automated visualisation & advice on feet scanned images
7	End users support	14	Dynamically linked Cloud & HPC infrastructure

15	Expert support service for (end-user support, end-user simulation consulting, software vendor support for set-up, operations & integration)	25	Finance, administration, and legal cost
16	Relationships with software vendors (one-stop-shop operating, integration services, consulting services)	26	Simulation usage through Podoactiva
17	Relation with end-user customers	27	Market analysis
18	End-user training & consulting services	28	Competitive analysis
19	Direct online channels / PR	29	Technical implementation
20	Series of specific manufacturing & engineering markets (Healthcare institutions, Podiatrists, Footwear manufacturers)	30	Closed (unknown)
21	Service operations (CloudSME one-stop-shop, Cloud platform, workflow and portal technology Cloud & HPC infrastructure connectivity)	31	Governance (unknown)
22	Technology maintenance	32	Health care companies / Podiatrists
23	Customer support (end-user, simulation software vendors)	33	Podoactiva ERP / Customers (direct, indirect)
24	Infrastructure provider resource charges	34	Insole validation for Podoactiva (insole validation service in Podoactiva ERP)

4.4.2.4 Podoactiva’s business model elements through V4 concept business model

Other than the total number of elements, the above matrix table 4.11 also reflects roughly similar results as it has been found by comparing V4 BM and BMC based on CloudSME business elements. Elements 27, 28, 29, 31, 32, 33 and 34 are identified within the business model of Podoactiva however these elements can be analysed using V4 BM. The main differences is obtained through the elements of ‘value network’ and ‘value architecture’ where elements related to competency, competitive & market analysis can be considered within the business model methodology using V4 BM, whereas these are evaluated in case of podoactiva through an independent analysis. Also, since using BMC technological elements are subsumed under value proposition and resources, the Podoactiva could not identify these elements explicitly.

4.4.2.5 Comparing BMC & Business Model Engineering Approach through Podoactiva:

The following table shows a comparison between BMEA and BMC using business elements of Podoactiva use case of insole validation (source - the project of CloudSME).

MODELS	BUSINESS MODEL CANVAS (BMC)																								Differences		
	Components/ Elements			Value Proposition		Customer Segments	Customer Relationships		Channels		Key Partners		Key Activities		Key Resources				Cost Structure					Revenue Structure			
Business Model Engineering Approach (BMEA)	Value Proposition	Customer Profiles	Customer Jobs			20																					
			Pains											5				10	21	22	23	24	25				29
			Gains	14			16	17									8	9						26		31	32
		Value Map	Product/ Services	15									6	7													
			Gain Creators								1	2															30
			Pain Relievers					18	3	4	3	4						11									
	Revenue Model	Output																						26			
		Duration of Provision																									
		Performance Level																									
		Usage																									
	Value Chain and Processes	Design Level																									
		Planning Level		12	13																						29
		Operational Level												5													
	Technologies, Competencies and Key Resources	Technologies																									
		Competencies																							27	28	33
		Resources													8	9	10	11									
Differences										19																	

Table 4.12 Comparison Matrix for BMEA & BMC through Podoactiva use case

Values	Description	Values	Description
1	Technology core solution providers	8	Cloud Infrastructure
2	Cloud infrastructure providers	9	Cloud Management Platform
3	Software vendors	10	Finance, legal & administrative operation
4	Experts and consultants	11	Maintenance & User Support Staff
5	Preparation & maintenance of platform	12	Capabilities for easy set-up & integration of third-party software (e.g. ERP)
6	Software vendors support	13	Real-time automated visualisation & advice on feet scanned images
7	End users support	14	Dynamically linked Cloud & HPC infrastructure

15	Expert support service for (end-user support, end-user simulation consulting, software vendor support for set-up, operations & integration)	25	Finance, administration and legal cost
16	Relationships with software vendors (one-stop-shop operating, integration services, consulting services)	26	Simulation usage through Podoactiva
17	Relation with end user customers	27	Market analysis
18	End user training & consulting services	28	Competitive analysis
19	Direct online channels / PR	29	Technical implementation
20	Series of specific manufacturing & engineering markets (Healthcare institutions, Podiatrists, Footwear manufacturers)	30	Governance (unknown)
21	Service operations (CloudSME one-stop-shop, Cloud platform, workflow and portal technology Cloud & HPC infrastructure connectivity)	31	Health care companies / Podiatrists
22	Technology maintenance	32	Podoactiva ERP / Customers (direct, indirect)
23	Customer support (end user, simulation software vendors)	33	Insole validation for Podoactiva (insole validation service in Podoactiva ERP)
24	Infrastructure provider resource charges		

4.4.2.6 Podoactiva's business model elements through the Business Model Engineering Approach

The matrix table 4.12 highlights the relatively parallel results as examined through both by using CloudSME business processes as well as Podoactiva business elements while comparing BMEA and BMC components. The elements of 'value chain' of BMEA has not been identified, because those components are not divulged through this use case of Podoactiva. Nevertheless, some distinct elements are examined such as element 19 and all elements between 29 and 33 (inclusive). The major important difference is found that the market and competitive analysis can be constructed within the business model using BMEA.

4.4.2.7 Comparing BMC & Lean Canvas Model through Podoactiva

The following table 4.13 shows a comparison between Lean Canvas Model and BMC through the business elements of Podoactiva use case of insole validation (source - the project of CloudSME):

Models	Business Model Canvas (BMC)																										Differences	
Lean Canvas Model	Components/ Elements	Value Proposition		Customer Segments	Customer Relationships			Channels		Key Partners				Key Activities			Key Resources				Cost Structures					Revenue Streams		
	Problem																											29
	Solution																											30
	Unique Value Proposition	12	13																									
	Unfair Advantage																										27	28
	Customer Segements			20																								
	Key Metrics													5	6	7												
	Channels							3	19																			
	Cost Structure																				21	22	23	24	25			
	Revenue Streams																									26		
Difference			14		16	17	18			1	2	3	4				8	9	10	11								

Table 4.13 Comparison Matrix for LCM & BMC through Podoactiva use case

Values	Description	Values	Description
1	Technology core solution providers	12	Capabilities for easy set-up & integration of third-party software
2	Cloud infrastructure providers	13	Real-time automated visualisation & advice on feet scanned images
3	Software vendors	14	Dynamically linked Cloud & HPC infrastructure
4	Experts and consultants	15	Expert support service for (end-user support, end-user simulation consulting, software vendor support for set-up, operations & integration)
5	Preparation & maintenance of platform	16	Relationships with software vendors (one-stop-shop operating, integration services, consulting services)
6	Software vendors support	17	Relation with end user customers
7	End users support	18	End user training & consulting services
8	Cloud Infrastructure	19	Direct online channels / PR
9	Cloud Management Platform	20	Series of specific manufacturing & engineering markets (Healthcare institutions, Podiatrists, Footwear manufacturers)
10	Finance, legal & administrative operation	21	Service operations (CloudSME one-stop-shop, Cloud platform, workflow and portal technology Cloud & HPC infrastructure connectivity)
11	Maintenance & User Support Staff	22	Technology maintenance

23	Customer support (end user, simulation software vendors)	27	Insole validation for Podoactiva (Insole validation service in Podoactiva ERP)
24	Infrastructure provider resource charges	28	Experienced Project Partners
25	Finance, administration and legal charges	29	Production and design of tailored insole for Podoactiva users
26	Simulation usage through Podoactiva	30	Linking and simulating 3D foot scanning for validation the insole design

4.4.2.8 Podoactiva's business model elements through Lean Canvas Model

Similar results are found by comparing Lean Canvas Model and Business Model Canvas using business elements of both the Podoactiva use case and the CloudSME project. Lean Canvas Model does not contain partners analysis, customer relationship and main resources of the business instead emphasise on customer's problem and providing their unique solutions. A difference among elements analysis through BMC and LCM has been confirmed through the element 14, all elements between 1-4, 8-11, 16-18 and 27-30 represented in table 4.13.

One additional table has been created through the business elements of Podoactiva use-case showing similarities and difference among elements of generic business model and lean canvas model. Please note the values of tables are exactly same as the previous table that is why it has not been provided here. This table has also highlighted fairly similar results obtained through the comparison of LCM and GBM through the business elements of CloudSME and clearly underlined in below table 4.14 (source - the project of CloudSME):

Models	Generic Business Model (GBM)																						Difference	
	Components/ Elements	Customers	Competitors		Offerings		Activities & Organisation					Resources				Factor Market Interactions						Longitudinal Dimension		
Lean Canvas Model (LCM)	Problem																							29
	Solution																							30
	Unique Value Proposition				12	13																		
	Unfair Advantage																						27	28
	Customer Segements	20																						
	Key Metrics								5	6	7													
	Channels									3	19													
	Cost Structure						21	22	23	24	25													
	Revenue Streams					26																		
Difference			31	32		14		1	2	3	4	8	9	10	11	3	15	16	17	18	19	33		

Table 4.14 Comparison Matrix for GBM & LCM

4.4.2.9 Point-to-point analysis through the comparison tables:

Finally, the above comparison matrices are found to be very useful to discover some of the important elements, which have not been identified within the business model of CloudSME using business model canvas. For further justification, the research outlined point-to-point discussion on the elements of business model canvas based on CloudSME's business elements for better evaluation of these comparisons results (source - the project of CloudSME):

A. VALUE PROPOSITION:

Clark et al. (2012) explained value proposition as the ability to provide incomparable value to the customers so that they get some benefit from buying/consuming the offered products/services from an organisation such as a product/service which is convenient to use, saves time and money, exceptional design or brand.

Value proposition is the key business component to be identified by a business of any size or any stream. Therefore, each examined business model methodology considers this analysis. CloudSME project has analysed its business elements by employing Osterwalder's Business Model Canvas (BMC) which includes the following products and services as value creation for their customers:

- Capabilities for easy setup of dedicated simulation one-stop-shops
- Series of dedicated simulation one-stop-shops for European M&E SMEs
- General purpose one-stop-shop for M&E SMEs
- Dynamically linked cloud and HPC infrastructures
- Expert support services:
  - End user support
  - End user simulation consulting
  - Software vendor support for setup, operation and integration

Generic business model (GBM) comprises with an element of 'offerings', which includes the same consideration of delivering unique value to the customers as 'value proposition' of business model canvas (BMC). The first four business activities under 'offerings' of GBM are analysed as same as 'value proposition' of BMC. BMC also contains an activity of 'expert support services' under 'value proposition' however this element has been considered under the component of 'factor market interaction/suppliers' of GBM. According to GBM, this component represents a fundamental relationship among other significant components such as linking customer segments & competition to offerings and offerings to configuration of value chain (further explained in 'Customer Relationships') and so on.

Next, V4 concept of business model (V4 BM) also consists of 'value proposition' as similar as BMC, yet also contains three sub-components as 'products/services', 'value elements' and 'target segments'. Whilst the first three business activities under 'value proposition' of BMC has been identified in 'products/services' of V4 BM, the remaining business activities of 'value proposition' has been evaluated through the 'value elements' of V4 BM. Lastly 'target segments' of V4 BM has been identified from the 'customer segments' of BMC, since V4 BM represents its specific customer segments under the analysis of 'value proposition' component.

Furthermore, Business Model Engineering Approach (BMEA) also covers the analysis of 'value proposition' however the analysis of its elements has been arranged in a totally different appearance. In CloudSME particularly, a business plan has been created using business model canvas however, the analysis of market, competitor, ‘PESTLE ‘and ‘value proposition’ factors has been conducted separately. BMEA evaluates ‘value proposition model’ within the business model methodology, therefore it covers analysis of each aspect of value proposition model (which has been analysed independently in CloudSME project) within the ‘value proposition’ component. Value proposition segment of BMEA represents two sub-components ‘customer profiles’ and ‘value map’. Customer profile has been divided in three sub-components named ‘customer jobs’, ‘pains’, ‘gains’ and value map has also been divided further as ‘product/services’, ‘gain creators’, ‘pain relievers’. Although BMEA creates a widespread analysis of value proposition and a business do not need to make a separate analysis for value proposition, yet this analysis makes the model too complex to comprehend.

Last but not least, lean canvas model (LCM) also represents value proposition with its element of ‘unique value proposition’ however it is somewhat different from ‘value proposition’ of BMC. Unique value proposition has been considered to evaluate a single & unique value specification to approach its target customers effectively. It is identified that value proposition of CloudSME can be elaborated in a single statement representing a unique value proposition of LCM that is; ‘to develop a general purpose one-stop-shop solutions and easy set-up of cloud-based simulation usage for European M&E SME’s’. Nevertheless, it really depends on a business to identify their value proposition in one statement or five different statements. Perhaps an organisation has more than one unique propositions to consider.

Review: It is clear from above evaluation that the ‘value proposition’ is one of the core components of all identified business models. Nonetheless, having a value proposition model with the business model methodology such as of Business Model Engineering Approach, makes the overall analysis very messy and difficult. Likewise, V4 concept business model also offers analysis of target customers within the value proposition section, which can also make the analysis slightly unreliable. However, the analysis of value proposition in remaining three business model methodologies (BMC, GBM, LCM) has been considered to be well-defined and proved to be certainly straightforward.

B. CUSTOMER SEGMENTS:

(Zott and Amit, 2010) articulated that *"the overall objective of a focal firm's business model is to exploit a business opportunity by creating value for the parties involved, i.e., to fulfil customers' needs and create customer surplus while generating a profit for the focal firm and its partners."* Therefore, it is essential to establish its customer segment/s while figuring out the value proposition for a business

In view of CloudSME's business model (of BMC), the following attributes are evaluated as their main customer segments:

- Series of specific, manufacturing and engineering markets:
  - Tool manufacturers
  - Podiatrists
  - Breweries
  - Insole manufacturers
  - Multi-physics engineering SMEs
  - UAV operators
  - Open call use cases
  - Use cases by further promotion
- Any European M&E SME
- Simulation software vendors

Although all these activities are considered within each business model methodology (except BMEA), the analysis has been made through different components with different name; such as 'customer segments' in Lean Canvas Model, 'customers' in Generic Business Model (GBM), sub-component 'target segments' of 'value proposition' in V4 Concept Business Model has been analysed as similar as 'customer segments' of BMC.

Business Model Engineering Approach has brought a different conception of business model elements and covers a wide range of business analysis which makes it exceptional. In case the business considerations are not examined well, this can lead to omission of some important insights of business. BMEA contains 'customer segments' under its 'value proposition model'. First two business activities of 'customer segments' of BMC using CloudSME are covered in 'customer jobs' of its 'customer profiles' sub-component of 'value proposition model' of BMEA and the last activity of ‘customer segments’ in BMC are identified through the element ‘gain creator’ of ‘value map’ in BMEA.

Review: Any business exists because of its customers. It is certainly a major analysis to carry out while constructing business models. Addressing customer segments as a separate building block can be more viable which is approximately constituted wisely in each business model except BMEA.

C. CUSTOMER RELATIONSHIPS:

According to Morris et al. (2005), a concrete business model must outline ‘how an entrepreneur intends to achieve advantage over competitors’ i.e. how a firm positions itself in the market. They explained that ‘external positioning’ is a critical factor of value creation within the large value network. An entrepreneur must form appropriate relationships with the suppliers, the partners, and the customers as part of their positioning.

‘Customer Relationships’ of CloudSME’s business plan has included the following possessions to establish relationship with customers:

- Relationships with software vendors
  - One-stop-shop operating
  - Integration services
  - Consulting services
- Relations with end user of simulation software vendors (indirect customers)
- Relations with end user customers (direct)
- End user training and consulting services

In GBM, all these four activities are identified through the component of ‘factor market interactions/ suppliers’. This component has been retrieved through the interaction among various components and for the execution of value Chain.Hedman and Kalling (2003) represented causal relations between various components within this concept. They explained, in order to achieve a favourable position (better price/quality) in market, a firm needs to offer customer perceived products/services. This requires successful arrangement of value chain activities (effective communication and distribution of labour & authority). This further requires human, physical and organisational resources which could be obtained on factor markets and supplier of production inputs. Therefore, while concluding business elements of CloudSME, the ‘Factor Market Interactions/ Suppliers’ of GBM has been partially identified as ‘customer relationships’ of BMC. It additionally contains another business activity of ‘expert support services’ which has been covered under value proposition of BMC. Apart from this, the ‘factor market interactions/ suppliers’ have also been obtained through BMC’s element of ‘channels’. Thus, the elements of ‘factor market interactions/ suppliers’ in GBM has been identified as value ‘proposition’ ‘customer relationships’, ‘channels’ as according to GBM these elements are interconnected.

V4 concept business model comprises all the above contents under ‘customer relationships’ of BMC in the sub-component ‘relationships’ of ‘value network’ component. BMEA also includes all these elements under its ‘value proposition’ analysis however divides in three different sub-components of ‘products/services’, ‘gains’ and ‘pain relievers’. Finally, in lean canvas model, the analysis of ‘customer relationships’ does not exist therefore, these elements have not been evaluated through this model.

Review: A business model is feasible when it defines its value proposition and customer segments however it is equally important to reach customer for delivering the value which is promising through establishing relationships. In this section, it has been examined that, each business model methodology (except lean canvas model) has at least a single building block to analyse relationships to make market position and to indicate its proposed value to the targeted customer segments. Nevertheless, LCM does not comprise with this important component of ‘customer relationships’.

D. CHANNELS:

It has been examined in the literature that there is a direct link between ‘channels’ and ‘customer relationships’. Both, the generic business model ofHedman and Kalling (2003) and business model canvas of Osterwalder & Pigneur (2010) has portrayed this connection in their concepts. Apart from this, Peters et al. (2013) also illustrated that both these elements are interdependent of ‘customers’. customer relationship defines the ways to communicate with the customers and channels are the arrangements to deliver the value to customers.

The activities of ‘channels’ of BMC (to deliver value) has been identified in CloudSME as below:

- Software vendors
- Experts and simulation consultants
- Value added simulation software reseller
- Industry associations
- Direct online channels

All these above business processes under ‘channels’ of BMC are evaluated through the component of ‘activities and organisation’ as well as ‘factor market interactions/ suppliers’ of generic business model. It is learnt from the previous sections that the elements of ‘factor market interactions/ suppliers’ are analysed from both the ‘customer relationships’ and ‘channels’ of BMC as GBM arranges these activities to represent the interdependency of customer relationship and channels towards the customers. This analysis however leads to slight overlapping and replicating of some components’.

Similarly, all business processes from ‘channels’ of BMC are identified from the analysis of V4 concept of business model (with a slight overlapping) and lean canvas model. Business model engineering approach does not contain ‘channels’ components however due to interdependencies of other components, these factors are partially covered in its ‘value proposition’ analysis under ‘pain relievers’ and ‘gain creators’. Last business factor of ‘direct online channels’ have not been covered at all in BMEA.

Review: Several authors and business experts have expressed to consider the association in business components when planning a business model. One business model methodology implies to inter-connect two or more components representing a single component while others use methodology to consider and express each business aspect as an individual component. For instance; ‘channels’ and ‘customer relationships’ of BMC are represented through the elements of ‘factor market interactions/ suppliers’ of GBM. Moreover, some methodologies suggest not to incorporate certain business components (according to business needs) such as ‘channels’ have not been considered in BMEA. Nevertheless, this research supports the view that the ‘channels’ is also a significant component of a business model to deliver the value and to reach customers.

E. KEY PARTNERS:

‘Key partners’ has also been considered as an essential component of business model. This is a special network of suppliers and partners which helps to reduce risk of business by sharing risks and to acquire their resources (Osterwalder & Pigneur 2010). Besides, the element of ‘key partners’ has also been considered in various sources as part of the value network or value chain (Peters et al., 2013).

Following facts are assessed as ‘key partners’ in CloudSME project based on BMC:

- Technology core solution providers
- Marketing core solution providers
- Cloud infrastructure providers
- Software vendors
- Experts and consultants
- Value added simulation software resellers
- Manufacturing & Engineering associations and organizations

While evaluating business elements of CloudSME using GBM methodology, all the above analysed business aspects in ‘key partners’ of BMC are found under ‘Activities and Organisation’ component of GBM. In general, ‘activities and organisation’ includes all activities of value chain, management & organisational (operational, production etc.) and logistics & supply. Therefore, this component of GBM contains large number of business possessions.

Similarly, using V4 concept of business model, all these assessed elements of ‘key partners’ can be acquired within its ‘actors’ sub-component under ‘value network’. Moreover, BMEA also consists of these elements within its ‘value chain and processes’ sub-component under ‘operational level’. These elements have also been found within its ‘gain creators’ under value proposition of BMEA, which create duplicity of these elements. Lastly, these business factors have not been constituted in lean canvas model; because the model does not contains partners analysis within the methodology.

Review: It is clear from the prior studies that, analysing business partners is also very useful consideration for an optimised business model. Consequently, this element has been featured in each examined business model methodology other than lean canvas model. This methodology (LCM), therefore, could lead an industry to oversight some important views of business or one has to define partners information from an individual analysis.

F. KEY ACTIVITIES:

"The activities of a focal firm and its partners play an important role in the various conceptualizations of business models" (Zott, Raphael and Massa, 2011).The element of 'Key activities' has also been considered as part of a firm's value network. Firms, that are facing on-going issues to exploit technological innovations for business prospects, they inevitably require to identify and arrange new activities to overcome the challenges (Seppänen, 2009). The component of 'activities' is an integral part of an effective business model which allows a business to operate efficiently.

Using this element of BMC, CloudSME business plan implied the following activities in the project and to operate well:

- Operation and maintenance of the platform
- Software vendors' support
- End users support
- Software vendors, value added resellers, experts and consultants marketing
- European M&E SMEs marketing
- Channels (industry associations such as NAFEMS) marketing
- Consulting and integration services

Each of these activities have also been analysed in GBM methodology under the element of 'activities and organisation'. The element of 'activities and organisation' contains all the processes of value chain including all operational & financial actions and associate members etc. Similarly, these features have also been analysed in both the methodologies; V4 concept of business model as well as in lean canvas model however with different descriptions as 'roles' and 'key metrics' respectively.

Likewise, the elements of ‘key activities’ of BMC are identified under two sub-components of ‘value proposition’ analysis of BMEA. The elements ‘operation and maintenance of the platform’, ‘consulting and integration services’ found within the subcomponent ‘pains’, while the elements ‘software vendors support’ and ‘end users support’ are evaluated through ‘products/services’ of ‘value proposition’ of BMEA. Besides, some of the elements of ‘key activities’ have also been evaluated through the sub-element ‘operational level’ of ‘value chain and processes’ of BMEA which creates repetition of analysis.

Review: ‘Activities’ enables an enterprise to analyse its major operations which then support to create and offer a value proposition, reach markets, maintain customer relationships and earn revenues (Osterwalder & Pigneur 2010). Because of its usefulness, ‘activities’ has been identified in each examined business model methodology. BMEA showed re-occurrence of some of its features however, the persistence and usage of these is different. This re-occurrence of elements certainly makes BMEA a complicated methodology.

G. KEY RESOURCES:

The business model is designed to aid exploitation of the business potential towards an innovation. This exploitation certainly generates new activities in the organisational context which then persuade firm to select and arrange its available resources. Also, the innovation may appear in the form of new solutions in products, processes or administration (Seppänen, 2009).

Seppänen (2009) highlighted the importance of resources as a component of business model concept. He referred to previous literature to prove that, for a business, resource allocation is at the heart of strategic management. Furthermore, resource allocation is highly substantial for business to manage environmental changes as well as to make competitive position.

This is why Business Model Canvas also suggests the use of this crucial component. Following features are analysed as the ‘key resources’ of CloudSME project plan:

- Marketing
- Cloud infrastructure
- Cloud management platform
- Finance, legal and administrative

- Maintenance and user support staff
- HPC infrastructure

GBM and V4 BM also consist of this core component as ‘resources’ and ‘core resources’ respectively, and therefore, all above features are identified through the analysis. The above elements have also been evaluated through BMEA within its ‘resources’ building block. However, these elements have also been represented in its ‘value proposition’ section under the sub-components of ‘pains’, ‘gains’ and ‘pain relievers’ which creates duplicate sets of elements. Nonetheless, this central element has not been identified in the lean canvas model, which may make it less effective.

Review: ‘Resources’ is considered to be an important component to be analysed through business model especially for a business incorporated with technical products/services. While designing a business model of GBM,Hedman and Kalling (2003) emphasised widely on the perspective of information systems (IS) and its economic role in a business. GBM considers IS as a potential resource. They explained in their research that in order to create offerings at a unique level, a firm should utilise it’s IS resources along with other resources, to disseminate those in activities and then manage those activities exclusively. Accordingly, this component has been included in all other examined business model methodology with the exception of lean canvas model.

H. COST STRUCTURE:

Morris et al. (2005) described the significance of economic factor of a business model. This economic factor has a huge influence on business towards making profit by defining the effective cost structure and revenue sources. Moreover, the element of cost structure provides assistance delivering value to customers at an appropriate cost (Casadesus-Masanell and Ricart, 2010).

The following factors are addressed as cost structure of CloudSME project using BMC:

- Service operations
  - CloudSME one-stop-shop
  - Cloud platform
  - Workflow and portal technology
  - Cloud &HPC infrastructure connectivity

- Marketing and sales
  - Towards software vendors
  - Towards industry associations
  - Dissemination
- Customer support
  - End users
  - Simulation software vendor
- Technology maintenance
- Infrastructure providers' resource charges
- Finance, administration and legal costs

Other identified business model methodologies also contain this component in a similar way though with the different terminologies. These properties are configures under GBM through the element of 'offerings'. Whereas in V^4 concept of business model, these are found within its element of 'total cost of ownership' under 'value finance' component. Besides, LCM incorporates as similar analysis of 'cost structures' as BMC, therefore the elements are identified similarly as BMC. Conversely, BMEA does not analyse 'cost structure' under any of its components within the methodology, however a few of 'cost structure' elements are discovered through its 'pains' subcomponent. Those are 'service operations', marketing and sales' and 'technology maintenance', those. Another four important activities of cost structures have not been examined in the methodology such as 'customer support', 'infrastructure providers' 'resource charges' and 'finance, administration and legal costs'.

Review: Precisely, 'cost structure' is also a valuable component of business model. It supports in estimating the overall cost to deliver the value to the customer. All examined business model methodologies has suggested this essential component excluding BMEA. Although some of the activities occurred in 'pains' of value proposition section, their determination is not related to the cost structure.

I. REVENUE STREAMS:

It has been examined that the business model components have fundamental relationship with each other. Teece (2010) also mentioned this relationship in his theory, where he explained on how the business's revenue and cost structures should be designed, how value should be captured, and competitive advantage be sustained – and these are the key issues in designing a business model. He depicted that it is not enough to do the first without the second.

The business model of CloudSME has identified the following elements as their 'Revenue Streams' based on the elements of BMC:

- Simulation usage
- Insertion fees
- Membership fees
- Integration & consulting fees
- Simulation training fees
- End-user support services
- Software vendors' support services

Each of the above activities are evaluated in each business model methodologies. Generic business model has defined these activities from its 'offerings' component and V4 concept of business model has examined these within its 'revenue structures' of its 'value finance' component. In the same way, lean canvas model has classified these in its 'revenue streams' block. Lastly, Business model engineering approach has also analysed these activities within its 'revenue model' of 'output' and 'performance level'. These elements have further been evaluated under the value proposition's 'gains' and 'products/services' sub-components however the purpose of this analysis is different from revenue.

Review: Evidently, 'Revenue Streams' is also an imperative component of the business model. This is the reason; this has been evaluated in each examined business model methodology.

4.5 Analysis Results

It has been evaluated through both, by creating comparison matrices and making a point-to-point discussion that all the nine components suggested by Osterwalder in the business model canvas are crucial. It has also been examined through the SWOT analysis that BMC is one of the leading business model methodologies and being used widely. Undoubtedly, each of the other methodologies has its own unique approach. This is because the relationship between each element is identified differently using different perception. Also, because the purpose and perspective of each business model methodology are distinct with respect to business type, size and orientation, it has been identified that the lean canvas model is also applicable but does not define some of the vital elements such as 'partners' 'customer relationships' 'resources' which are proved to be equally important as other elements. Besides, the business model engineering approach is found to be comparatively exclusive and covers a considerable number of business factors within the business model concept. It, in fact, contains technological factors and some additional considerations; however, the structure becomes very complex and generates a large number of duplicities. Besides, this methodology is specifically created for manufacturing & engineering companies (that are end-users in my case) and has not been validated or tested.

Furthermore, almost all the business elements of CloudSME (originally using BMC) are identified through both the V^4 concept of business model and the generic business model. Besides, some additional business components are discovered in these two methodologies, and the most important component found through GBM is the element of 'competition'. Peters et al. (2013) illustrated that factor of competition is significantly important for the development of business model, this supports a firm to sustain competitive advantage by being at least at a similar position as its competitors.

Other than this, other authors also described the importance of this factor while discussing the concept of the business model. Zook and Allen (2011) highlighted that *"differentiation is the essence of strategy, the prime source of competitive advantage. One earns money not just by performing a valuable task but by being different from your competitors in a manner that lets you serve your core customers better and more profitably".* As a matter of fact, a firm can identify a point of difference by making a competition analysis and by identifying the current notions of competition, and new trends in the market. This analysis has partially been examined in the business model engineering approach as well as in the lean canvas model within its components of 'technologies, competencies, and key resources' and 'unfair advantage' respectively. Through this perspective, by integrating the component of “Competition analysis” within the business model canvas, the methodology can be more strategically efficient. Although the significance of technological elements in the new business model methodology is also required to be evaluated, the business model canvas cannot be extended at this stage for developing disruptive (cloud-based) business models.

As a result, it is not well rationalised if adding this only element is useful for cloud-based businesses. Furthermore, it is evident that creating comparison matrices through a systematic comparison of business model methodologies (§4.4) is a multifaceted job. This analysis would be much more complicated in the event of identifying comparison between many other business model methodologies covering a large number of business processes (perhaps for large scale businesses). Therefore, this research requires a further approach to investigate the core business logics to be used for developing cloud-based business models, where the business model canvas can be extended further.

Undoubtedly, the business model canvas is a very useful methodology and are used broadly. At the same time, it is examined that this methodology may not be very useful for businesses that require tailor-made disruptive business models, i.e., for the firms that develop high-tech solution utilising disruptive technologies. It is apparent from the above analysis of CloudSME project that some specific business analysis is created individually, outside the business model methodology. This is because the business model canvas methodology does not include a detailed competition and market analysis, which is really important for businesses like CloudSME, that adopt or offer cloud-based solutions. Besides, technological elements are subsumed in other business elements (e.g., value proposition, resources) and does not reflect the dynamism of disruptive technology and social influence on business model elements explicitly. Also, there are no analysis measures defined, to identify which external and internal capabilities are used.

Since, it is reflected from the literature that technical factors are constituted with some social factors which are someway identified through the lean canvas model such as problem solutions (focused on customers’ perspective), although the description of the model does not include an explanation of the relationship of technology and society. These technological and social factors then influence the development of the relevant business model. Therefore, to understand the dynamics of the interrelationship of business model change, technological development and sociomateriality, it is concluded to consider developing the abstract level of relationship between business model elements influenced by social and technical factors. These relationships can be developed by conducting in-depth empirical analysis. These relationship dynamics are used to develop the intended framework by adopting an ontological approach to develop a business model methodology by extending the business model ontology created by Alexander Osterwalder.

4.6 Summary

In this chapter, I analysed existing business model methodologies to evaluate the best methodology or the key business elements that can be applied in my proposed methodology to develop disruptive business models. For this evaluation, I selected the five most relevant business model development methodologies (§4.3). First, I created a SWOT analysis on these five methodologies. Then, I conducted a systematic framework to compare the business elements of all five methodologies with each other. I arranged and mapped business elements of the defined case study (§4.4.1, §4.4.2) and created 13 matrices analysing similarities and differences among the business components of those five methodologies. The comparison matrices helped me identify the requirements of two main business elements, competition analysis and market analysis, other than the vital business elements that Osterwalder included in his business model canvas. It is also evaluated that the technological factors are subsumed within other business elements of Osterwalder's business model canvas, that are required to be decomposed. Therefore, Osterwalder's business model canvas is not too effective in developing disruptive business models to address technological and other necessary external factors. Finally, the chapter concludes by defining the general business elements of the proposed framework (§4.4.2.9). It also guides in conducting further in-depth analysis (next chapter) to evaluate social, technological, and disruption-related elements for the proposed framework to create disruptive business models.

Chapter 5 An Empirical Analysis to Identifying Technological Elements to Create Dynamic Business Models

5.1 Overview

Major business model elements are identified formerly in chapter 4, where it is considered to extend the Osterwalder's 'business model ontology' (Osterwalder, 2004) explicitly customised for the organisations that commercialise disruptive technology (for this analysis, cloud computing). It is comprehended that the business model canvas is currently static and provides the same general level of analysis to arrange business models in each business use case. It is further learnt that to create an ontological framework, a high-level relationship between the business models and the socio-material (in the context of organisations and technological change) elements is required. This relationship then guides forming a new methodology to develop business models to support the adoption of solutions utilising relevant disruptive technology. The relationship between the business model and the technology is depicted evidently in the literature. Further, the interrelationship of technology and social is also highlighted in the context of technological and organisational change; however, this association is still required to be conceptualised in the business model change.

This chapter outlines the main findings of the empirical analysis, which is conducted to identify the interrelationships of socio-materiality and technological solutions in the context of the business model change. The research carries out a pattern analysis and thematic analysis through reviewing organisations' original data documented in CloudiFacturing Project. The proceeding paragraphs describe the main themes generated through this analysis. Further, it also reflects on the interdependency of sociomaterialty (in the essence of disruptive technologies) for the development of technological products and how these technological products affect the arrangement of value elements of organisations. The analysis also shows the contradictory views of end-user companies and technology companies about introducing new technological solutions, and how this affect ISVs to change their business models.

5.2 Data Analysis & Findings:

As mentioned in chapter 2 (§2.2.3.2) that the empirical analysis is carried out based on 7 application experiments (which I call seven business use cases). These seven use-cases involve 8 end-user companies (manufacturing companies) and 7 ISV companies (Independent Software Vendors) that acquire access to the CloudiFacturing platform. While ISVs receive support to develop or customise their individual technological solutions to be executable on the platform, end-user companies utilise these cloud-based solutions that are integrated into the platform. All these 15 companies are distinct in terms of their geographical location, expertise, and offerings. Although all the end-user companies have employed cloud/HPC-based solutions, they require different levels of proficiencies and requirements; thus, adopted distinct commercial solutions developed by their respective ISVs. Likewise, all ISV companies have different technical specialities and they designed unique and customised solutions addressing their corresponding end-users' requirements. In addition to these 15 (end-users and ISVs) companies, another 15 technical companies are involved in the project that contributed to supporting these use-cases' application development by providing their individual proficiencies. These companies also hold diversity in terms of capability, such as research and development, technical and advanced knowledge (experts in digital innovation), as well as resource and infrastructure providers (CloudiFacturing, 2021).

The thematic analysis is carried out on the project documents (and some from participant observations) to identify patterns through the generated codes, that are subsequently arranged, and re-arranged into key themes. The codes are generated and managed through NVivo software (Best Qualitative Data Analysis Software for Researchers, 2022), which is specifically designed for qualitative researchers to conduct a deep level of analysis of rich text-based data and/or data related to multimedia. The analysis resulted in two key themes (see Figure 5.1):

(i) End-users face challenges in their production processes yet lag in introducing new technological arrangements due to lack of knowledge of technology and lack of resources.

(ii) Organisations change their business models by collaborating with technical organisations (who have the required knowledge, expertise, and resources) for the development of personalised technological products utilising disruptive technology and making them commercially available to their end-users with easy set-ups.

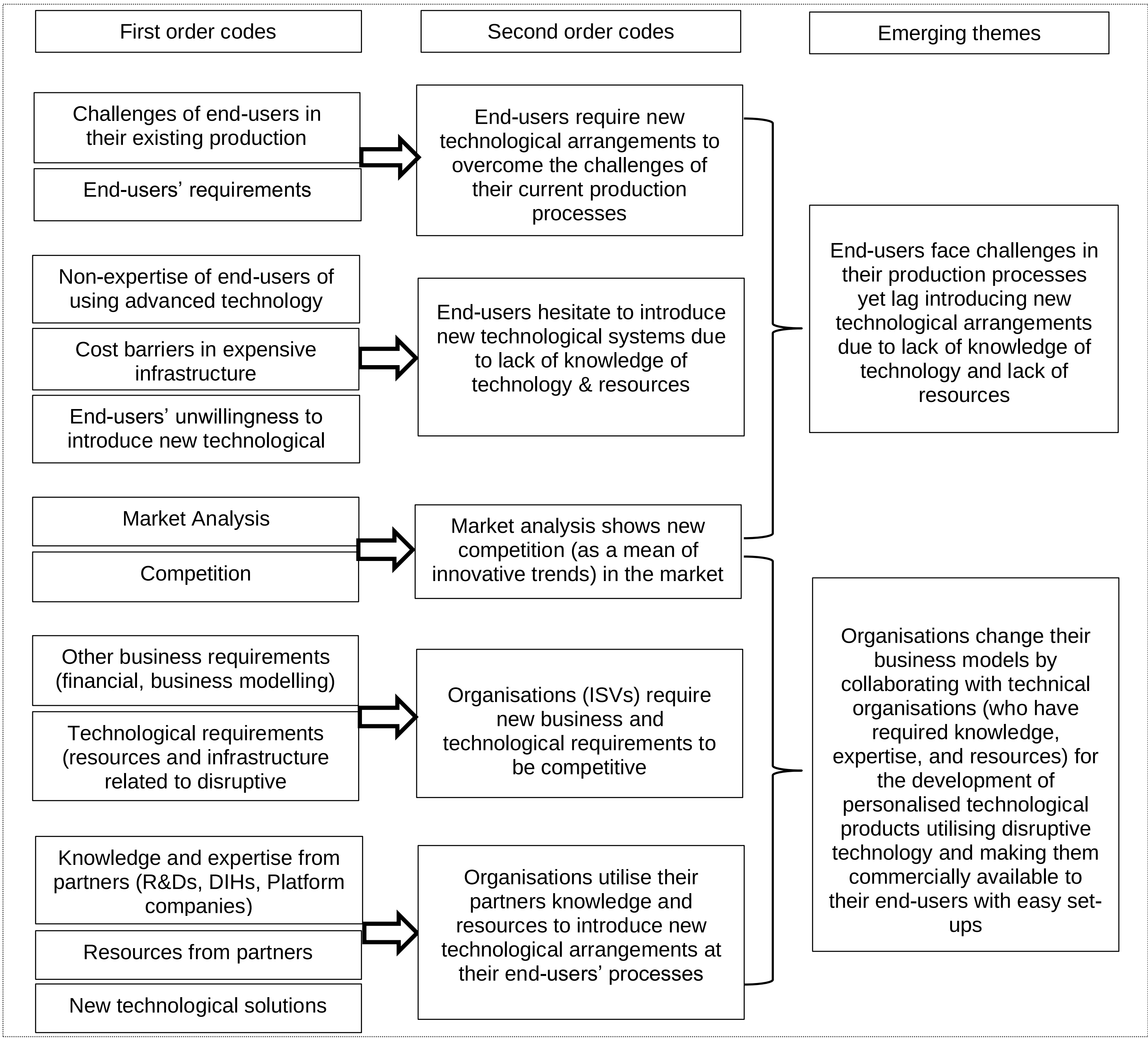


Figure 5.1 Themes showing the interrelationship among organisations, technology, and business models

As explained above and in chapter 2 (§2.2.5.2) that the thematic analysis is created by summarising data (data condensation) by generating codes and developing themes. I conducted a thematic analysis on the project documents and data collected from the participant observations (The CloudiFacturing Project). I created hundreds of qualitative codes (providing short phrases or words as a summative to a portion of collected data (§2.2.5.2) in several iterations (see Appendix A). Figure 5.1 shows the main and relevant themes created by coding the data vigilantly. First cycle codes represent repetitive codes found in the data. Second cycle codes represent patterns of information identified out of the first cycle codes. Emerging themes represent categorisation or association among found patterns of concepts. The research describes the most significant codes (theme by theme) and the relevant findings in the below paragraphs by describing themes and a few relevant codes.

5.2.1 Theme 1: End-users face challenges in their production processes yet lag in introducing new technological arrangements due to lack of knowledge of technology and lack of resources

The above theme is generated through a similar pattern identified from the seven use-cases. This analysis shows that all eight end-user companies (manufacturing companies) face certain challenges in their main business processes and they require specific technological systems to overcome those challenges. They evaluate their specific requirements of introducing technological solutions to overcome their operational challenges. Nevertheless, they hesitate to integrate those new technological solutions. Although they identify the existence of relevant technology through the competition and the market analysis, they seem uncertain in adopting the solutions utilising disruptive technology. The main reason identified for this hesitation is the lack of knowledge of technology and lack of resources. A few qualitative coding showing patterns are displayed in Appendix A, which shows how many times, a similar code (e.g., required expertise and knowledge) has been described in the text (for my case document and observation).

5.2.1.1 End-users require new technological arrangements to overcome the challenges of their current production processes

The end-user companies face challenges in their manufacturing processes and require technological solutions to resolve the challenges (CloudiFacturing, no date).

Challenges: The analysis results in identifying 8 end-users (manufacturing SMEs) that struggle to operate their current processes and require adopting new technological solutions developed by 7 ISVs with the support of other technical organisations. The end-user companies experienced *complex, costly, and time-consuming production* in their production processes. The reasons for facing these operational difficulties vary at the individual end-user company. For example, some processes are *not fully automatic* and therefore *require experienced operators* for task execution. Besides, certain complex tasks involve a *lot of wastage*, where they are *carried out manually* or *required calculation accuracy*. Some processes include *precision* (production of a unit with different shapes, sizes, colours, structures, temperature etc.), where each customer (customers of end-user companies) has different requirements and in some cases completely new requirements. Therefore, this process's dependency on human intervention requires *running several tests* to match the customer requirements, which *escalates cost and time* in the process of manufacturing. In some events, where processes require precision attribute, cause *wastage of raw material* even with a slight error, but in worse cases, it also presents *defects in the final products*. This further leads to *wastage of time and material*, *cost* of the processes, as well as leaves *adverse effects on the environment*.

Requirements: In order to automate these processes and to integrate different production requirements, the *production data must be available*, i.e., data that involves certain manufacturing scenarios. Such data also remains unavailable due to the *tasks' dependency on human experts*. The manufacturing companies require *optimisation in their processes* to overcome all these issues by adopting *technological solutions*. Nevertheless, the automation in the processes requires the *technical knowledge* of employees and a *huge investment* in introducing *new resources*. A few of the actual quotations from the use-case 2 (raw data that is coded for this analysis) are displayed below:

Manufacturer 2:

Problem statement: "VARTM is critical for products with large dimensions or complex shapes, such as catamarans. While the hand lay-up resin method is the most commonly used for catamaran production it has several drawbacks: the process lacks in repeatability and thus reliability; it is not environmentally friendly; it is a time-consuming process, and the final quality strongly relies on the skills of laminators (human beings); Health and safety issues related to the resins; Low productivity rate as it is a manual process".

"On the other hand, resin infusion has some problems as well: A high entry barrier. You need a specialized consultant and a lot of trial and error in order to gain know-how about the process. If something goes wrong, you waste the entire piece. If something goes really wrong, you may waste the entire mould. Know-how is strictly related to the specialized craftsman. If you lose them, you have to start again".

Solution requirement: "Accurate numerical models may lead to optimisation of the resin injection points/vents and will help to verify the presence of defects in the final component, thus ensuring a complete and correct mould filling. Moreover, simulating complex large-scale structures involves a very fine discretization in terms of control volume and time step to accurately represent geometry and material variations. Simulation can address all these issues, but they significantly increase the computing resources required. Such large numerical models cannot be run on in-house workstations because the computing time would be up to 15-20 days".

The above quotations reflect that Manufacturer 2 (one of the 8 end-user companies) faces problems in their day-to-day operations for different reasons and requires adopting new technological solutions to overcome the operational challenges. However, the solution requires a lot of investment in necessary resources and knowledge of using that technology. Similar patterns are found in other 7 use-cases indicating, a number of difficulties manufacturers face, that they require new technological arrangements to resolve the issues, nevertheless, the solutions require technical knowledge and a huge investment to arrange related resources. Please note that there are several other similar statements are found regarding the themes and subthemes. Including each statement is not possible due to the length restrictions.

5.2.1.2 End-users hesitate to introduce new technological systems due to the lack of knowledge of technology and resources

The end-user companies initially hesitate to exploit new technological solutions that are anticipated by ISV companies. The data (from the document as well as from the observations) reflects events of this hesitation as two main interrelated reasons (CloudiFacturing, no date):

Lack of knowledge of technology: Most end-user companies neglect or hesitate to bring a change in their organisational processes, more specifically in the way they create value for their customers. They do not realise the different potentials of technology, because they do not have the knowledge and expertise of cutting-edge technology. They perceive technology and a product of technology (technological solution) as a challenge itself. These challenges include requirements of hiring some trained technical staff that have knowledge of using projected technology as well as, arrangements to engaging training options for their existing staff, allowing them to use the new technological product. I also identified through the participant observations that most of the end-user companies do not even know “what cloud computing is and how it works.”

Lack of resources: Since end-user firms lack technical knowledge, they do not recognise the functionalities that disruptive technology offers, in this case, cloud computing. At the same time, they do not have the required infrastructure or platform (computational power, hardware, software to run cloud-based solutions etc) to consider adopting technological solutions. Therefore, they perceive that they need to invest in expensive resources before introducing the required technological product. The following excerpts from the data (document as well as observation) shows this hesitation (please note these findings are described in the form of exact data representation in the document, and resources and technologies may refer to as dynamic capabilities):

Manufacture 2:

<u>Lack of knowledge and resources</u>: “In order to use simulation of VARTM process, the main requirements of the stakeholders listed above are: 1. ICT skills (to use HPC, to run jobs, to upload and download files); 2. know-how about resin infusion

process (to set-up the boundary and operating conditions, the injection points). These are input data for the simulations; 3. know-how about material properties (porosity and permeability)".

"The main barriers to the widespread usage of VARTM at SMEs are the lack of know-how and computing resources needed to simulate the infusion process, which is particularly critical for large products in small series".

Manufacturer 6:

Lack of knowledge and resources: "The current hybrid solar panel manufacturing process at Manufacturer 6 involves several steps. The most critical one is the adhesion of the photovoltaic and heat recovery layers, which is made by means of an EVA encapsulating film…The actual process (see Figure 100) includes trial-and-error approach, which consumes a lot of time and energy, each error results in a wasted PVT module. Moreover, the environment and oven temperatures have major influence on the manufacturing process. However, considering these major complexity, Manufacturer 6 does not use any simulation tools to address these challenges".

"It would definitely be helpful if there is more information available concerning the individual components of the CloudiFacturing solution. The experiments involve users with little to no experience with cloud computing at all".

The quotations displayed above reflect the fact that despite the necessity of new technological solutions, end-user companies delayed or avoid introducing technological solutions due to one or both two reasons: lack of knowledge of technology and lack of resources.

5.2.1.3 End-users market and competition analysis

Although the end-users' market and competition analysis are not too essential (for the project perspective as well as for this research), the document includes this at a marginal level. It is evaluated from the project data (from both the document and observation) that the competition analysis resulted in mixed of scenarios regarding technological evolution. For some end-user companies, it is easy to evaluate the kind of solutions their competitors use, on the contrary, for some companies it did not confirm conclusive results because of the uncertainty in the market. Overall, the data reveals that end-users' market analysis has benefited end-users to determine the new trends of technological solutions, that are prevailing in the market. At the same time, the analysis can be useful for ISVs also to acquire new customers, as is clear from the following passages (CloudiFacturing, no date):

Manufacturer 1:

Market and competition analysis: "While this document will elaborate on the view and benefit of Manufacturer 1, the first analysis of the market is focused on ISV 1's perspective as with their developed solution. It embodies a big potential of scaling up fast in this project (this will be better argued later). The idea is to look into Manufacurer 1 competition as these companies are expected to be potential customers for ISV 1".

Manufacturer 3:

Market and competition analysis: "The companies studied make use of technologies very similar to a competitor Manufacturer, which is why they can be considered as potential customers for ISV 3".

Thus, end-users' market and competition analysis are not only effective for end-users to identify new prevailing technological solutions available in the market, but also valuable for ISVs to reach their potential customers. It is also perceived from the participant observations that overall market and competition analysis is important (including end-users') to estimate the pricing criteria and methods.

5.2.1.4 Sociomateriality, disruption, and new technological product

Theme 1 implies that both the factors of sociomaterial (social and technology) and the disruption (constantly changing external factors) influence the development of the new technological product. In other words, it reflects on the facts of end-users' challenges, requirements, and the necessity to introduce technological solutions. Although they (end-users) hesitate initially, the new market environment, competition and dynamic knowledge of research and technology organisations influence the introduction of the new technological product. Figure 5.2 shows the interdependencies of sociomateriality, and disruption-related factors for the development of the new technological product.

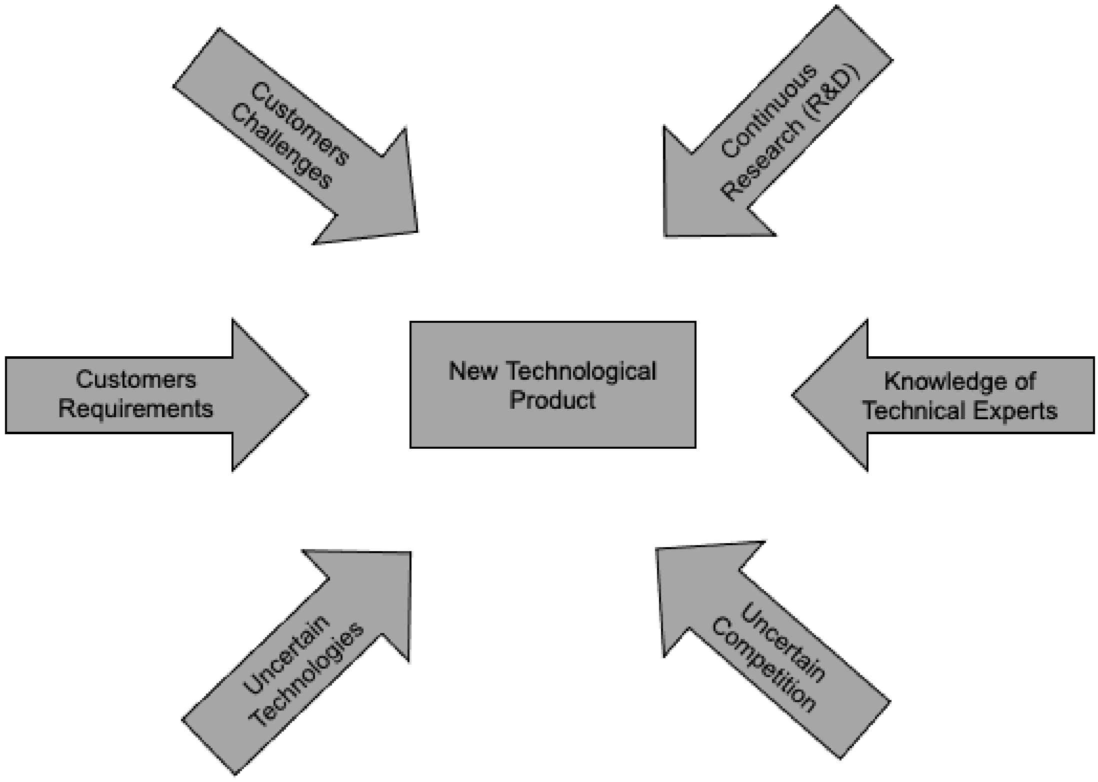


Figure 5.2 Sociomaterial & disruption factors influencing the development of new technologies

In figure 5.2, the arrow-shaped elements represent causal factors of sociomaterial (customers' requirements, challenges, technologies, R&D, knowledge of experts), and signs of disruption (uncertain technologies and uncertain competition) for the development of a new technological product (the rectangle box).

All the above causing factors are identified in all 7 use-cases of the project. As mentioned earlier, all manufacturing companies (end-users/customers) have individual requirements, as their business expertise and offerings are distinct. At the same time, they all utilise different technological solutions (such as simulation and modelling) that are optimised using cloudifacturing platform. For maintaining the Project's confidentiality, this thesis does not include project documents in the appendices. The following paragraphs show end-users' case analysis (regarding the challenges and requirements they have and possible solutions they can opt for) case by case for each end-user company.

Use-Case 1:

Manufacturer 1 is a multinational company produces customer specific electrical drive systems including motor, inverter, and other relevant components. The company manufactures products for different industrial sectors such as, textile machineries, vacuum pumps, medical equipment, ventilation, and home appliances. Currently, the construction & development, the work order plan & acquisition, and the assembly of requested prototypes may take up to 100 working days. Such a long lead time is due to several issues in manufacturing processes. For example, various processes interface in different formats, resulting in high risk of inconsistencies, difficult data management and data handover. The number of challenges articulated by manufacturer 1 are:

- The production of highly customised electrical drives provokes **long prototype production lead time.**
- With current **experience-based estimations,** electrical drives are often **less efficient** and **more expensive** than necessary.
- **Long and error-prone manufacturing activities** due to **non-collaborative design and production processes**.
- **Several processes interface** in different formats causing **high risk of inconsistencies, difficult data management.**

Since Manufacturer 1 offers customised and flexible electrical drives to their customers but their manufacturing activities are being carried out according to experience-based approximations, which leads to complex, time-consuming, expensive, and error-prone processes. To optimise this complex product and system design, Manufacturer 1 requires a functional simulation solution where multiple simulation steps can be cascaded and combined. This requires the acquisition, installation, maintenance, and application of know-how for all required software tools, including the necessary interfaces. When additional optimization is needed for these simulation chains, high and potentially distributed computational power is necessary. This requires the acquisition, installation, maintenance, and application of know-how for high-performance or distributed computing clusters. As a matter of fact, Manufacturer 1 **does not have the required technical knowledge** (of using high-power computing applications, cloud-based applications, tools, etc.)

and the necessary resources (high-performance computing, cloud infrastructure, required hardware and software for the solution, etc.) to optimise its current production processes.

Use-Case 2:

Manufacturer 2 is an esteemed shipyard specialised in building catamarans. The company offers safe, strong, and liveable catamarans within the leisure and workboats market. Currently, Manufacturer 2 uses hand lay-up as a production method which is very challenging to build complex designs & shapes and need highly experienced operators. In most cases, a boat manufactured with this process can most likely be defective. Moreover, this manual process is time-consuming, and the quality of products depends totally on the ability and experience of the laminator who crafts the resin. In a large volume of production, this turns into a lack of repeatability. A second important drawback, especially for high volume productions, is that the hand lay-up process allows styrene to be dispersed in the air, causing environmental and safety issues.

Therefore, manufacturer 2 wants to overcome these issues and improve their production processes by switching to the VARTM process (an advanced production method for building complex shapes like Catamarans). VARTM is the most effective process to produce large and complex parts. It also improves repeatability of the process, and the quality of the product. Nevertheless, if the process could not carry out correctly, VARTM could lead to significant defects in the final products, preventing the utilization of the process advantages. To avoid this situation, a trial-and-error approach is used to set the process up. These tests could also consume a lot of time, may increase overall cost with the wastage of raw materials. Despite of being the most efficient approach, the VARTM process involve following drawbacks:

- The process has a **high entry barrier**. This requires a **specialised consultant** and several **trial-and-error** tests to gain know-how about the process, thus it can be **time-consuming** and **expensive**. These tests must be performed every time geometry or lamination sequence changes which **decrease flexibility**.

- The know-how of this complex process is strictly related to a **specialised craftsman**, who estimates the behaviour of resin flow. Therefore, the process involves **risk of resin leakage**.
- An issue on resin flow during mould-filling, could lead to significant **defects in the final product**. In some cases, it may even cause a failure of the entire process with subsequent **loss of materials and time**.

Nevertheless, in VARTM process, the ability to predict the correct flow behaviour of the resin would allow the Manufacturer 2 to overcome such risks. They need to acquire a simulation solution based on a specialised numerical model that predicts the flow behaviour of resin within their production process using VARTM. On the one hand, simulation can significantly reduce the cost of getting into VARTM technology. It minimises the number of trial-and-error tests, reducing overall production cost, enhancing repeatability, flexibility, and quality. On the other hand, accurate numerical models could lead to optimisation of the resin injection points. It helps verify the presence of any defects in the final artefact and ensures the correct mould-filling. Besides, simulating complex and large-scale structures comprise a very fine discretization (in terms of controlled volume and time step) to represent geometry and material variations precisely. Therefore, simulation and modelling can address all the issues Manufacturer 2 faces, but they can significantly increase the requirements of relevant computing resources and knowledge. Additionally, large numerical models cannot be run on in-house workstations because the computing time could be much higher. As a result, the main barriers to the usage of VARTM at Manufacturer 2 **do not have know-how** (knowledge of using HPC, CFD tools and other applications needed for simulation), **and access to computing resources** (cloud/HPC tools and resources) **needed to simulate** the infusion process, which is exceptionally critical for large complex products in small series (pp 104).

Use-case 3:

Manufacturer 3 produces high precision small metal components for several sectors such as automotive, valves, hydraulic and pneumatic sectors, household appliance and white goods industries, electromechanical and electronics sectors. Such high precision manufacturing processes (turning, deburring, honing, final check 100%) are necessary to deliver high quality batch production of small metal components (e.g. electro valves used for car transmission systems). The process monitoring, and diagnoses are the key approaches for improving quality and proactively detecting abnormal behaviour.

Generally, the quality control process is conducted using a conventional threshold-based process, generating out-of-limits (OOL) alarms. It contains a defined upper and lower threshold and when parameter/setting goes beyond these limits (upper or lower), an alarm is triggered. Then the engineer inspects that out of limit parameter and identify if there is any anomaly and take actions accordingly. The maintenance processes used at Manufacturer 3 are not so efficient since they may not be able to identify the problems in the machines (such as unknown wearing process, tool breakdown, warranty period etc). The current monitoring process does not consider all available quality data, which means several process parameters remain undetermined that influence the quality of a process. Therefore, the underlying challenges Manufacturer 3 facing are:

- An improperly planned maintenance process leads to **huge downtime and costs**. Non-availability of continuous data transports **non-optimal process settings**, and results in **higher scrap rate and lower capability process-index** (with the risk of scrap rates not able to match the increasingly demanding automotive standards).
- Presently, the quality control of the components for hydraulic electro valves is conducted only on a statistical basis and **there is no real-time feedback for the adjustment of the process parameters**.
- The behaviour of the production process is not monitored. Since the **quality data is not accessible**, the behaviour of complex system cannot be modelled using traditional methods (Digital Twin based on CAD model).

To resolve these issues, Manufacturer 3 requires a solution that will offer an effective quality control and maintenance process to identify any issues with the machines or potential variations in the process. This requires deep knowledge about certain process and about the concrete usage of the machine. This knowledge can be obtained using application of Artificial Intelligence (AI) techniques. The solution should be able to predict the behaviour of a particular machine in a particular situation, such as if room temperature changes, if speed of rotation is increased. They require a solution (predictive maintenance) where they can identify when a tool wear happens, very precisely, for a specific tool on a particular machine.

This solution can help Manufacturer 3 saving a lot of time by not having to detect every individual machine. Besides, components quality can be improved if the real-time production data be collected and processes. Big data analytics enable a real-time monitoring and analysis of variances in the production process which help detecting any anomalies in the process. Using data analytics driven production process monitoring for high-dimensional and multi-variable process control, process capability can be improved, and scrap rate can be reduced. Nevertheless, Manufacturer 3 **does not have knowledge about using AI-based applications** (such as machine learning algorithms, other related software) and analytical techniques based on big data. The **data-based modelling also requires huge amount of data capacity** (thus needed cloud/HPC resources) **which Manufacturer 3 also lacks**.

Use-case 4:

This use-case involves two end-user companies (manufacturers). Both Manufacturer 4 and Manufacturer 5 requires solution to improve their production process specifically for heat-treating processes.

(i) Manufacturer 4 holds a strong position in the field of Mechanics. They as a producer of water quenching machine, are experienced in production, high precision, and project management. They are well-known manufacturer with capabilities range from the technical preparation to cutting, welding, machining, and assembling, custom weldment production, production of engineering equipment and assembly units, mining equipment, metalworking and milling. The production activities involve precision processes such as heat treatment processes of aluminium components which requires rapid and well controlled cooling to obtain the material properties and strength of thin-walled aluminium profiles. To guarantee these indicated characteristics the parameters of the heating process must be established and controlled carefully for each individual product. Manufacturer 4 face challenges in their production processes related to heat treatment of aluminium profile. Besides, they want to develop new or improve the existing designs of nozzles. Further, they want to develop new water quench machine for the following reasons:

- The settings of the water quench machine for cooling of a given profile is based on **the experience of staff** that operates it.
- This makes it very **difficult to automate this process fully** and **challenging to use** it when new profiles are being treated.
- The same also applies when designing and developing new water quenches or for improving existing ones. This very complex product is also developed based on the **past experiences of the engineers**.

Manufacturer 4 requires numerical modelling and simulation to overcome these obstacles. They particularly require CFD (Computational Fluid Dynamics) simulation of the quenching process to be able to improve the designs of nozzles and the water quench machines. To develop this CFD simulation for the water quench, a numerical model is necessary that comprises all physical processes during quenching including cooling process of aluminium profiles. Further, a heat transfer simulation is required to automatically define real-time operation conditions for cooling of a required profile. Besides, Manufacturer 4 requires all the necessary knowledge to develop the numerical models and simulations (CFD), software development and integration tasks to run and visualise these simulations using HPC resources. Nevertheless, they seem to have **no prior experience to run such simulations and no access to relevant resources.**

(ii) Manufacturer 5 has a special focus on the development, construction and production of extrusions, components, and products in aluminium. It runs the business in making aluminium extrusions, surface treatment and fabrication. Water quenching is a core part of the company's usual production process. This process is performed by cooling an aluminium profile with a mixture of air and water at constant pressure, depending on some parameters (operating conditions) such as the size, shape, and temperature of the aluminium profile. The water quenching happens just after the aluminium profile leaves the extruder and enters the water quench immediately for cooling. Since the parameters are manually defined for the quenching process, variations in the final product (especially for the new profile) are inevitable. Overall, Manufacturer 5 face underlying challenges in their production processes:

- To perform the cooling process several **“custom parameters”** must be set based on the **operator’s experience**.
- This makes it very **difficult to deliver this process completely in an automatic manner**, meaning potential **variability in the final result**.
- This happens especially when a new profile is being treated, where the current process involves a **trial-and-error approach**, potentially **wasting time, energy, and other resources**.

As similar as Manufacturer 4, Manufacturer 5 requires improving their products (aluminium components) by obtaining real-time operating conditions for their heat-treating process involved in water quenching. Since, they do not design water quench machines, they only require heat transfer simulation. However, to run heat transfer simulation, several complex tasks need to be performed such as calculation of heat transfer coefficient using empirical formula. These calculations can only be derived when the full CFD simulation is run, and its results be obtained. To run or develop a simulation of this complex system, Manufacturer 5 **requires specific knowledge, experience and all the necessary tools and resources** (specific hardware, software, more specifically HPC-based resources), which they presently **do not have.**

Use-case 5:

Manufacturer 6 has a vision to be leader in solar technology innovation and offer its pioneering solutions focused on renewable energy and energy efficiency. Company works at any stage meeting the specific demands of every single client. The main product provided by the company is ECOMESH Hybrid panels that can produce heat and electricity in a single panel. The panel consists of a transparent insulating cover (TIC) (that includes a transparent cover (glass) and an insulating gas), a poly-crystalline (pc-Si) PV module, an EVA encapsulating film, an absorber-exchanger which transforms the solar radiations into heat and transfer this to collector fluid (heat recovery unit), and a layer of insulation material at the bottom.

The manufacturing process of solar hybrid panel contains several complex steps. The most critical step is the adhesion of the photovoltaic and heat recovery layers which is carried out using EVA encapsulating films. For the lamination process the ensemble is placed in the oven tray (total six trays) and covered with a silicone blanket to keep vacuum during the process. Thereafter, a temperature ramp (heating rate) is applied to allow the EVA to melt and then cure. The ramp depends on a particular geometry, and it must be defined for each new configuration. Currently, the temperature ramp is configured based on previous tests (using a trial-and-error method). This process is time consuming, transmits wastage of energy and PV module, if it leads to any error. Overall, the production process involves the following issues:

- The environment and oven temperatures have major influence on the manufacturing process. However, their variations are not currently considered in the **manufacturing process due to the complexity** of defining a proper oven configuration.
- **Existing process does not include any simulation tools** to improve the manufacturing of its solar panels. Every time the geometry of the absorber is changed, special attention must be paid to avoid hot points that may damage the blanket or welding points of absorber.
- The temperature should be homogeneous over the oven to ensure EVA has a required functioning, however the ramp definition is made through a **trial-and-error process**, which is **time and energy-consuming**, while each **error results in a wasted PVT module**.

To optimise the process of solar panel production, Manufacturer 6 requires an efficient model to predict the performance of the oven to laminate a PVT system. They need a solution that considers transient heat transfer, complex geometry, multiple domains, multiple temporal and spatial scales and several variables. For this purpose, a solution that combines CFD simulations and optimisation algorithms are necessary. The development and execution of the solution can be very multifaceted and requires specific knowledge (of numerical models, algorithms, CFD tools and models etc.) and significant computational resources (cloud/HPC-based resources). They **do not appear to have adequate knowledge, experience and resources required for the solution**.

Use-case 6:

Manufacturer 7 deals with manufacturing special parts for the automotive industry, traffic safety and energetics. These special parts are the equipment used to provide industrial automation, energy optimisation, monitoring systems, intelligent house, products used for manufacturing preparation and post-work and other customised products and services. Manufacturer 7 found difficulty in their production processes due to lack of production data and lack of planning and monitoring system. They are not able to produce reports on processes and functions. Since there is not enough production data, they have absolutely no integration of data with the information systems. Besides, they have limited information about the manufacturing process i.e., there is no data about congestions and no analysis about how teams and shifts have been delivered. Overall, Manufacturer 7 face the following challenges in their production processes:

- Due to **Lack of manufacturing data, Lack of planning and monitoring production processes and functions,** the technicians are **not able to optimise the weekly production plan** as the actual component **cycle times are not measured**.
- Besides, the product **unit costs are high** due to the issues in the processes**,** many times **overtime needed** to avoid additional shifts, which is costly and usually not welcomed by workers.
- Manufacturer 7 **requires efficiency in their current production processes** to be competitive and receive more orders from the customers.

Manufacturer 7 requires improving their manufacturing processes to increase its competitiveness, which depends on its capacity to reduce production costs, time, and decrease production losses. They need an effective optimisation solution that can continuously control and optimise process. Access to reliable data related to manufacturing process is necessary for this optimisation. The solution should support them to analyse on-demand manufacturing scenarios, ensure production planning in advance, and verify manufacturing capacity (better forecast and faster production). Therefore, they need a customised solution based on big data analytics along with the implementation of sensors in the factory (to integrate production data) for better structured and organised production processes. For this data analytics and modelling solution, Manufacturer 7 requires resources to access data analytics toolkit (such as cloud/HPC-based applications and resources) as well as sufficient level of experience to implement and use the solution. To obtain access to relevant resources and knowledge, the company needs to make a huge investment and where **they seemed uncertain and hesitant**.

Use-case 7:

Manufacturer 8 is one of the leading manufacturers of dairy products in their country. Their production processes involve transforming raw milk into finished products such as fresh milk, cream, UHT milk, whipped cream, cheese, chocolate, and cream desserts etc. Currently, Manufacturer 7 faces a lot of problems in their fast-paced production process. The company uses a production line for filling dairy products. If any problems appear in the production line, they have a very limited timeframe to solve the problem. If problem is not resolved in that specific timeframe, they currently have two solutions. First involves manually taking packets off the line and stacking them next to the line. Second includes stopping the machine completely, where sometimes the material must be disposed of. This results in wastage of time and raw material. Generally, the problems that company addresses while using their production processes are:

- If one or more elements of the production line are out of order, the company has a **timeframe of five minutes to fix the problem** until the line must be completely stopped.
- If fixing the problem takes longer than 5 minutes, **sometimes the products must be dismissed** (depending on what is currently produced).
- The dismissal of product could compromise efficiency **(economic problem)**, **delivery delays** and in the worst-case **discharge of the raw material (waste)**.

Since the production processes at Manufacturer 8 involves manual intervention, the potential solution should be based on real-time physical simulation supporting them to extend the available timeframe needed to fix the issue occurs in the production line. That means the simulation solution should consider several manufacturing scenarios for every possible failure, supporting the machine operator to take countermeasures in case any error occurs. The development of this complex solution is possible with the use of visual modelling such as 3D modelling or CAD-based (Computer Aided Design) applications. They may also require cloud-based physical applications, cloud infrastructure, and tools. To integrate this physical-based solution and achieve the desired optimisation in the processes, Manufacturer 8 must have necessary technical knowledge about these applications and essential resources.

5.2.2 Theme 2: Organisations change their business models by collaborating with technical organisations (who have required knowledge, expertise, and resources) for the development of personalised technological products utilising disruptive technology and making them commercially available to their end-users with easy set-ups

For this empirical analysis, the organisations are referred to ISVs (however the results are not limited to ISVs but to other technological organisations too). It is comprehended in the previous section that despite having issues, end-user companies hesitate to introduce new technological arrangements in their processes due to a lack of technical knowledge and lack of resources. On the contrary, research and technology organisations, including ISVs hold contradictive views of technology. Since they renew their technical knowledge on a daily basis, by analysing new market trends and competition (as shown in figure 5.2). Due to their working customs, knowledge, and expertise, they can scan new potentials of technology through their cognitive lenses. The below sections describe the relevant sub-themes or analysed patterns related to theme 2.

5.2.2.1 Market and competition

The market and competition are briefed as end-users' viewpoints in section (§5.2.1.3). This section is presenting the market and competition analysis for ISVs. It is interpreted from the literature, document analysis, and observations that market and competition analysis are of utmost importance specially to deal with current disruptive innovation trends. The analysis becomes inevitable for technology organisations, specifically for the organisations that require to develop disruptive business models, i.e., the organisations that offer commercial high-tech solutions integrated through disruptive technologies. It is also perceived from the empirical analysis that market and competition analysis is required not only to acquire new knowledge about new technological trends but is also useful to explore new business model mechanisms and financial aspects. Besides, it is also understood that the market and competition analysis should not be limited to direct competitors, but the analysis should be aligned with other stakeholders involved (such as customers). In the following paragraphs, I outline a few statements extracted from the document and observation notes (CloudiFacturing, no date), and figures of these pattern coding can be found in Appendix A.

ISV 1:

In-direct competition: “The competitor analysis of Manufacturer 1 is of paramount importance to see how their competitors are already designing electrical drives and what other alternatives are there for ISV 1 to offer. ISV1 will gain important information as a result of this analysis about how to improve its value proposition and therefore how to position itself around the competition”.

Revenue linking with competition and market: “In order to define the interesting market segments to be targeted by ISV 1, it is first important to understand the sectors in which Manufacturer 1’s competition (thus ISV 1 potential customers) is mostly operating, which means there could be a bigger source of revenue for ISV 1. In doing so, the first step is to check the different market segments in which electrical drives can be found”.

Statement from Business Analysis Document:

Business analysis aligned with competition and market: “First of all, the complete analysis of the environment along with the trends and market will allow deriving a relevant vision and mission statement for the CFG platform. This will include the competition analysis (direct, indirect competition, different technologies, business analysis such as methods) and different trends of business models already in place by different and/or similar value propositions on the market. Most importantly, the financial planning (i.e., profit & loss) and a roadmap of the CFG platform needs to be accessed to achieve the sustainability of the business model chosen".

Drivers of innovation: DIH hubs, Competence centres (or R&D) such as Research and Technology Organisations as well as Research Institutions are specified as drivers of innovation. "Each of these partners contributed to the analysis, design and/or implementation of the individual experiments, and also to the writing of the project reports. These partners are also involved actively in all experiments, collected and specified their business and technical requirements, decided on a design, and completed their implementation using the CloudiFacturing solution".

"In each experiment, there is one or more dedicated Competence Centre, that provides the necessary technical support and expertise for the implementation. The design and implementation in each team is monitored by a dedicated DIH, whose role is to communicate and coordinate the efforts in each experiment, deal with any issues raised, and monitor the overall progress".

Observation:

To identify uncertainty and stay competitive: I got involved in an informal chat with my colleagues that were involved in the collection and representation of business requirements and business modelling. These companies are two special competence centres (in addition to the 30 companies I conducted empirical analysis on). The conversation was started regarding financial analysis (focusing mainly on generating revenue), which was carried out (during the last few weeks) to finalise the business model for digital analysis, where they specified how crucial is to conduct financial analysis in line with the competition analysis. We further discussed how the combination of disruptive technologies (e.g., cloud, AI, Big data, IoT) offers innovative technological solutions, which are also very economical, so staying sustained in terms of both technicality and economically is significant. Also, establishing new collaborations to exchange information and share competencies is highly economical. When I questioned, how they assess whom to collaborate with, and which capabilities to share, they said they know with the years of experience as well as continuous market and competition analysis."

Competition network: "This competition and market analysis helped in improving the set offerings for the end-users both in terms of performance and cost. The analysis allowed us to discover new trends of collaborations and the exchange of technical information between companies to reach innovation potential. The competence centres (research institute and R&D) and technology organisations were so convinced with the fact that some selective companies (including ISVs and other technology companies that were assessed as competition and that develop innovative unique solutions can be contacted and proposed to collaborate within the CFG project."

A strong emphasis on carrying out the routine competition and market analysis is found in this analysis. The statements on the importance of both these analyses are found 75 times within 2 documents (including a large project document for business model analysis) that are coded.

5.2.2.2 Organisations require new technological resources to optimise their offerings aligned with disruptive trends

The pattern of the requirement of technological resources is found in each use case, which also shows association with market and competition analysis. Although ISVs develop excellent simulation solutions for their respective end-users, it takes longer and requires costly in-house infrastructure (for end-users) to run those simulations. Besides, ISVs also need to stay aligned with the current market and competition trends to sustain competitiveness. As is clear from the following excerpts, to compete in dynamically changing markets, ISVs require dynamic resources and expertise related to disruptive technologies (in this case cloud and HPC-based tools, resources, and relevant knowledge to integrate the simulations on the cloud, and to organise easy set-ups for their customers) (CloudiFacturing, no date).

ISV 2

<u>Required resources for solution optimisation</u>: "ISV 2 requires implementing cloud-based and simulation tools through HPC to effectively change and improve the systems requirements and the current manufacturing process at Manufacturer 2. ISV 2 requires support to develop a cloud/HPC-based numerical model to be able to predict the flow of the resin during the production of a composite part, such as a

catamaran hull, using the VARTM process. The numerical complexity of the VARTM process simulations demands high solution power and a high capacity of memory.

ISV 4

Required resources for solution optimisation: “To offer optimised simulation solution to Manufacturer 4 and Manufacturer 5, there are two conditions to be met. The HPC resources and an effective numerical model and cloud interfaced simulation for water quenching are to be developed. This will support establishing the operating conditions of the water quenching process required by end-users. If the operating conditions are delivered by deriving guidelines (based on various parameters, such as profile shape and temperature), this requires developing a numerical model of the entire quenching process along with the CFD simulation using HPC resources. This complex.

The above evidence reflects that to remain competitive, firms require to look for competition and market trends and evaluate which steps can be taken to improve customers’ processes as well as firms’ own performance. It is important for a firm, specifically a firm that offers technological solutions to its customers, to continuously assess new requirements and ways to meet those requirements. This section provides information regarding ISVs requirements for meeting their customers’ demands as well as improving their own services to be competitive. The next section outlines the way how ISVs can meet their own requirements of accessing dynamic capabilities, and customers’ requirements at the same time.

5.2.2.3 Organisations utilise their partners' resources and knowledge to introduce new technological arrangements at their end-users

The empirical analysis shows that organisations change their business models, and collaborate with platform companies to access their services, as well as other stakeholders involved in the platform. They can easily manage their competencies requirements that need due consideration in the event of uncertain market conditions and the continuous need for arranging dynamic capabilities. The technology organisation not only can access the third-party tools, resources, and other support (e.g., knowledge, financial, marketing, and communication support from Digital innovation hubs, or competence centres) from these platform industries but they can also utilise their resources for setting-up disruptive solutions for their customers. This collaboration between organisations further opens the path for innovations, and yet saves investment for arranging in-house infrastructure and other capabilities for both organisations themselves and for their customers. The following quotes explicitly show the dynamics of interaction among organisations, technological resources, and business model change (CloudiFacturing, no date).

ISV 1 and Manufacturer 1 utilising knowledge and resources from partners

Improved business performance: "Establishing cloud-based simulation integrated through CloudiFacturing platform as a standard solution for ISV 1's current customers from the area of electrical drive design will increase the user base of the simulation cloud solution, creating both direct revenue and follow-up engineering projects for ISV 1. Additional enlargement of the model component space (where sub-models of common electrical drive components are located) into other domains will open the market also for other domains (e.g., aerospace, automotive, etc.)".

"Manufacturer 1's business performance will be significantly improved through the capacity to quickly deliver highly individualized, numerically optimized prototypes to its customers by using cloud-based simulation solution.

Busines Model: "In fact, in the case of Manufacturer 1, the main advantages may result in lead time optimisation, thus resulting in lower costs and increased customer demand, bringing a major benefit for the company. With this business model, the costs is expected to be as much as linear in respect to the forecasted revenue.

ISV 6 and Manufacturer 7 utilising knowledge and resources from partners

Improved business performance: "By developing/using cloud-based data analytics solution, both ISV6 and Manufacturer 7 were hugely benefitted. The expected overall impact on ISV 6 in the experiment, is able to explore new application areas for advanced technology in manufacturing at large attracting number of new users, in particular SMEs and mid-caps. Moreover, the experiment has allowed more innovative and competitive technology suppliers, in particular SMEs, both on the level of technology and on the level of manufacturing equipment. Another impact will be to become a more competitive European service provider through provisioning new types of services, through strengthening the presence on local markets".

"Manufacturer 7 is able to reduce manufacturing costs by reducing both unit and additional costs, minimize the production losses and the manufacturing time. Other benefits include the increase in turnover, create additional jobs and establish new contacts or business partners".

Business Model: The solution outcome is positive for ISV 6 as they achieve business model change. "A critical mass of pan European experiments that demonstrate innovative, sustainable business models covering the whole value chain is another positive impact".

It is comprehended from the above sections that to meet customer demands, and to keep aligned with the dynamic competition, the firms change their business models by collaborating with research organisations, the innovative competition networks (including DIHs and R&D). By changing the business model this way, the ongoing technological requirements can be accessed and meet.

5.2.2.4 Sociomateriality, Disruption, and New Dynamic Business Model

This section evaluated leading factors of sociomaterial and disruption i.e., volatility of technology and uncertainty in the market, ongoing customer demands, dynamic capabilities of competition networks (R&D knowledge and experience), instigate organisations to re-arrange their capabilities. Re-arranging the capabilities should be done precisely according to the changing capabilities requirements. In case, these requirements cannot be met internally, (such as in our case, ISVs developed perfect simulation solutions, but they need optimisation and access to the cloud environment), they require to arrange external competencies and collaborate with different competence centres by joining CloudiFacturing platform. By integrating their major capabilities (resources) and value network (partners and other stakeholders) for value arrangements, they fulfil their own business requirements as well as their customer's. The figure 5.3 display sociomaterial, dynamic and disruptive factors causing the business model change in an organisation.

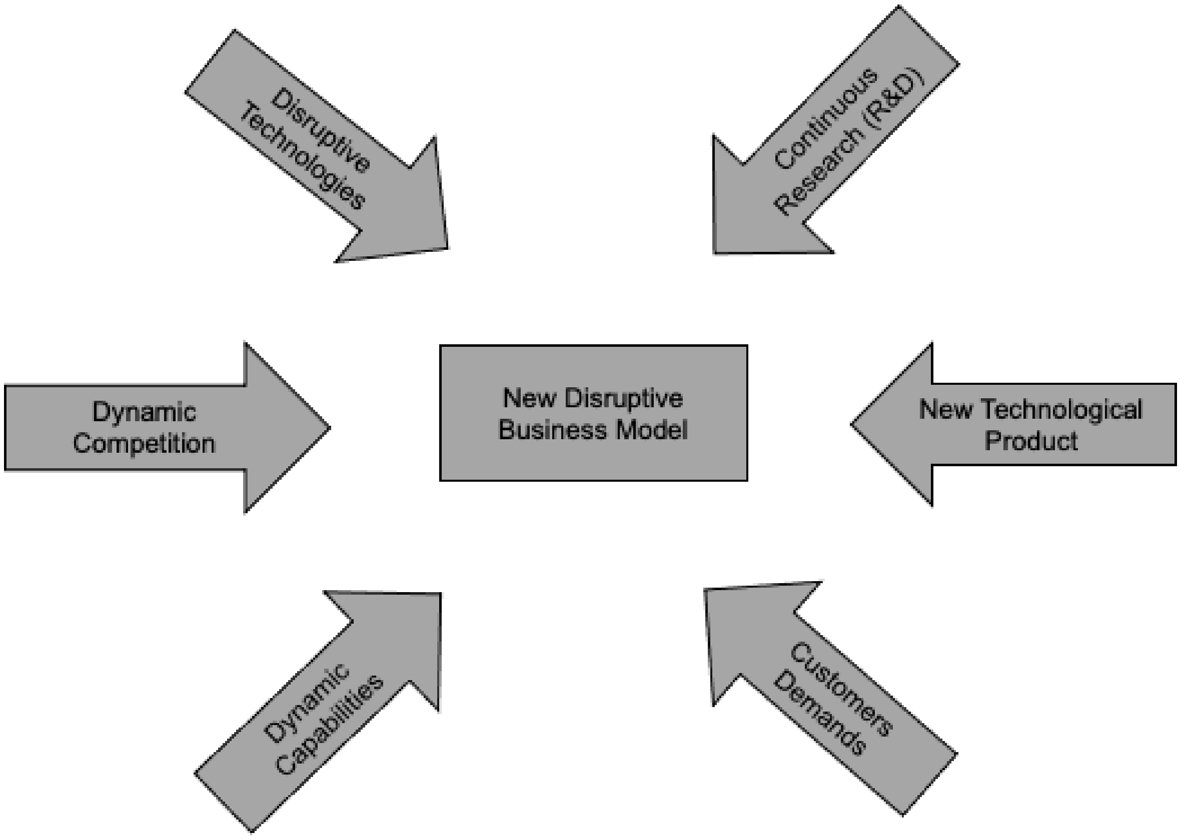


Figure 5.3 Sociomaterial & disruption factors influencing the development of new business model

In figure 5.3, the arrow-shaped elements represent influential factors of sociomaterial (customers' demands, disruptive technologies, R&D), and signs of disruption (dynamic competition, dynamic capabilities, and new technological product) prompt organisations to develop new business models (the rectangle box). This causal relationship of sociomaterial and disruption related factors are evidently found in this empirical investigation and depicted in below paragraphs. Since an individual experiment cannot be explained thoroughly, and to maintain the confidentiality of the companies, the thesis only provides central and relevant information about the companies. Just to brief, I have included a below summary displaying ISVs expertise and the solutions that require optimisation using CloudiFacturing platform (CloudiFacturing, 2021).

Use-Case 1:

ISV 1 is a research centre, who supports its customer from research and development to the introduction of series production. It offers services in simulation and modelling, control engineering, rapid prototyping, system development, absorption of vibration and sound, sensors, early detection, support and advice electrical drives and hydraulic drives. In the use-case 1, ISV 1 develops an all-in-one electrical drive design solution for orchestrating simulation and optimisation tasks using different software tools through a single interface. The solution run an automatic and continuous simulation chain on cloud, allocating data from one software tool to another, thus provide process optimisation.

Use-case 1 (or experiment 1) requires an always running interface to optimise production processes of manufacturer 1. Therefore, cloud and HPC-based tools and resources are being used. Some third-party tools are interfaced through the solution created by ISV 1, which are FEMM, Femag, LTSpice, FreeCAD, HOTINT, Python engine, Java engine. All applications are run on a Windows Server platform. Hardware configuration of the used cloud nodes required 2 cores and 4GB RAM. Apart from this, the solution required hard disk storage <2GB at each individual cloud machine. The data transfer is carried out via RTP remote protocol link.

Use-Case 2:

ISV 2 is a non-for-profit Research and Technology Organisation (RTO), who supports SME’s to speed up the commercialisation of their innovative ideas. The company’s expertise includes experimental development and technology transfer in the field of advanced materials (composites, bio-based, polymers and recycled), applied research, ICT (development of dedicated software) and product development. The company has research expertise in interdisciplinary fields of technology and business, such as material characterisation, robotics and automation, advance visual systems, development and processing of advanced materials, information system and knowledge management, product design and engineering, 3D printing, business planning and market analysis, structural monitoring, contract research and training. In the use-case 2, ISV 2 develops numerical models and implements cloud-based simulation tools through HPC, that effectively improved existing production process (from hand lay-up to VARTM) at Manufacturer 2.

Use-case 2 demands a simulation solution using HPC resources for manufacturer 2 to effectively use an advanced (VARTM) process and optimise its production process. ISV 2 developed a specialised numerical model to run this simulation. The simulation solution requires a toolbox to run CFD (computational fluid dynamics) simulations. Therefore, an OpenFOAM suite is being used, which is an open-source toolbox. Other than that, a minimum hardware configuration of 32 cores and 32GB RAM with 2 TB of available disk space is needed as each simulation require up to 50GB of storage space.

Use-Case 3:

ISV 3 is an Innovation Centre, develops cutting edge software technologies using big data, complex event processing and advance edge/mobile processing. The company provides different solutions in various sectors, such as manufacturing, transportation, healthcare and fitness. Their solutions offer new prospects to process optimisation, predictive maintenance and quality assurance releasing new business opportunities. One of the advanced solution they offer is based on industry 4.0 paradigm. This new generation big data analytics platform is effective to analyse past experiences in several real-time context to make accurate future predictions. The process execution is different for each customers according to their requirements, but mainly include patterns of data ingestion, data adaptation, data cleaning, exploratory analysis, data transformation, dimensionality reduction, machine learning, visualisation, reporting and data atlas. Use-case 3 embraces a novel approach developed by ISV 3. Such approach provides a real-time process monitoring, that is based on new methods to process cloud-based data analytics enabling an automatic derivation of models appropriate for the quality control from the past data.

Use-case 3 offers a process monitoring approach to manufacture 3 to improve their production quality using big data analytics with the help of ISV 3. This data-based modelling requires a number of software’s, Linux operating system, Python, Java, Apache Big Data Stack. The solution requires 2-16 cores with 4-40 GB RAM and up to 10 TB of available storage.

Use-Case 4:

ISV 4 is a research and development company specialised in the field of supercomputing. The aim of the company is to deliver scientifically excellent and industry-relevant research in the fields of High-Performance Computing (HPC) and embedded systems. The company is involved in the European Technology Platform for High Performance Computing (ETP4HPC), and a member of PRACE (Partnership for Advanced Computing in Europe). Although, ISV 4 is a resource provider in the CloudiFacturing project, it also acts as an ISV in the use-case 4. They develop CFD simulation of the water quenching process (simulation of heat treatment process) by deploying its expertise in using HPC for numerical modelling and simulation.

Use-case 4 aims to provide solutions of heat-treating processes to both manufacturer 4 and manufacturer 5. ISV 4 used HPC resources and provide solutions based on numerical modelling and simulation of heat-treating processes. Software used to create this solution are OpenFOAM, ESPRESO, ParaView and Linux operating system. Also, the hardware requirement included HPC cluster with minimum 20 computing nodes, 16-24 cores per node, 128GB RAM per node and 10 TB of disk space.

Use-Case 5:

ISV 5 is an engineering firm and well recognised as digital enabler, who offers its services in the field of computational fluid dynamics (CFD). The company is specialised in consulting and services based on fluid flow simulation. Their clients are mainly multinational companies in the energy and industrial sectors. They are also involved in European projects whose objective is to integrate CFD techniques for fluid simulation in small-to-medium sized companies. They aim to expand their work as digital enablers by incorporating fluid simulation techniques within SME's and contribute to their digital transformation towards Industry 4.0. ISV 5 planned a new solution based on optimisation algorithm and CFD simulation, integrated in cloud environment to improve production process at Manufacturer 6.

Use-case 5 addresses the optimisation through simulation software in producing solar panels for manufacturer 6. ISV 5 uses CFD tools and optimisation algorithms to obtain the required result of this experiment. This use-case uses HPC resources to optimise the Oven. OpenFOAM toolkit, Salome, ParaView and Linux operating system to run simulation solution. In order to carry out simulation tasks, the hardware requirement is estimated up to 24 cores, 40 GB RAM and 200GB space for temporary storage.

Use-Case 6:

ISV 6 is specialised in developing customised and intelligent applications, introducing decision support systems. They provide services to develop product like business intelligent system, customised software and analytical solutions. They also provide services in nearshore development, data quality assurance and data cleansing, data mining, data analytics and testing. ISV 6 utilised it’s data analytics toolkit to create an effective and customised cloud analytics solution. The virtual modelling is configured on the cloud architecture, that offers a continuous and controlled optimisation in the production process at Manufacturer 7.

The objective of use-case 6 is to develop a customised solution based on data analytics to optimise manufacturing process for manufacturer 7. The solution uses JaamSim open-source tool and Linux/Ubuntu operating system. Apart from these, Tomcat 8.8.29, JDK 1.8.0_161 and PostgreSQL 10.2 software components (with specified or newer version) are required. Besides, one simulation process requires approximately 500MB of data to be processed and transferred.

Use-Case 7:

ISV 7 develops innovative software solution for real time 3D material flow and robot simulation. The company offers visualisation and simulation solutions in the division of sales, virtual commissioning, mechatronic design and development. In the use-case 7, ISV 7 supports end-user to optimise their production processes by implementing a cloud-based physical simulation solution. Such solution runs on cloud platform, involves simulation models for different scenarios (e.g., simulation for production line, simulation for packaging line) based on industrialPhysics application.

Use-case 7 aims to enhance manufacturing process for manufacturer 8 by offering a cloud-based physical simulation. The solution uses 3D simulation and virtual prototyping so that the design and development of products can be accelerated. For this solution, industrialPhysicsService simulation software has been used which runs on Windows operating systems. Moreover, CQueue infrastructure (master + workers) is needed. For CQueue master node, the system of 1 core with 2600 MHz per core, 1GB RAM, Ubuntu 16.04 operating system is required. For the worker nodes, the system of 4 cores with 2600 MHz per core, 4GB RAM and a special VM-image (with pre-installed version of industrialPhysicsService) is needed. This solution uses around 300 MB of data on the cloud and about 150-200 MB of data is processed per model.

5.3 Factors affecting Business Model change

It is found during the above empirical investigation that all eight manufacturers struggle to operate their daily activities and meet their customer demands, thus requiring technological solutions to optimise their processes. Whilst the processes are not fully automatic, they require physical involvement (Manufacturer 2, Manufacturer 4, Manufacturer 5, Manufacturer 6, and Manufacturer 8) or experienced operators (Manufacturer 1, Manufacturer 2, Manufacturer 4, and Manufacturer 5) for tasks execution. Further, the process dependency on human intervention requires running several tests (Manufacturer 2, Manufacturer 4, Manufacturer 5, and Manufacturer 6) to meet the customer requirements, which escalates cost and time (generally at all eight manufacturers) in the process of manufacturing. In addition, some of these companies strive to automate their production processes due to a lack of manufacturing data/process-related data (at all manufacturing companies). Thus, the production processes run based on estimated settings in most cases (Manufacturer 1, Manufacturer 2, Manufacturer 4, Manufacturer 5, and Manufacturer 6).

Besides, certain complex process (precisely at all eight manufacturing companies) considering high precision (Manufacturer 1, Manufacturer 2, Manufacturer 4, and Manufacturer 5), various scenarios/parameters (Manufacturer 2, Manufacturer 3, Manufacturer 4, Manufacturer 5, Manufacturer 6, Manufacturer 7, and Manufacturer

8) or multiple interfaces (Manufacturer 1, Manufacturer 6) often include several steps in the process (Manufacturer 1, Manufacturer 2, Manufacturer 4, Manufacturer 5, and Manufacturer 6). Subsequently, these complex and physical tasks may involve process errors (roughly at all eight manufacturers) or variations in the final product (Manufacturer 1, Manufacturer 2, Manufacturer 4, Manufacturer 5, Manufacturer 6, and Manufacturer 8), where they carried out manually or require calculation accuracy (Manufacturer 2, Manufacturer 4, Manufacturer 5, Manufacturer 6, and Manufacturer 8). Consequently, these errors/defects lead to poor quality product/process (Manufacturer 1, Manufacturer 2, Manufacturer 3, Manufacturer 4, Manufacturer 5), wastage of material and resources (at all manufacturers), and in some cases cause production losses/process failure (Manufacturer 1, Manufacturer 2, Manufacturer 3, and Manufacturer 8).

To overcome these challenges and meet new business requirements, they need to employ new technological solutions, however, they hesitate to do so because of lack of knowledge, and lack of resources. Although from the market and competition, they do not understand the possibilities that new technology offers, and its evolutionary effects on the market until they face issues in the business operations, or fail to meet their customers' demands. Nevertheless, ISVs support the end-user companies by providing technological solutions that are customised to specifically address their needs.

Although ISVs developed optimum solutions, they also require access to major capabilities. Being technological positioned, they understand the uncertainty of technologies and find new ways of meeting their needs by conducting regular market and competition analysis. They integrate and arrange new technological competencies to meet their requirements and addressing their customers' needs at the same time. They evaluate that technological resources and tools (such as cloud-based resources), are virtually yet easily available through third-party organisations, allowing both ISVs and end-user companies to access them anywhere and at any time. Moreover, these technological solutions can be integrated into simple steps and training and consulting feature is also available through third-party as well as through ISVs themselves (for end-users), therefore end-user companies do not necessarily need to arrange a separate training facility for their staff.

Eventually, ISVs support the end-user companies by changing their business models, providing technological solutions, and meeting their needs. Besides, they support end-users by providing access to their partner's resources, tools, and knowledge to bring automation to their production processes. Each end-user utilised an individual technological solution developed by their respective ISVs, in the collaboration of different partners, where some partners offered their industrial resources, and some offered technical skills and experience. All these solutions are based on cloud/HPC technology yet involve different functionality and operations. The developed solutions not only support manufacturing companies to manage their production data but to optimise their existing production processes. This ultimately helps manufacturing industries in leveraging data (anticipating several manufacturing scenarios based on various customers' requirements (customers of end-user)). They neither need experienced operators to execute the tasks, nor do they require to run different tests, boosting the speed of their production processes, and saving overall manufacturing and investment costs.

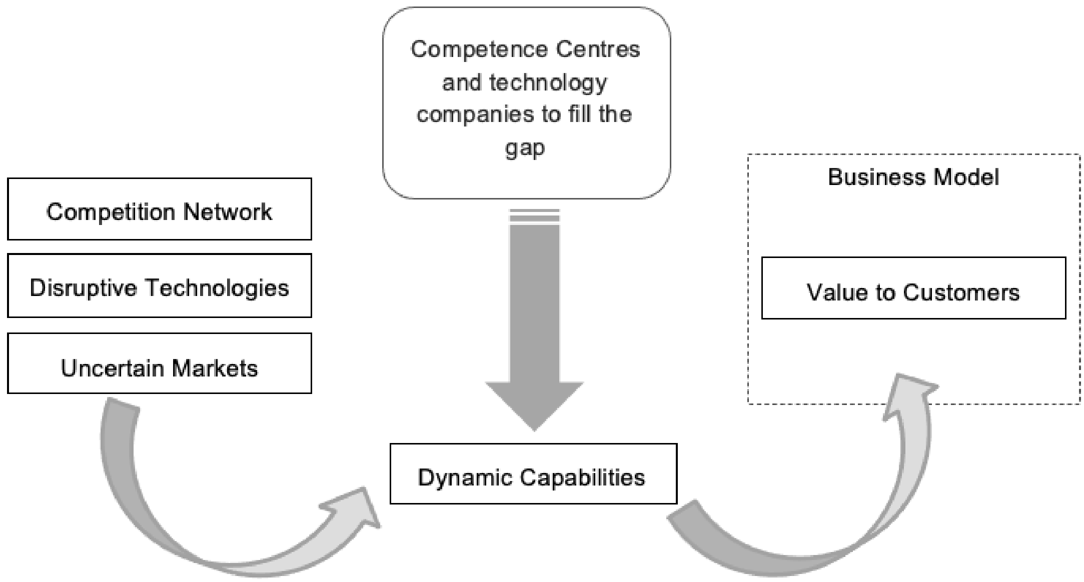


Figure 5.4 Factors contributing to business model change

Figure 5.4 highlights the main external factors (competition network, disruptive technologies, uncertain markets) that bring uncertainty in capabilities requirements (dynamic capabilities) for organisations and influence them to change their business models and collaborate with research and technology organisations to deliver value to their customers. As explained earlier that I conducted qualitative analysis by evaluating the data abductively (going back and forth from literature to data). Therefore, these findings are aligned with my initial conceptual framework (figure 3.8), which I developed by linking together the concepts of sociomateriality, disruption, disruptive technologies, and business modelling. Hence, these identified factors can be considered as technological and disruption factors for my final conceptual framework to develop disruptive business models.

5.4 Summary

This chapter conducts an empirical investigation to evaluate different factors causing technological change and, ultimately, a business model change in organisations. The chapter describes the main themes (figure 5.1) created through cycles of qualitative coding conducted on data collected from 7 use cases comprising 30 individual companies. These 30 companies provide samples of 7 Independent Software Vendors (ISVs), 8 Manufacturing companies (end-users), 5 companies that operate as Digital Innovation Hubs (DIHs), 2 Resource Providers (RPs), and 8 Competence Centres. The research findings (figures 5.2 and 5.3) show that technological factors (including social factors, i.e., sociomaterialty) and disruption-related factors influence the development of new technological systems, and new business models in an organisation. Finally, the dynamic changes (technological and disruption) instigate the requirements for dynamic capabilities in the firm, and fulfilling these capabilities, eventually, impact the firm’s business models (figure 5.4). Therefore, these results reflect a number of factors to be considered, i.e., disruption-related and technological elements for my final framework to develop disruptive business models. The next chapter introduces the final ontological framework, highlighting all the elements of business, technical, social, and disruption together to be used to develop disruptive business models.

Chapter 6 Ontological Approach to Building a Methodology to Develop Disruptive Business Models

6.1 Overview

This chapter delivers a final framework to develop disruptive business models and provides a detailed description of each element introducing technological elements as an extension to Osterwalder's Business Model Ontology. It is explained in the previous chapters that disruptive technologies do not create innovations or disruptions themselves instead, they are fast-paced, volatile, and emerging technologies that offer several new opportunities (Manyika, 2017). These technologies are socially constructed, i.e., shaped by human action, that too is used for social welfare. Organisations such as R&D and technical experts (those that offer high-end solutions, such as ISVs but not limited to these organisations), use their knowledge and expertise to continuously work on these technologies, shape them, and develop innovative technological products/ services or improve existing ones. This constant process of technological development creates a threat of disruption for other organisations in terms of uncertainty in the market and the competition (Bower and Christensen, 1995; Danneels, 2004; Ekekwe and Islam, 2012; Manyika et al., 2013; Christensen, Raynor and McDonald, 2015; Manyika, 2017; Disruptive Technology: Definition, Pros vs. Cons and Examples, 2021).

Besides, organisational change is inevitable in the event of any technological change (Golson, 1977), which also affects an organisation's business model. Although the effect size depends on the nature of the organisation and type of technology, this research focuses on the intents of ISVs (technical experts) while developing innovative technological solutions for their end-users (that are mainly manufacturing companies). Further, this study suggests a novel methodology to develop business models, that I call the 'Dynamic Business Model' (chapter 7) for

ISVs and similar technical organisations. The research findings show a number of factors indicating *‘signs of disruptions’* and influencing ISVs for the development of new technological products, i.e., “disruptive innovation”, and “nature of competition”. These factors then impose them to change their business models and, meet their own requirements of *‘dynamic capability’* by collaborating with organisations that provide dynamic tools & resources as well as knowledge & expertise; leveraging disruptive technologies (in this study cloud and HPC bases tools and resources) and I call it “disruptive technology management”. This building block is useful to assess and access the possible technical support in terms of technological infrastructure, technical knowledge and experts’ network that eventually allow organisations to create value for customers by providing “improved performance”. This research extends Osterwalder’s Business Model Ontology based on the above-mentioned elements and offers a suitable methodology by combining the elements of disruption, disruptive technologies, and business models.

6.2 Outline of Business Model Ontology

Business model canvas is briefly discussed in the literature which is derived through Business Model Ontology (BMO) developed by Osterwalder’s in his doctoral research project . This section provides an overview of BMO and how it relates to my research. I have conducted a systematic comparison in five business model development methodologies including Business Model Canvas (BMC). Business Model Canvas was created by Osterwalder after a few years, he created business model ontology. For the systematic comparison (chapter 4), I used real business elements from a successfully completed CloudSME project. The original business analysis of the project (documented in the CloudSME project’s documents) was conducted through BMC. Although I identified some similarities and differences among these five methodologies, the comparison did not provide business model elements considering utilisation of disruptive technology. Nevertheless, it gave deep insight to other elements of business model methodologies, specifically BMC. BMC is one of the popular choice of entrepreneurs because of its simplicity and flexibility but it provides a static view of business model where technological elements are subsumed with other business model elements. Besides, the view of technology is merged into the firm's infrastructure management. This methodology is not applicable for firms, specifically early start-ups, who offers technological solutions (ISVs) employing disruptive technologies. Therefore, I proposed a framework (as well as business model methodology) which provides a technological side of the analysis within the business model concept. For this, I have extended the Osterwalder's Business Model Ontology by introducing technological aspects along with the relevant business aspects providing a dynamic view of the business analysis. Figure 1 shows the business model ontology developed by Osterwalder.

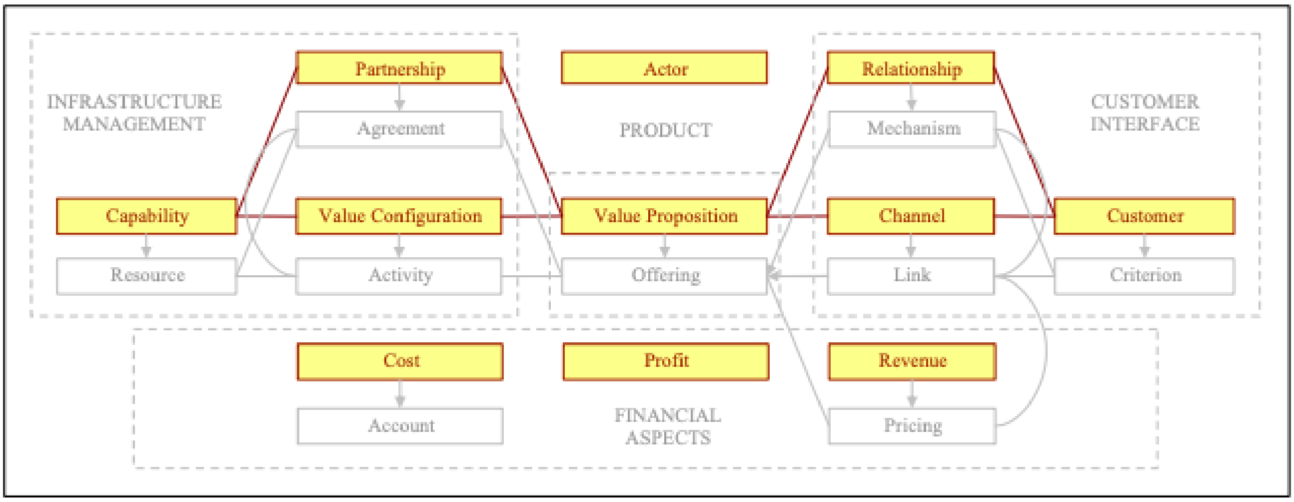


Figure 6.1 Business Model Ontology (Osterwalder, 2004)

6.3 Ontological Framework for Developing Disruptive Business Models

The most sited definition of ontology presented by Gruber (1993) is: *"An ontology is an explicit specification of a conceptualization. The term is borrowed from philosophy, where an Ontology is a systematic account of Existence. For AI systems, what "exists" is that, which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program represents knowledge."*

Where explicit means that all concepts of the domain must be defined, conceptualisation refers to as an abstract model or framework (a domain, its relevant concepts and relations). He further described ontology as, *"In the context of computer and information sciences, an ontology defines a set of representational primitives to model a domain of knowledge. The representational primitives are classes (or sets), attributes (or properties), and relationships (or relations among class members)"* Gruber (1993). Besides, the most common method to develop ontology is to use existing ontology. It is important to re-use of existing knowledge for example if a large ontology development is needed, to represent different perspective, covering different domains (Noy & McGuinness 2001).

In this research context, I adopt the concept of ontology which can be refer to as an ontological framework. Ontological framework represents a new business model ontology which is reconceptualised from Osterwalder's Business Model Ontology. I have revised his ontological structure by adding the pillars of 'Signs of Disruption' and 'Disruptive Technology Management', as well as I removed a pillar of Infrastructure Management. Osterwalder's ontology considered infrastructure management as the array of IT infrastructure, that is for connecting the different parts of the firm and linking to customers, suppliers, and partners. I also modified a pillar of Customer Interface, which is represented as 'Value Network'. Figure 6.2 shows the main pillars of extended business model ontology (Ontological Framework for Developing Disruptive Business Model).

The ontological framework not only includes business elements but technical elements and their relationship with each other. The aim of building this framework is to demonstrate the causal relationship of technological factors and business factors, which is required to be synchronised in business model development methodology, specifically for organisations that continuously serve their customers with the offerings of new technological development based on disruptive technologies.

Please note (in figure 6.2), all the green coloured boxes reflect the new business model elements (directed through my research findings) and the yellow coloured boxes represent the original business model elements suggested by Osterwalder. Besides, all the white coloured boxes represent the sub-elements of its related boxes with either an “isA” relationship or a “setOf” relationship or both. These relationships are explained thoroughly in the proceeding paragraphs. Since I am extending Osterwalder’s business model, I follow his approach of defining each business model element that provides description, reasoning in the form of tables, graphical representation, and textual explanation (with use-case examples and where possible I describe through the related literature).

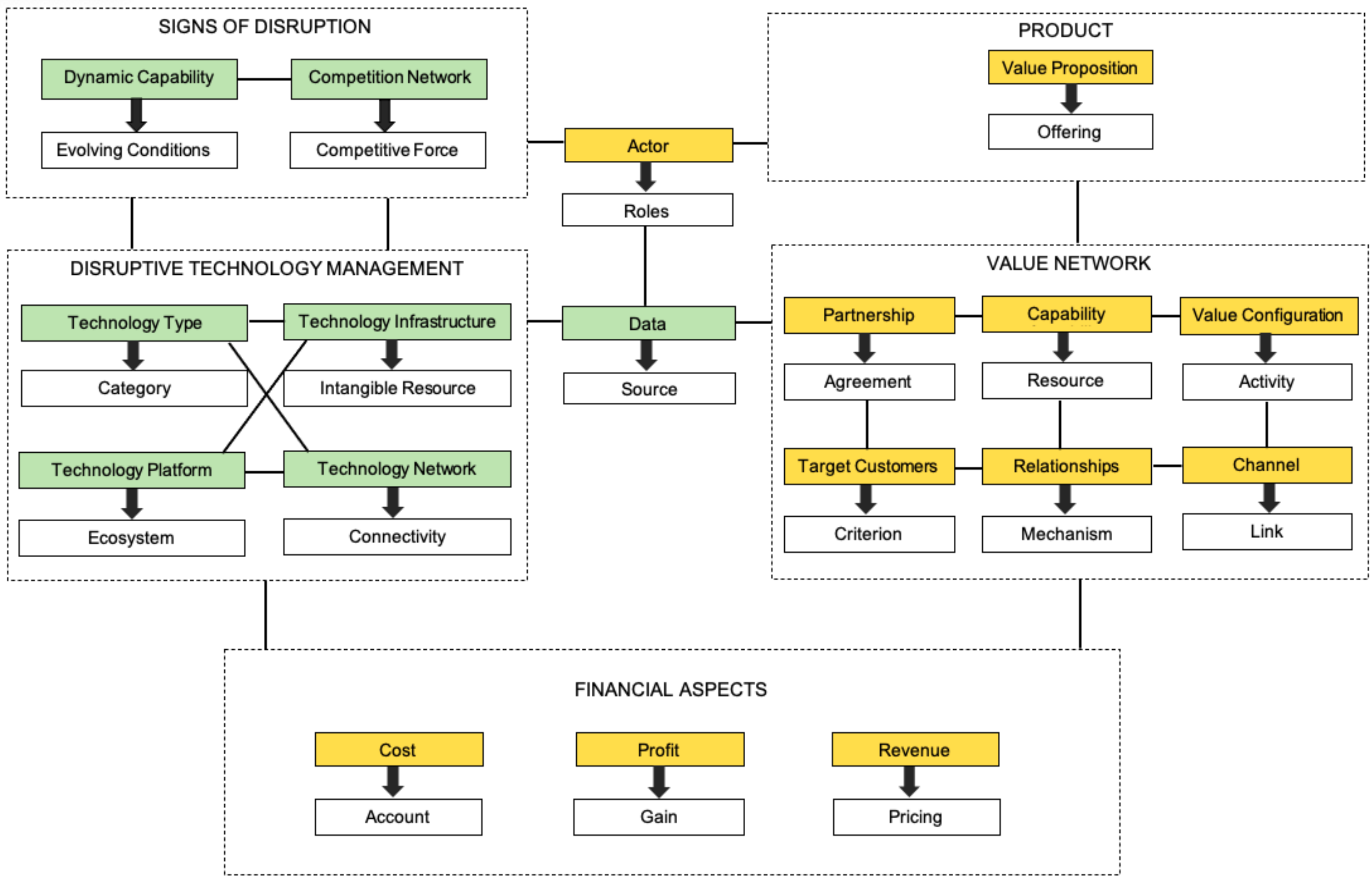


Figure 6.2 Ontological Framework for Developing Disruptive Business Models

Following Osterwalder's structure, I discuss each pillar of business ontology individually showing the relationship of one element to another, including elements outside that specific pillar. Parallel to his approach, I explain each element with the help of a table (Table 6.1 as an illustration), that describes the characteristics of the specific element.

Business Model Element	**Name of the element**
Definition	It gives the brief description of the business model element.
Part of	It signifies from which pillar of the ontology the element belongs to or of which element it exists as a sub-element.
Set of	It reflects to which sub-element an element can be decomposed into.
Related to	It indicates from which other element of the ontology an element is related to.
Cardinality	It limits the number of occurrences of the element or sub-element inside the ontology.
Attributes	It lists the number of attributes of the element or sub-element. The allowed values of an attribute are specified in '*italics'* between accolades {e.g., Value1, Value2}. Their occurrences are indicated in brackets (e.g., 1-n). Each element or sub-element has two typical attributes which are '*Name*' and '*Description*' that contain a chain of characters {xxxx}.
References	This presents all related references (if any) for the business element.

Table 6.1 Illustration table of business model element
(Osterwalder, 2004)

Likewise, in the graphical illustration (Figure 3), elements and sub-elements outlined with thick borders signify the points of detailed discussion in that section. Further figure 3 depicts an isA relationship and a setOf relationship between Element 1 and its Sub-element. An isA relationship denotes that the element can be decomposed into the finer level of granularity. Whilst a setOf relationship shows the relationship of inheritance between Element 1 and its Sub-element (Osterwalder, 2004).

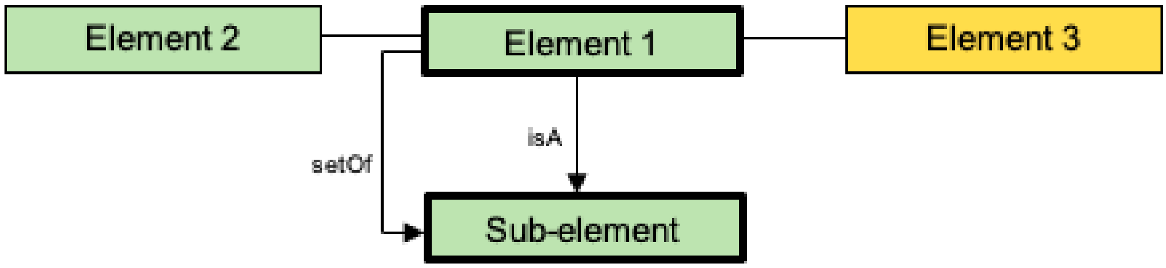


Figure 6.3 Graphical illustration of an element of the ontology (Osterwalder, 2004)

6.3.1 SIGNS OF DISRUPTION

SIGNS OF DISRUPTION is the first pillar of my ontological framework. This pillar is crucial to evaluate if a firm requires to change its business model to a disruptive business model. The typical reason for firms to fail in the event of facing disruption is they sense disruption as a threat and start overreacting and committing possible mistakes in resource allocation (Gilbert and Bower, 2002) or taking time to respond (Woodson, 2015). Disruption occurs in every organisation at some point, especially presently when technologies are dynamic; however, it can be seized as an opportunity (Gilbert and Bower, 2002; Christensen, Raynor and McDonald, 2015), by preparing to respond as soon as the signs of disruption occur. Signs of disruption can be measured by two important characteristics of disruption, ‘dynamic capabilities’ and ‘competition network’ and are explained below showing their association with other business model elements.

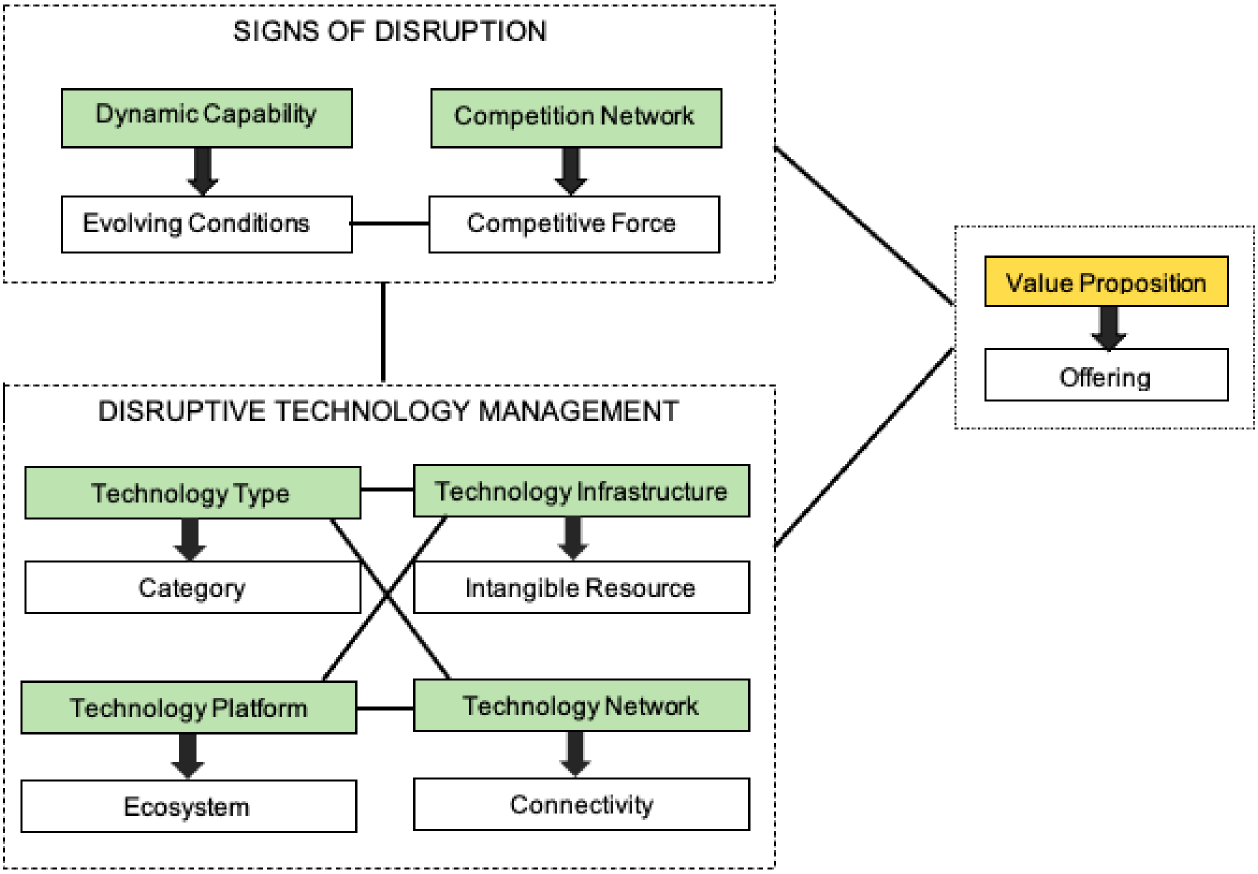


Figure 6.4 Signs of Disruption

6.3.1.1 Dynamic Capabilities

Dynamic capability is a condition of introducing new technologies, resources, skills, knowledge, or other competencies as a reaction to evolving markets (Edwards, 2014; Teece, 2018). Dynamic capabilities are constantly evolving competencies that support an organisation in sensing, seizing, and shaping through market or competition change (Teece, 2007; Baden-Fuller and Teece, 2020). In this ontology, 'Dynamic Capability refers to the requirement for dynamic capabilities to be arranged to endure the disruption. These dynamic capabilities may depend on the customers' demand, competition network, or ongoing issues with current competencies and technologies in practice.

Business Model Element	Dynamic Capability
Definition	An element of 'Dynamic Capability' represents ongoing changing requirements of new competencies that may or may not affect 'Value Proposition' now but will create challenges at some point in future. It is, therefore, necessary to arrange these capabilities as soon as they are recognised. This element is linked to each and all elements of 'Disruptive Technology Management'; but most importantly to seize the opportunity, it must determine the 'Technology Type' and organise related competencies.
Part of	SIGNS OF DISRUPTION
Inherits from	'Evolving Condition'
Set of	'Evolving Condition' (0-n)
Related to	A 'Dynamic Capability' provides awareness of the requirement of change of 'Technology Type' (0-n), 'Technology Infrastructure', 'Technology Platform' (0-n) and Technology Network (0-n). A 'Dynamic Capability' establish the reconfiguration of the 'Value Network' that enables 'Actor' (1-n) to perform certain activities to create value. A 'Dynamic Capability influences the creation of a specific 'Value Proposition' (1-n).
Cardinality	0-n
Attributes	Inherited from the 'Evolving Condition' element (§6.3.1.2).

Table 6.2 Dynamic Capability

Presently when both the technologies and the business create uncertainty. Disruptive technology provides different choices in terms of its utilisation requirements (e.g., cloud technology offers SaaS, PaaS, IaaS etc.). Similarly, organisation also offers its customers a choice of employing customised products to be competitive. These choices demand firm's ability to adapt to continuous change in resources, infrastructure, know-how and other related skills. By introducing dynamic capabilities (through the disruptive technology management pillar), an organisation is able to address its issues related to a sudden change in competencies, or threats of disruption and re-configure its value network to deliver value to its customers. Figure 6.5 describes how dynamic capabilities re-arrange value drivers in the value creation process.

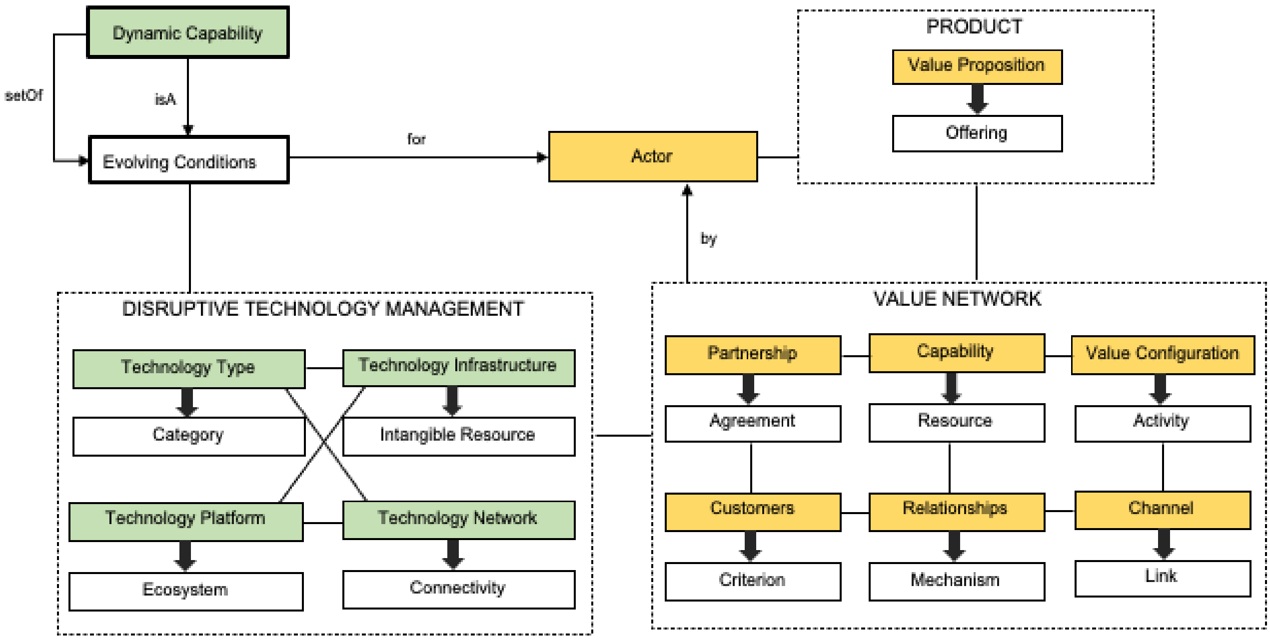


Figure 6.5 Dynamic Capability and Evolving Conditions

6.3.1.2 Evolving Condition

An element of 'Evolving Condition' belongs to the element 'Dynamic Capability'. In a fast-paced technological era, a dynamic capability is a conditional (uncertain) requirement of evolving methods, advanced knowledge, skills, tools, resources, and access to the disruptive technology itself to conduct value creation activities. These conditions include customers' demands, the firm's performance, cost-related conditions etc., (Teece, Pisano and Shuen, 1997; Pervan, Curak and Pavic Kramaric, 2017). In some cases, these conditions can be filled through using internal capabilities, and in some events, these conditions are necessary to be filled by out-source capabilities required competencies and capabilities along with the internal competencies (in some cases) through alliances (Danneels, 2011). These alliances can be according to the firm's requirements, for instance, if a technological competence is needed that can be filled with *"second-order R&D competence"* (Danneels, 2011) to explore new technologies.

Business Model Element	Evolving Condition
Definition	The 'Evolving Condition' is part of 'Dynamic Capability' and depicts a condition or requirement of necessary competencies to deal with the evolving environments and to create 'Value Proposition'.
Element of	'Dynamic Capability' (0-n).
Related to	'Evolving Conditions' can be for 'Actors' (0-n) to access through 'Disruptive Technology Management' and create a new 'Value Network' with new competencies to achieve 'Value Proposition' (1-n) and deliver value to customer.
Cardinality	0-n
Attributes	*Name* {xxxx} *Description* {xxxx} *Function* {Sensing, Seizing, Maintaining} *Measure* {Integrating, Learning, Reconfiguring}
References	(Teece, Pisano and Shuen, 1997; Rehman and Saeed, 2015; Teece, 2022)

Table 6.3 Evolving Condition

Function:

The function attribute enables a firm to recognise its functional requirements and capabilities in reaction to the changing environment (e.g., technological change) to perform ultimate tasks (activities performed by one or more actors to create value for customers) that may lead to the competitive developments and firm's greatest success (Teece, 2007; Wang and Ahmed, 2007; Pervan, Curak and Pavic Kramaric, 2017).

{Sensing}

This represents the ability to "*sense and shape opportunities and threats"* (Teece, 2007), that means searching, creating, learning, and communicating activities (Pervan, Curak and Pavic Kramaric, 2017) in response to market and technological change. These processes include analysing customers' needs, suppliers and competitors, technological shifts, new regulations, processes that require technological development or deployment (Helfat et al., 2007; Ambrosini and Bowman, 2009).

{Seizing}

Seizing involves addressing the sensed opportunities and threats of change (Teece, 2007). In other words, the sensed factors are the processes that need to be reconfigured by reinforcing the arrangement of dynamic capabilities (Helfat et al., 2007). Firms must have the ability to act on these opportunities and threats (Ambrosini and Bowman, 2009) which depends on their knowledge and skills. They must have the capacity *"to seize them by reconfiguring both tangible and intangible assets to meet new challenges"* (Helfat et al., 2007, pp 25).

{Maintaining}

When a firm is able to analyse and reconfigure its dynamic capabilities they need to be protected, enhanced and combined to maintain competitiveness (Teece, Pisano and Shuen, 1997; Teece, 2007, 2022). In this process of maintenance, the firms may need to change their business processes, business models, functions of products, and effective integration of technology. Besides, firms not only require unique capabilities that are difficult to copy, but they need to be able to adapt to changing market conditions and emerging technological opportunities (Teece, 2007).

Measure:

This attribute provides an insight into the factors affecting the firm's performance and competitive advantage based on the key processes. Dynamic capability should be measured with the varying levels of dynamism in the external environment. That means measure allows to address both, the rapidly changing environment, as well as the moderately changing environment (Ambrosini and Bowman, 2009), to accordingly restore the firm's resources and other competence, leading the firm to long-term success (Pervan, Curak and Pavic Kramaric, 2017). (Teece, Pisano and Shuen, 1997) describe three concepts to measure the levels of capabilities: integration (static level), learning (dynamic level), and reconfiguration (transformational level).

{Integrating}

Integrating is a concept to efficiently manage the integration and coordination of activities to create value. In order to obtain a competitive advantage, the firm must be able to identify which activities are to be integrated internally to arrange them in building new competencies, as well as externally (Teece, Pisano and Shuen, 1997; Teece, 2007; Rehman and Saeed, 2015; Lin et al., 2020; Wang and Photchanachan, 2021) (in case of changing environment and uncertainty in technology). In this case, an effective strategic choice is to make alliances with technology and research organisations.

{Learning}

(Teece, Pisano and Shuen, 1997) explained that learning is another important process of dynamic capability. The learning process is a social and collective effort, as well as a joint contribution to learning complex problems. It is repeated patterns and experimentation activities in routines, while routines are patterns of interactions that find effective solutions to respective problems. Learning has different features, it involves individual, organisational, and experiential skills. While some skills can be honed by imitation, alliances and partnerships are necessary for building new organisation learning (Teece, Pisano and Shuen, 1997; Teece, 2007, 2022; Lin et al., 2020).

{Reconfiguring}

In the event of constantly changing markets and technologies, there is a need for regular ability to sense the corresponding reconfiguring and transforming capabilities linking both firm's internal and external structure (Teece, Pisano and Shuen, 1997; Teece, 2007). This continuous process of sensing and reconfiguring new matching abilities that contribute to a firm's long-term success and competitiveness. Since the renewal of capability is costly, firms often scan and form new partnerships for integrating internal and external capabilities; as well as transforming the firm's asset structure to remain ahead of competition (Teece, Pisano and Shuen, 1997; Teece, 2007, 2014, 2022; Hunt and Madhavaram, 2020).

6.3.1.3 Competition Network

In the age of disruption, it is so important for an organisation to analyse which new technologies and new trends to follow to remain competitive. This can be done through anticipating market change, understanding the drivers of innovation (Dotsika and Watkins, 2017), making use of internal ventures and establishing external alliances (Paap and Katz, 2004). I refer competition network as a network of firms that may fall under indirect or potential competition as an effect of disruption and disruptive technologies and market change. The threat of disruption depends on the pace of technological shift (Adner and Zemsky, 2005); likewise, a threat of a new competition wave arises through the continuous attempts of creating innovations or improving existing products. In this situation, competition turns out to be dynamic and uncertain. According to (Dynamic Competition and Endogenous Entry, 2007), the competition becomes dynamic when disruptive technology creates uncertainty, customers' preferences change continuously, and innovators like R&D work constantly to find new ways of refining social welfare and economic gain. In this process of developing innovation, the more uncertain the environment is, the more uncertain the outcome (Callander and Matouschek, 2022), and the competition. The related elements of 'Competion Network' are displayed in fig 6.6.

Business Model Element	Competition Network
Definition	The elementary 'Competition Network' represents an angle of new or developing industries or organisations that offer innovative products/services, and can be potential competition, threat, or ally. It is important to timely assess these organisations and develop vital competence to stay competitive. A 'Competition Network' provides new ways of creating 'Value Proposition' or a completely new one.
Part of	SIGNS OF DISRUPTION
Inherits from	'Competitive Force' (0-n)
Set of	'Competitive Force' (0-n)
Related to	'Competition Network' is associated with 'Dynamic Capability' (0-n), that can be accessed through 'Disruptive Technology Management'. It may or may not create a new 'Value Network' with new competencies to improve or innovate 'Value Proposition' (1-n).
Cardinality	0-n
Attributes	Inherits from the element 'Competitive Force' §6.3.1.4

Table 6.4 Competition Network

The element 'Competition Network' represents a network of dynamic competition which relates to new markets or new trends of technological innovations, business models or disruptive technologies that are developing and changing constantly. By evaluating these new trends of innovation, an organisation may be able to identify sets of competencies required to improve or create a new 'Value Proposition'. These competencies may only be required shaping to create new activities for deriving value. The competition network may indicate introducing new dynamic capabilities in response to the disruption (see table 6.4). In case external capabilities are needed, the organisation may access these through 'Disruptive Technology Management', depending on the individual assessment.

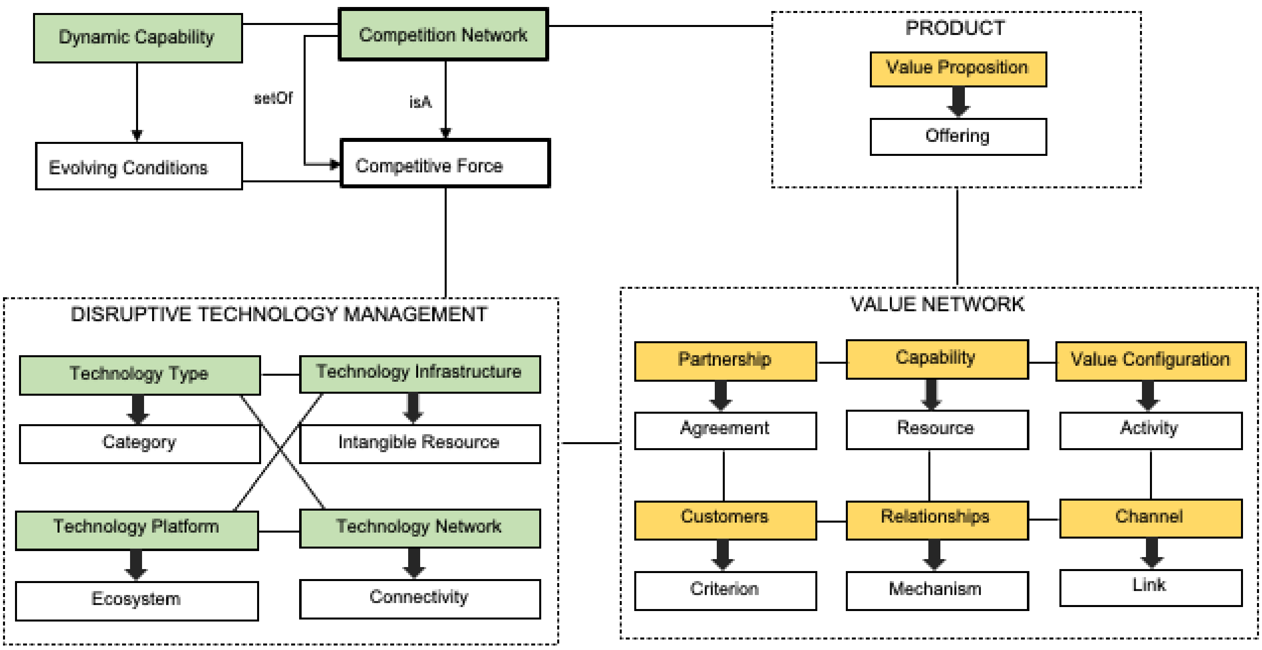


Figure 6.6 Competition Network and Competitive Force

6.3.1.4 Competitive Force

'Competitive Force' is an element displaying external forces that influence new technological innovations, that further build new unknown competition network. The further arise condition to the use of dynamic capabilities. 'Competitive Force' is an element that is decomposed from the element of 'Competition Network', that is there to assess the uncertain and continuous changing external environment. These need to be addressed to better forecast the business model elements of disruptive business models (Dynamic Competition and Endogenous Entry, 2007).

Business Model Element	Competitive Force
Definition	The 'Competive Force' is part of 'Competition Network' and depicts environment uncertainty and accordingly needing competencies to deal with the evolving environments and to create 'Value Proposition'.
Element of	'Competition Network' (0-n).
Related to	'Competitive can directly associated with 'Dynamic Capability' (0-n) to access through 'Disruptive Technology Management' and create new 'Value Network' (0-n) with new competencies to achieve 'Value Proposition' (1-n) and deliver value to customer.
Cardinality	0-n
Attributes	*Name* {xxxx} *Description* {xxxx} *Uncertainty* {Demand, Technology Trends, Competition}

Table 6.5 Competitive Force

Uncertainty

Uncertainty refers to a state being uncertain in a situation. In this research context, it refers to uncertainty in business through changing external environments, those environments can also affect the internal environment and affect a firm's business model (Adner and Zemsky, 2005; Callander and Matouschek, 2022).

{Demand}

The first attribute that reflects an uncertain environment, is demand. This demand can be from customers, employees, or the organisation itself (Porter, 1999). Since disruptive technologies are volatile and competence centres such as R&D, platform companies, and other technology organisations interact with technology, continuously develop new technological artefacts for improvements (CloudiFacturing, no date; da Silva, Oliveira and de Moraes, 2016). This continuous technology development influence social factors such as volatile customers preferences, attract new entrants, rapid market change to cause disruption.

{Technology Trend}

The attribute ‘Technology Trend’ signifies the current affairs of technology use. Firms need to evaluate these new trends regularly, specifically if firm offers value of technological product. It is not only important for these technology firms to stay up to date with new technological development, but how to arrange capabilities to at least balance the current market trend. The concept introduced by (Porter, 2008) is perfectly applied here. Technology firms (especially R&D specific) exploit technologies to make substitutes of prevailing technological systems. Thus, technology trends if evaluated well may help firms to arrange new capabilities to position itself with those trends.

{Competition}

Assessing current ‘Competition’ is the most important factor for a business model change (Adner and Zemsky, 2005; Callander and Matouschek, 2022). This attribute not only refer to rivalry in technology or offering, but competition of innovative business models. For example; Uber taxi started digital taxi booking, connected the disruptive technology with new business model effectively aligned with external capabilities and having no direct investment of taxis (Earn Money by Driving or Get a Ride Now | Uber United Kingdom, no date), Deliveroo borrowed the concept and arrange their capabilities to start digital food ordering without having to invest in chefs, caterers or restaurants, other than building partnerships (Deliveroo - Takeaway Food Delivery from Local Restaurants & Shops, no date). Although Uber then added another model of Uber Eats and competitively challenged Deliveroo.

6.3.2 DISRUPTIVE TECHNOLOGY MANAGEMENT

An organisation that considers developing a disruptive business model first requires assessing and arranging all the technological aspects of the business model and positioning itself to create desired value for its customers. Therefore, in my ontological representation, the second pillar, i.e., DISRUPTIVE TECHNOLOGY MANAGEMENT supports firms to analyse all necessary technological resources and competence they require.

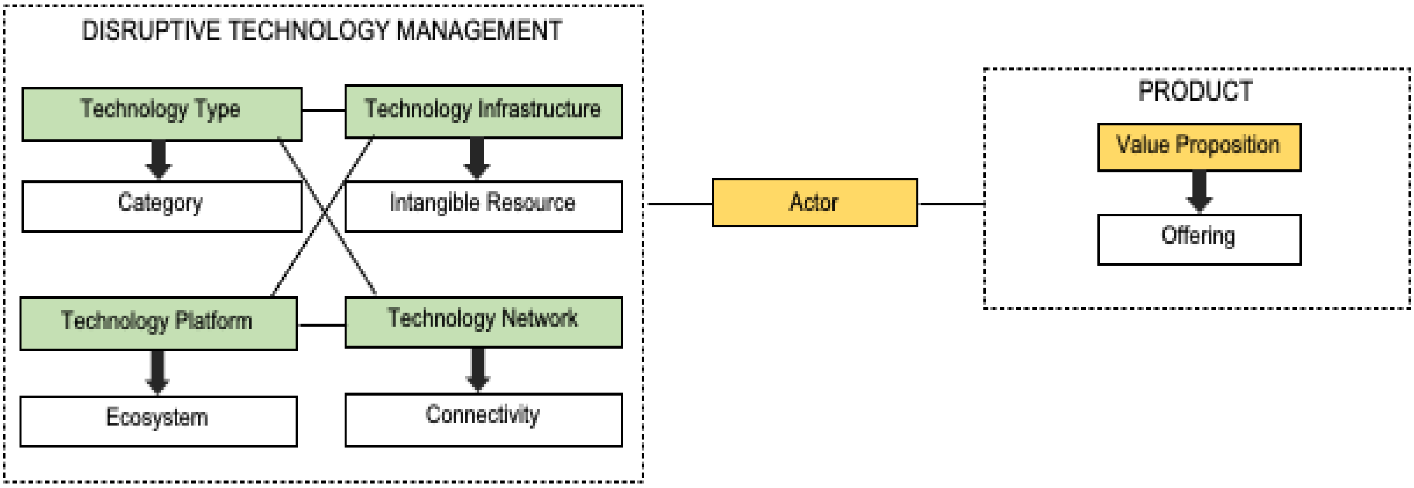


Figure 6.7 Disruptive Technology Management

DISRUPTIVE TECHNOLOGY MANAGEMENT is an important pillar of this business model ontology which represents the technological analysis within the business model concept. This pillar allows organisations to define and plan specific technology/technologies to be used to develop a particular technological product as their value proposition. This pillar also outlines the ways to access that technology and all other related resources needed for the development process. Disruptive technology management provides organisations with an insight to arrange external infrastructure (from partners) in case in-house infrastructure is not adequate or unavailable. In addition to the powerful computing capacities, current technologies require strong expertise which can also be arranged through the partners. I described all individual business model elements and their relationships of the relevant elements (or sub-elements) with each other by breaking down the business elements into parts.

6.3.2.1 Technology Type

Various authors provide view of technological product as an interaction of technology and knowledge. Essentially, technology is a product of bringing knowledge into the practical use (Weick 1990; Orlikowski, 1992). Besides, (Kim and Magee, 2017) explained that the "technological evolution is typically shaped by problem solving activity which integrates knowledge from the same and/or different technology areas, leveraging the cumulative character of knowledge". Undoubtedly, technology is used to continuously improving the ways of getting things done in our daily lives, irrespective of any domains or settings. Nevertheless, the specific technological improvements are resulted through the use of particular branch of knowledge within the specific area of business. In other words, technology has been used and managed differently for different business sectors, hence divided in different categories.

Business Model Element	Technology Type
Definition	A 'Technology Type' represents the specific type of technology that the company works on to develop its 'Value Proposition'. It is necessary to assess the technology in specific 'Category' (categories). This element also relates to the 'Technology Infrastructure', 'Technology Platform' and 'Technology Network' that company requires to create value. This may also be part of 'Capability' where the necessary resources and know-how is required for the process of creating Value.
Part of	DISRUPTIVE TECHNOLOGY MANAGEMENT
Inherits from	'Category'
Set of	'Category' (categories) (1-n)
Related to	A 'Technology Type' provides insight into the requirement of 'Technology Infrastructure' (0-n), 'Technology Platform' (0-n) and Technology Network (0-n). A 'Technology Type' specifies the necessary 'Capability' (1-n) to perform an activity performed by an 'Actor' (1-n), needed to create value. A 'Technology Type' influences the creation of a specific 'Value Proposition' (1-n).
Cardinality	1-n
Attributes	Inherited from the 'Category' element (§6.3.2.2).

Table 6.6 Technology Type

A 'Technology Type' is a part of DISRUPTIVE TECHNOLOGY MANAGEMENT. 'Technology Type' is a set of a 'Category'/Categories of technologies that allows organisations to solve specific business problems within the specific business domain. 'Technology Type' element is related to elements of 'Technology Infrastructure', 'Capability' (knowledge or other resources) and 'Value Proposition'.

A ‘Technology Type’ outlines all the necessary ‘Technology Infrastructure’ and ‘Knowledge’ required to create its ‘Value Proposition’.

Table 6.6 and Figure 6.8 represent how ‘Technology Type’ relates to ‘Value Proposition’. A ‘Technology Type’ element of the business model represents a certain type of technology that a company works on to develop its ‘Value Proposition’. Due to globalisation and new technology drives, it is difficult for businesses to sustain (or establish as a start-up) position in the market (Walton and Pyper, 2019). Therefore, organisations that sell the technological product as the main value to their target customers, typically offer customised products, especially if the offering is related to disruptive technology-based technological products. For this type of organisations, the customer base is usually itself a business that requires technological products for their day-to-day operations. These companies (technical experts) typically require identifying the problem area and apprehending the customer’s business requirements to provide the relevant technological solution. Besides, each customer (in terms of business) is different, and the type of technology, resources, tools, and techniques needed for technological development, completely vary within each ‘Category’. It is therefore important for an organisation to firstly access the particular type of technology, to understand what kind of ‘Technological Infrastructure’ and ‘Knowledge’ (expertise) are needed to create its ‘Value Proposition’.

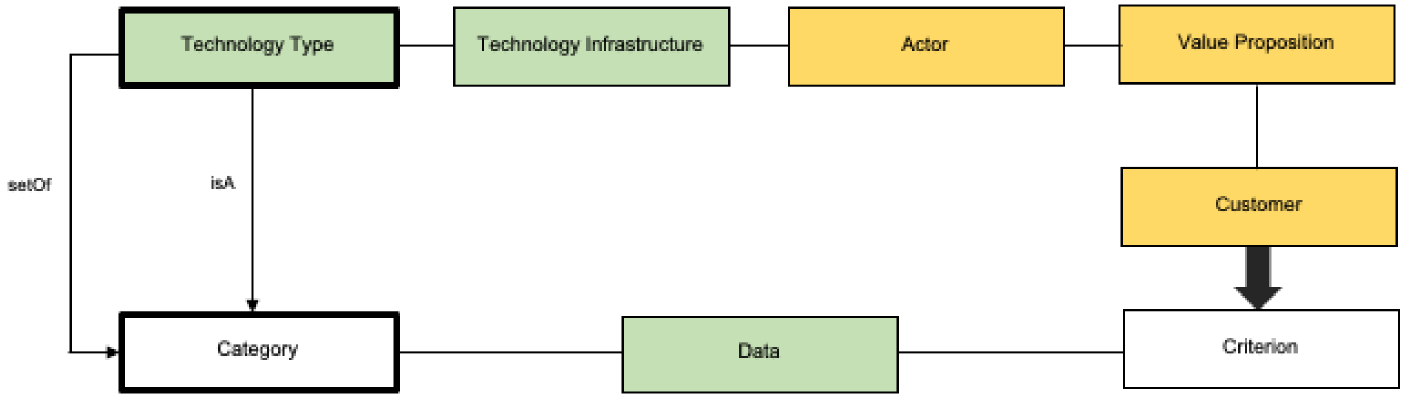


Figure 6.8 Technology Type and Category

6.3.2.2 Category

A 'Technology Type' element is being inherited from the element 'Category' (table 6.7). An element 'Category' depicts a typology of technology. This means, the 'Category' allows an organisation to set a specific typology of technology to create value corresponding to the customer's business and technological requirements. Besides, a 'Category' is linked to an element 'Criterion' of 'Customer' through the element 'Source' of 'Data'. Since there is a relation between 'Category' and 'Criterion', the typology of technology is arranged according to the customer segment and its domain of business. As explained above, there is a diversity in intentions of developing technological product that vary according to the different business sectors. Therefore, technology can be categorised for different business sectors and their needs, for instance; electrical technology (e.g., circuitry appliances), mechanical technology (construction and production machinery), communication technology (network tools), Energy technology (wind turbines, solar panels etc.). It is also significant to categorise the technology in order to use appropriate methods and techniques (knowledge) required for the product development (value) process.

Business Model Element	**Category**
Definition	An elementary 'Category' is part of 'Technology Type' and depicts a specific type of technology required to create 'Value Proposition'. Since 'Category' element may be derived through 'Source' of element 'Data', it may also be related to 'Criterion' of element 'Customer'.
Element of	'Technology Type' (1-n).
Related to	'Category' can be designated through the 'Source' (0-n) which is established from 'Criterion' (0-n).
Cardinality	1-n
Attributes	*Name* {xxxx} *Description* {xxxx} *Reasoning* {Purpose, Evaluation}
References	(Grant, 1991)

Table 6.7 Category

Reasoning

This attribute provides reasoning on selecting type of technology to be used to create ‘Value Proposition’. In the product development process, the first and foremost task for an organisation is to state its “identity” and “purpose”, which precisely defines its target customers and the way to serve their needs (Grant, 1991). An elementary ‘Category’ is an important element for the value creation process because it precisely outlines the area of technological development. In present times, technology provides a wide range of opportunities in terms of creating innovative product/service developments. A ‘Category’ helps organisations to narrow this scope for a certain ‘Technology Type’ to arrange a specific ‘Technology Infrastructure’ and precise ‘Knowledge’ required for the development of a specific technological product/service.

{Purpose}

The purpose of product development describes the kind of value to be offered to the customer. Currently, customers play an essential role in the development of new products. Organisations collaborate with customers in different ways to understand their requirements. This collaboration results in generating customer related data. The data can be in the form of product related requirements, their operational challenges, some innovative ideas (from feedback) etc., which gives organisations a purpose to develop new products.

{Evaluation}

Above paragraph describes how ‘Purpose’ defines the area of a product development. Once the purpose is clear, it derives towards the evaluation of appropriate ‘Category’ and ‘Technology Type’. In this section, Evaluation is a direction of analysing an appropriate choice of technology that is required for the process of developing value for the customers.

6.3.2.3 Technology Infrastructure

‘Technology infrastructure’ is a second element of DISRUPTIVE TECHNOLOGY MANAGEMENT pillar. In the business model ontology Osterwalder, 2004., defines *“Infrastructure Management”* as the way how the organisation delivers value to their customers. I describe ‘Technology Infrastructure’ as an assessment of all the necessary technological resources required in the process of value creation. In the last sections (§6.3.2.1 and §6.3.2.2), I explained about businesses turning towards more narrowly defined products due to dynamism in technology and diversity in the business sectors. The technological dynamics influences the development of dynamic infrastructure. Therefore, parallel to the volatility of technology, the assessment of resources must also be created for each specific product (Walton and Pyper, 2019)

Business Model Element	Technology Infrastructure
Definition	A ‘Technology Infrastructure’ refers to as the arrangement of necessary ‘Resource’ (resources) required for a value creation process. These set of ‘Resource’/resources indicates the key resources needed to generate value. The analysis of required resources allows organisations to assess if they have access to the relevant resources or they require external help. In case the organisation has access to the relevant resources, they identify further if they have relevant knowledge (skills and expertise) to create ‘Value Proposition’.
Part of	DISRUPTIVE TECHNOLOGY MANAGEMENT
Inherits from	‘Resource’
Set of	‘Resource’ (Resources) (0-n)
Related to	‘Technology Type’ (1-n) outlines the needed ‘Technology Infrastructure’. The ‘Technology Infrastructure’ element may indicate the use of specific ‘Technology Platform’ (0-n), ‘Technology Network’ (0-n), and ‘Dynamic Capability’ (0-n). A right ‘Technology Infrastructure’ brings the right ‘Value Proposition’ (1-n).
Cardinality	0-n
Attributes	Inherited from the ‘Resource’ element (§6.3.2.4).
References	(Walton and Pyper, 2019)

Table 6.8 Technology Infrastructure

An element ‘Technology Infrastructure’ is part of DISRUPTIVE TECHNOLOGY MANAGEMENT. Due to uncertainty in the technological requirements (specifically in case of utilisation of disruptive technology), it is not always possible for organisations to invest on discrete infrastructure. Therefore, organisations collaborate with different partners and utilise the shared infrastructure. This requires a process of building new partnership or new investment at each time there is a need of new orchestration of new resources. Thus, the organisation requires to assess all essential resources needed for the value creation, once the ‘Technology Type’ and ‘Category’ is obtained. ‘Technology Infrastructure’ is inherited from ‘Resource’. The ‘Technology Infrastructure’ element also depicts the relevant ‘Capability’, ‘Technology Platform’, ‘Technology Network’ needed for the value creation process. Table 6.8, and Figure 6.9 show main related elements of ‘Technology Infrastructure’.

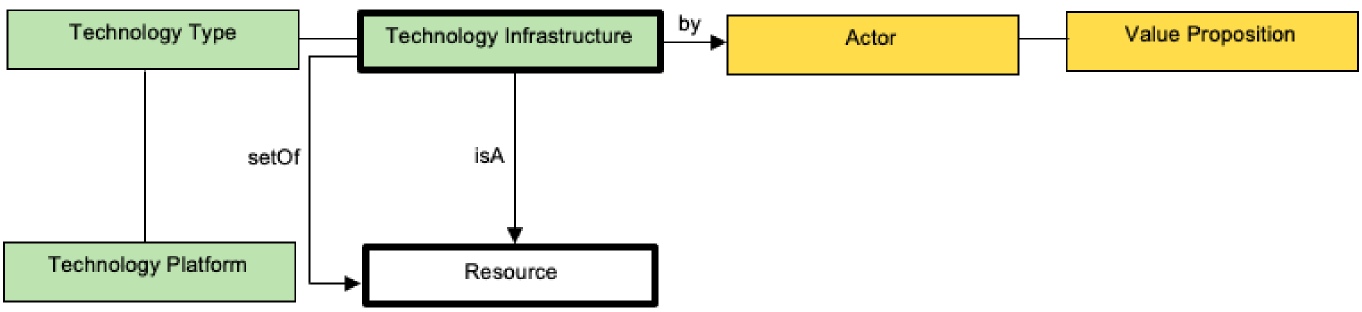


Figure 6.9 Technology Infrastructure and Resource

6.3.2.4 Resource

“Resources are inputs into the production process – they are the basic units of analysis” (Grant 1991, pp. 118). Organisations generally require any physical, non-physical, and human-based resources for the value creation process. Since present businesses have become more customer-focused where customers’ preferences are constantly changing, the solutions they offer vary from one case to another. Consequently, this variation also appears while configuring relevant resources for the possible solutions (proposed value to customer). This means that for each

specific product requirement (of customer), the set of necessary resources may differ, since the development process may be different for individual cases.

A product development process requires to arrange all material-based resources, financial resources, time, energy, human-based skills, and knowledge. In the context of element 'Technology Infrastructure', an element 'Resource' indicates the necessary technological-based resources required for the development of the technological product. Once these resources are settled, then the organisation can combine these 'Resource'/resources (i.e., technological-based resources) with relevant knowledge and competency of 'Capability' or required 'Dynamic Capability' to perform productive 'Activity' and produce desired 'Value Proposition'.

Business Model Element	**Resource**
Definition	This element presents an insight to all the necessary technological-based resources, tools, and other key resources, which may be combined with relevant 'Knowledge', and 'Capability' of 'Core Competency' element of VALUE NETWORK, to perform some 'Activity'/activities and generate 'Value Proposition'.
Element of	'Technology Infrastructure' (0-n).
Related to	'Resource' is generally provided by an 'Actor' (1-n). 'Resource' co-ordinate with relevant 'Actor' (1-n) and 'Capability' (0-n) to perform certain 'Activity' (1-n) and create 'Value Proposition' (1-n).
Cardinality	0-n
Attributes	*Name* {xxxx} *Description* {xxxx} *Resource Type* {Software system, Hardware system, Platform System, Workflow system}
References	(Grant, 1991) (Osterwalder, 2004)

Table 6.9 Resource

Resource Type

Since resources are the foundation of product development process, the development of technological product requires identifying all necessary technological-based resources first, and then arrange their coordination with other vital resources. This is specifically necessary when the customers' preferences are uncertain, there is a need of dynamic and flexible resources (Grant, 1991). The 'Resource' element of 'Technology Infrastructure', therefore, allow organisations to assess technological resources required for the value development process. *Resource Type* attribute gives the significant types of technological-based resources required for the value creation.

{Software system}

A software is a sequence of instructions, programs, routines, and data which instruct a computer system to execute certain tasks. The software system is an intercommunicating system of different software performing different functions. A software system generally includes a combination of the operating system, application program, utility software, middleware, device drivers and others (Reussner et al., 2019). Although these software functions differently, they result in useful outcomes while arranging to perform certain tasks. There is a number of different operating systems, application programs and other software available which are dynamically being updated for various reasons (changes in technology, hardware, storage, and data) (Reussner et al., 2019). Besides, the usage of this software also varies according to the user requirements. It is significant for organisations to arrange right software systems to create right value for customers.

{Hardware system}

A hardware is responsible to accomplish each task following the set of instructions given by the software system (e.g., operating system). Hardware is a combination of all physical components (such as hard disk drive, RAM, power supply unit, processor etc.) and network systems (e.g., internet) required for the task execution. Each application or software has different hardware requirements to run smoothly and may require additional hardware systems, such as electric components etc., (Reussner et al., 2019). Therefore, organisations need to analyse specific hardware requirements and co-ordinate with the necessary software system requirements.

{Platform system}

The platform consists of a combination of hardware and software components such as operating systems, libraries and certain software components arranged for the specific business and product-related requirements. A software system requires a specific platform (e.g., hardware, web browser, programming interface, operating system) to run. Platform systems provide an environment specified in terms of processes, requirements, and functionality for a software system (Reussner et al., 2019). These requirements may differ from one software system to another. Thus, the organisations require to organise specific platform systems with respect to the requirement specifications for each software system.

{Workflow system}

Workflow is a series of interconnected tasks (Georgakopoulos et al., 1995) included in a business process. It mainly involves the interaction of integrated data between different software systems and humans (Frye, 1994). Workflow systems allow organisations in automating and fast implementation of business tasks. Today organisations, their business processes and usage of technological resources need constant evolution due to the volatility of technology (e.g., disruptive technology). Likewise, organisations require to update (or introduce new) their workflow systems parallel to any changes that occur in the current technology and relevant system resources (Georgakopoulos et al., 1995).

6.3.2.5 Technology Platform

In the extended business model ontology, the element ‘Technology Platform’ refers to as one or more platform-based companies that offer several products/services related to different software, hardware, network and bring various technological applications, systems, tools with integration and extension capabilities together in a single platform. Platform-based companies offer on-demand services to technical experts or vendors and usually do not interact with the customers directly. “A digital business technology platform provides the architecture to allow software engineers to build initial capabilities and add to them over time as business needs and technology change" (de Crescenzio, Bagassi and Starita, 2021). Amazon Web Service, Uber, Microsoft Azure are very popular examples of platform-based companies, that offer on-demand products and services based on new and/or disruptive technologies. These technologies typically are expensive and difficult to manage in-house, thus organisations usually choose to request services (such as technological resources) from platform companies as and when needed.

My research findings (from qualitative research) show that the technology platforms provide a basic environment to organisations to develop and run different software applications, use different resources without worrying about the technology that supports them. While analysing 'Technology Infrastructure', an organisation can identify the number of resources they require for the product development process (creating value). The assessment also shows if the required resources and relevant know-how can be arranged in-house or through partners. Due to the volatility in resources, there is no assurance that all the arrangements of required resources are always made through the partners. Besides, organisations simply cannot invest in all required technological resources across the range of products they develop. Thus, it is critical for an organisation to identify if a technology platform can be used for the product development process, specifically if the product development requires the utilisation of disruptive technology. In this case, using a technology platform can save a lot of time and money for the business (Abdelkafi et al., 2019).

Although 'Technology platforms' are available for a long time, the recent shift of using disruptive technologies like cloud technologies have increased its usage (Abdelkafi et al., 2019; Walton and Pyper, 2019). Technologies like cloud computing, artificial intelligence, data analytics require powerful computing and resources. Further, these technologies have great potential and may create uncertainty while being used and managed in different ways. Therefore, organisations like ISV 1 usually consume on-demand products/services based on disruptive technologies from the companies that offer 'Technology Platform' without making huge investments and worrying about technology maintenance.

Business Model Element	Technology Platform
Definition	An element ‘Technology Platform’ implies as platform-based companies (also known as third-party to customers) that offer products/service based on utilisation of new and/or disruptive technologies.
Element of	DISRUPTIVE TECHNOLOGY MANAGEMENT
Inherits from	‘Ecosystem’
Related to	The element ‘Technology Platform’ may be used after the evaluation of ‘Technology Type’ (1-n). ‘Technology Platform’ may provide the necessary ‘Technology Infrastructure’ (0-n). ‘Technology Platform’ may provide the required ‘Resource’/resources (0-n) which can then be combined with ‘Dynamic Capability’ (0-n), ‘Capability’ to create Value Proposition (1-n).
Cardinality	0-n
Attributes	Inherited from ‘Ecosystem’ (0-n) (§6.3.2.6)
References	(Walton and Pyper, 2019) (Gartner, 2021)

Table 6.10 Technology Platform

An element ‘Technology Platform’ is part of DISRUPTIVE TECHNOLOGY MANAGEMENT and is being inherited from the element ‘Ecosystem’. The analysis of ‘Technology Type’ provides an insight into the related ‘Technology Infrastructure’ requirement. Further, a comprehensive analysis of ‘Technology Infrastructure’ outlines if there is a need of any ‘Technology Platform’ for the access of specific (or all) resources. Subsequently, the access to ‘Technology Platform’ allows usage of relevant ‘Technology Infrastructure’ in terms of associated technological resources (‘Resource’). The access to desired technological resources and the coordination of related ‘Dynamic Capability’ and ‘Capability’ lead to generating ‘Value Proposition’ for the ‘Customers’.

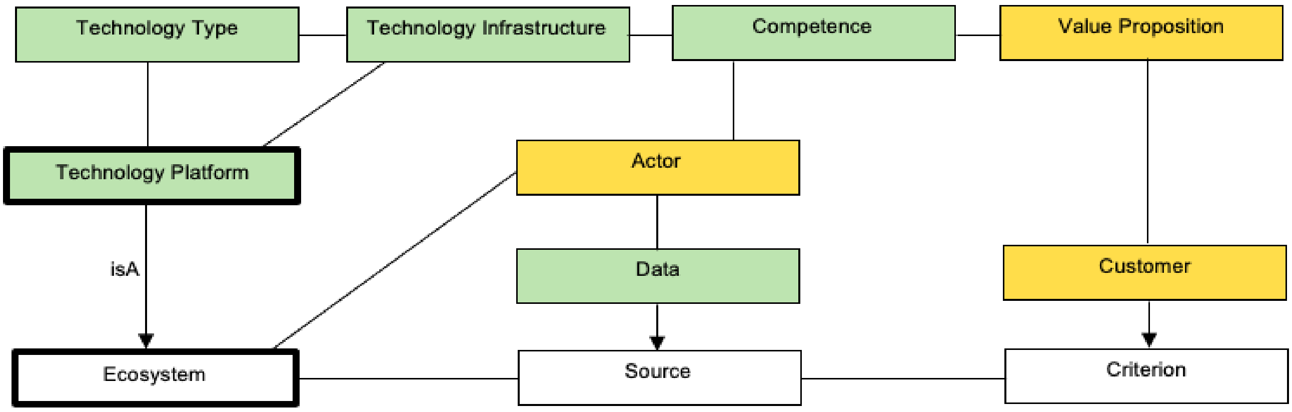


Figure 6.10 Technology Platform and Ecosystem

6.3.2.6 Ecosystem

The term ‘Ecosystem’ has different perspectives in different contexts. (Gawer and Cusumano, 2014) define this concept of *“external (industry) platforms as products, services, or technologies that act as a foundation upon which external innovators, organized as an innovative business ecosystem, can develop their own complementary products, technologies, or services”* (pp. 417). Besides, (Ghazawneh and Henfridsson, 2013) provide a view of platform ecosystems as platform owners involving third-party developers in developing software for mutual gain and for the platform’s end-users. Additionally, they also claim that “to successfully build platform ecosystems, the focus of the platform owner must shift from developing applications to providing resources that support third-party developers in their development work (Ghazawneh and Henfridsson, 2013, pp. 174) to deal with the volatility in information systems”.

Another outlook presents platform ecosystems as “digitally-enabled ecosystems” (Guggenberger et al., 2020). Although the authors provided interpretation of different types of ecosystems in the field of information systems, the platform ecosystems viewpoint is closely related to my research. They represent the platform as the technological infrastructure comprising various components to enable external innovation, while the corresponding evolving ecosystem involves users and vendors (Guggenberger et al., 2020). In the context of ‘Technology Platform’, I perceive 'Ecosystem' as a system that provides a dynamic interaction between new technologies, related infrastructure (technological-based software, tools, and settings), data, actors, and technological-based products/services in a specific technological-based environment. One major component of the platform ecosystem is data (Gawer and Cusumano, 2014; Xie et al., 2022). Today, not only businesses but every individual has a huge amount of data to upkeep. Organisations require that data to be available for their business as well as for the relevant stakeholders (technical experts, partners, customers, etc.). This influences the existence of data platforms, which I call 'Technology Network' (§6.3.2.7).

Business Model Element	Ecosystem
Definition	In relation to 'Technology Platform', an 'Ecosystem' manages the interaction of technology, related infrastructure, and 'Data' that support creating desired value to customers.
Element of	'Technology Platform' (0-n).
Related to	'Ecosystem' builds around 'Technology Type' (1-n), 'Actors' (1-n), 'Data' (1-n) and provides the right environment to develop 'Value Proposition' (1-n).
Cardinality	0-n
Attributes	*Name* {xxxx} *Description* {xxxx} *Usability* {Access, Data insight, Data management Integration, Speed, Cost, Scalability}
References	(Ghazawneh and Henfridsson, 2013) (Guggenberger et al., 2020)

Table 6.11 Ecosystem

An 'Ecosystem' is part of 'Technology Platform' that creates interactive co-ordination of new technologies (specifically disruptive technologies), 'Technology Infrastructure', 'Data' (acquired from end-users, partners, or internal practices), 'Actors' to generate 'Value Proposition' for 'Customer'. An ecosystem is not a network of companies that provide expertise and knowledge for developing innovative products. Therefore, it is not always possible to arrange the associated 'Knowledge' and 'Capability' from the platform ecosystem. 'Technology Platform' and related ‘Ecosystem’ precisely provide access to technological-based services and resources on-demand.

Usability

This attribute measures the usefulness of platform ‘Ecosystem’ in connection with the development of ‘Value Proposition’ for the ‘Customer’. An ‘Ecosystem’ (in relation to a ‘Technology Platform’) is effective if an organisation can gain access to relevant infrastructure, provides insight to data (data insight), arrange integration of systems for the fast (speed) processing and innovation for the development of the technological product (value).

{Access}

With ever-changing customer demands, technologies, and related technological environments, it is almost difficult for companies to invest in different infrastructures. Although organisations may be able to arrange some infrastructure from their partners, it is challenging to get access to specific infrastructure when technologies and customer preferences are unstable. To deal with these kinds of challenges, the platform ‘Ecosystem’/ecosystems evolve. The purpose of ‘Technology Platform’ is to build an ‘Ecosystem’ for organisations (technical experts, developers, vendors) providing access to radical infrastructure with respect to cutting-edge technologies.

{Data insight}

In today’s digital world, data is the leading component of the platform ‘Ecosystem’. Organisations require real-time and correct information (while developing technological products. Digital product development requires logical patterns of data, that needs to be properly structured and visualised. A Platform ‘Ecosystem’ offers data specific technological products/services (Cloud-Based Customer Data Platform (CDP) | SAP, no date) (e.g., analytics and machine learning tools and resources) that provides insight into accurate data, which can be useful for organisations in their product development process.

{Data management}

Any growing platform ‘Ecosystem’ generate a substantial amount of data that needs to be handled and managed efficiently. A ‘Technology Platform’ supports storing and managing the data effectively for internal and external databases. It also comprises a security feature since it controls the authorisation and access of data assets (Cloud-Based Customer Data Platform (CDP) | SAP, no date).

{Integration}

Modern technological systems comprise complex and multifaceted tasks, involving several interfaces. By posing the correct infrastructure, a platform ecosystem may support organisations by providing a specific technological environment to integrate these complex interfaces and provide seamless access to the central system.

{Speed}

The main challenge an organisation faces when new technologies are introduced is the speed of adoption and hindered innovation (Walton and Pyper, 2019). By accessing platform ‘Ecosystems’, organisations can competitively utilise necessary infrastructure without concerning about the technology they consume. This enables potential product innovation and faster adoption of technology as opposed to investing in in-house infrastructure related to the new technology.

{Cost}

Cost optimisation is another promising attribute of platform ‘Ecosystem’. Since organisations do not require to invest in heavy infrastructure while using technological-based products/services (e.g., cloud and HPC-bases services) through ‘Technology Platform’, they can save a lot of money. Besides, they do not need to worry about infrastructure maintenance costs.

{Scalability}

Other than security and reliability, scalability is one of the crucial components of platform ecosystems. The ‘Technology Platform’(platforms) usually are (and should be) scalable in terms of both evolving ‘Ecosystem’ as well as developing technologies.

6.3.2.7 Technology Network

In the context of my research, I express a 'Technology Network' as a network of companies (such as competence centres, research institutions (including universities), resource centres, network centres, RTOs, regional development agencies or government agencies) empowered by high-tech researchers, that focus on strategic research and work jointly towards a common objective to create value for end-user (customer) as well as for each other. Carayannis and Campbell (2006) described 'Technology Network' as the "*Innovation networks", that "are real and virtual infrastructures and infratechnologies that serve to nurture creativity, trigger invention, and catalyse innovation in a public and/or private domain context (for instance, government-university-industry, public-private research and technology development co-optitive – a combination of cooperative and competitive – partnerships)*."

A 'Technology Network' supports organisations (such as technical experts (ISVs), that develop technological products/services as the main value to their customers) with access to the latest technologies (specifically disruptive technologies), knowledge, and expertise; and help provide a competitive edge in their business processes, products, or services. These companies not only support organisations with piloting, testing, and experimenting ('Capability') with technological innovations; but also offer business and financial assistance to integrate these innovations. Organisations can be highly benefited by collaborating with 'Technology Network' and developing high-tech products using cutting edge technologies.

'Technology Network' is part of DISRUPTIVE TECHNOLOGY MANAGEMENT. 'Technology Network' acts as a dynamic innovation ecosystem that mainly focuses on helping organisations to be innovative and more competitive by providing access to the latest technologies. 'Technology Network' provides unique 'Capability' (high-tech skills and expertise) other than technological based 'Resource'(s) and 'Technology Infrastructure'. These capabilities lead to the process of value creation ('Value Proposition') when combined with essential knowledge and other competencies.

Business Model Element	Technology Network
Definition	The element 'Technology Network' indicates a collaborative network of research and technology companies. These companies work together for a common goal to support vendors, developers, and other similar organisations (like ISVs in our case) by providing access to radically new technologies, knowledge, other business, financial, and technological-based services to develop innovative products/services ('Value Proposition') for their 'Customer' (customers).
Element of	DISRUPTIVE TECHNOLOGY MANAGEMENT
Inherits from	Connectivity
Related to	The 'Technology Network' may provide their expertise and/or 'Technology Infrastructure' (0-n) based on new technologies along with unique 'Dynamic Capability' (1-n) to build or communicate technological-based products i.e., 'Value Proposition' (1-n).
Cardinality	0-n
Attributes	Inherited from 'Connectivity' (0-n) (§6.3.2.8).
References	(Carayannis and Campbell, 2006) (Korber and Paier, 2014) (Wanzenböck and Piribauer, 2018).

Table 6.12 Technology Network

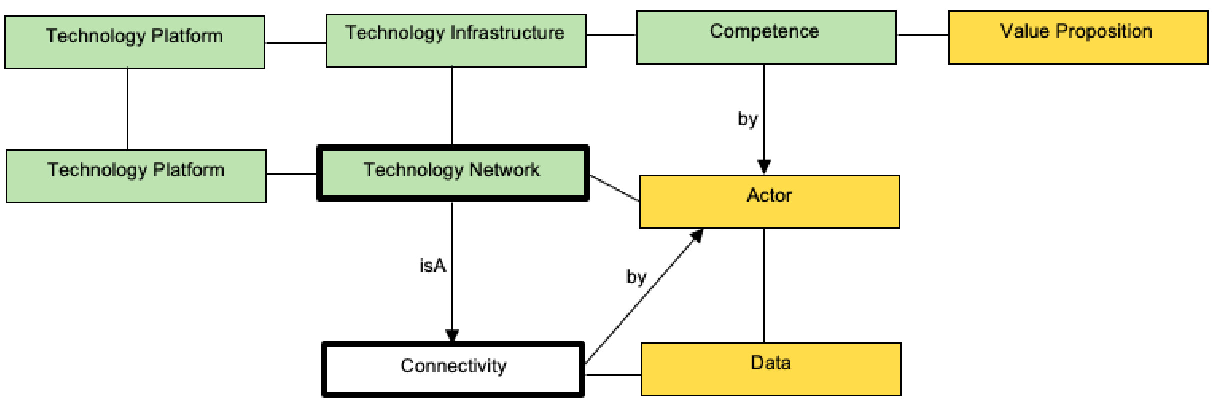


Figure 6.11 Technology Network and Connectivity

6.3.2.8 Connectivity

Volatility in technology brings uncertainty and ever-expanding technological needs in the business, especially for organisations that offer technological-based products (utilising disruptive technologies) to their customers (that have unpredictable preferences). In order to meet these dynamic technological needs and reach customers satisfaction, organisations require to have the dynamic infrastructure, knowledge, and other capabilities. Today, organisations are able to possess these changing capabilities by collaborating with ‘Technology Network’ and getting involved in the ‘Connectivity’ provided by the ‘Technology Network’.

‘Technology Network’ (networks) facilitates interconnected organisations with the ‘Connectivity’ of various knowledge categories and evolving resources and dynamic capabilities that promote knowledge diffusion and innovation (Wanzenböck and Piribauer, 2018). ‘Connectivity’ can be viewed as a channel for communication, collaboration, exchange of new knowledge, ‘Resource’(s), and ‘Dynamic Capability’, internal ‘Capability’ between different organisations (that are being geographically diverse and have dispersed knowledge, skills and resources) involved in the dynamics of ‘Technology Network’ (Korber and Paier, 2014; Wanzenböck and Piribauer, 2018). Due to geographically and specialisation diversity, ‘Technology Networks’ are regionally reachable. The ‘Connectivity’ enables organisations to communicate within ‘Technology Network’ and get support according to their needs. Besides this ‘Connectivity through’ ‘Technology Network’ provides other business or financial support.

Business Model Element	Connectivity
Definition	An elementary 'Connectivity' involves the interconnection of 'Technology Network' (the organisations that are continuously working towards innovation) and provides a collaborative environment and/or communication channel to exchange evolving need of 'Resource' and other 'Capability' to help organisations (such as ISVs) to produce innovative technological-based products ('Value proposition') and get benefitted too.
Element of	'Technology Network' (0-n).
Related to	'Connectivity' through 'Technology Network' (0-n) may facilitate 'Dynamic Capability' (0-n) for 'Technology Infrastructure' (0-n) and 'Capability' (0-n) required for the value creation ('Value Proposition' (1-n)) for the 'Customer' (1-n).
Cardinality	0-n
Attributes	*Name* {xxxx} *Description* {xxxx} *Collaboration* {Share, Exchange, Pool, Channel}
References	Carayannis and Campbell, 2006) (Korber and Paier, 2014) (Wanzenböck and Piribauer, 2018).

Table 6.13 Connectivity

Collaboration

In a business, collaboration is an interactive process between different stakeholders (actors or organisations), where they work on a common goal to solve some complex problems and find innovative resolutions (Di Iacovo, Moruzzo and Rossignoli, 2017). 'Connectivity' allows collaboration between 'Technology Network' (R&D etc.), and organisations (technical experts/ ISVs etc.) to share, exchange, and/or pool knowledge, resources, and capabilities to create value for customers. The below attributes of collaboration only provide a view of organisations (ISVs) that require support from 'Technology Network' for their product (technological product) development process.

{Share}

This attribute is necessary to provide ‘Connectivity’ for developing innovative products, by making technology, knowledge, resources, and other capabilities available to share over the ‘Technology Network’.

{Exchange}

The attribute may refer to as a channel. It may act as the main outreach channel for promotions and showcasing innovative products. The attribute exchange helps ‘Technology Network’ to communicate information, knowledge, skills, coordinate the activities and other related capacities within the network and contribute to the value creation process.

{Pool}

This attribute refers to the ability to combine capabilities of more than one organisation from the ‘Technology Network’. These can be scattered knowledge, various technological resources, different skills, or a combination of all needed to create value for customers.

6.4 Summary

This chapter represents the conceptual elements of new business model ontology showing a firm’s business model affected by the dynamics of disruption and ongoing innovation development. The new ontological framework is particularly effective for organisations that develop high-end solutions for their customers utilising cutting-edge disruptive technologies. Unlike the previous ontology, the new business ontology offers a business expert to evaluate technological and external elements (that are explicitly defined in section §6.3 and figure 6.2) along with the important (general) business model elements (evaluated in chapter 4). In this chapter, I have not defined other business model dimensions such as ‘PRODUCT’, ‘VALUE NETWORK’ and ‘FINANCE ASPECTS’, since their relationships are already defined in Osterwalder’s ontology (Osterwalder, 2004). As explained in section §6.3, the most common approach to creating ontological concepts is revising an existing methodology due to the complexity of defining each relationship and representation of elements in different domains. Besides, these business model elements are thoroughly identified and explained in chapter 4 (§4.4.2.9). I also considered the fact that the business analyst may not have the time and expertise to work with this framework. I, therefore, created a simple tool/canvas to work together with five flow diagrams which are explained and evaluated in the next chapter.

Chapter 7 Dynamic Canvas Model

7.1 Overview

The chapter provides a methodology to develop disruptive business models along with some analytical questions in the form of flow charts. These flow charts are clear, concise, and easy to use. To test the working of the methodology, the business elements of one of the CloudiFacturing use case is evaluated.

7.2 Business Model Development Methodology

Present technologies like disruptive technologies are very dynamic in nature because they offer numerous possibilities and prospects. Thanks to the continuous technological developments, these technologies are easily accessible (through third-party), therefore, firms (technology organisations/ISVs) can make use of these technologies by integrating them in different ways. This means these organisations no longer require thinking about in-house technological capabilities while developing new technological systems for their customers. Nevertheless, they need to plan what kind of technologies they require and the ways to access them, for example, they might build new partnerships where they can use their partner's resources. They may also use open access technological tools readily available for anyone, as well as some technological capability as a service of charge. These new ways of using technology have opened several new opportunities for technology organisations, simply because they need to invest comparatively less. They do not require to invest on buying expensive resources, large infrastructure, or plan any maintenance related to the technology.

Organisations that offer technological products exploiting disruptive technologies as their main value require assessing all technological aspects (thoroughly) before they develop that specific product based on the specific disruptive technologies and make them commercially available to their customers. The analysis can be carry out using a business model development tool or methodology. In the previous chapter, I showcase an ontological framework (chapter 6, figure 6.2) to develop disruptive business models. Although the logics I used to define ontological concepts are very simple, nevertheless for a business analyst is long. The ontological frameworks are generally long by nature since they describe each concept and associated concepts thoroughly. Therefore, the research derives a business model development methodology from the framework for quick business analysis. This chapter provides the resultant methodology to develop disruptive business models, which I call the ’Dynamic Model Canvas’.

7.2.1 Business Analysis through Dynamic Model Canvas

Although the dynamic model canvas is derived through the business model ontology, the elements of the disruptive technology management dimension are merged. Since the description of technology type and category is defined in the requirement analysis of the ‘PRODUCT’ development process (figure 7.2), it can be merged into the dynamic capability element of ontology. The dynamic capability element is an essential element to access all internal and external capabilities required in the product development process including types of technologies. Besides, as compared to the ontological framework, the business model methodology does not need to show high-level of relationships.

The Dynamic Model Canvas is a significant business model development methodology for organisations that intended to develop disruptive business models. Dynamic Model Canvas is an analytics tool coupled with a methodology (I have prepared five guiding flow diagrams along with the tool to be used for easier analysis for business elements), and works as follows:

When a business analyst wants to develop a suitable business model for utilising disruptive technology (in this case, cloud-based solutions), it first examines which typical business building blocks (reflecting sociomaterialty) characterise the business and the problem most (improved performance requirement, customer demand, dynamic capabilities, disruptive technologies, new competition, and market factors etc). As mentioned before that the methodology includes detailed guidance for this analysis (flow diagrams). Once the business building blocks are identified using flow charts; they can be mapped to the business model concept and can be populated (dynamically) with the headings of the dynamic model canvas (according to the disruptive technology and capabilities requirements) that the analyst needs to use when defining the business model. Below diagrams (from figure 7.1 to 7.6) represents dynamic model canvas and associated logical questions for the business analysis.

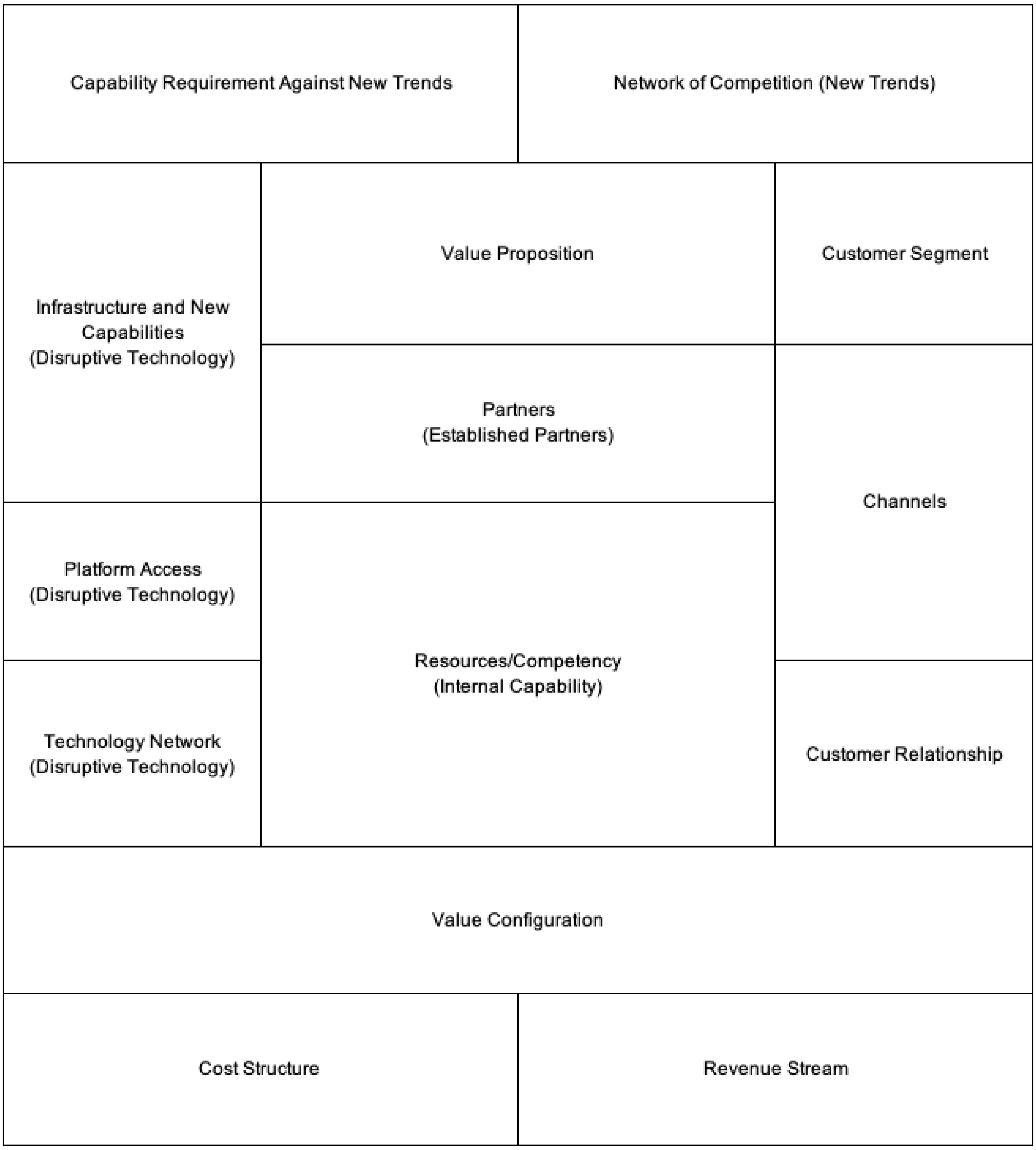


Figure 7.1 Dynamic Canvas Model

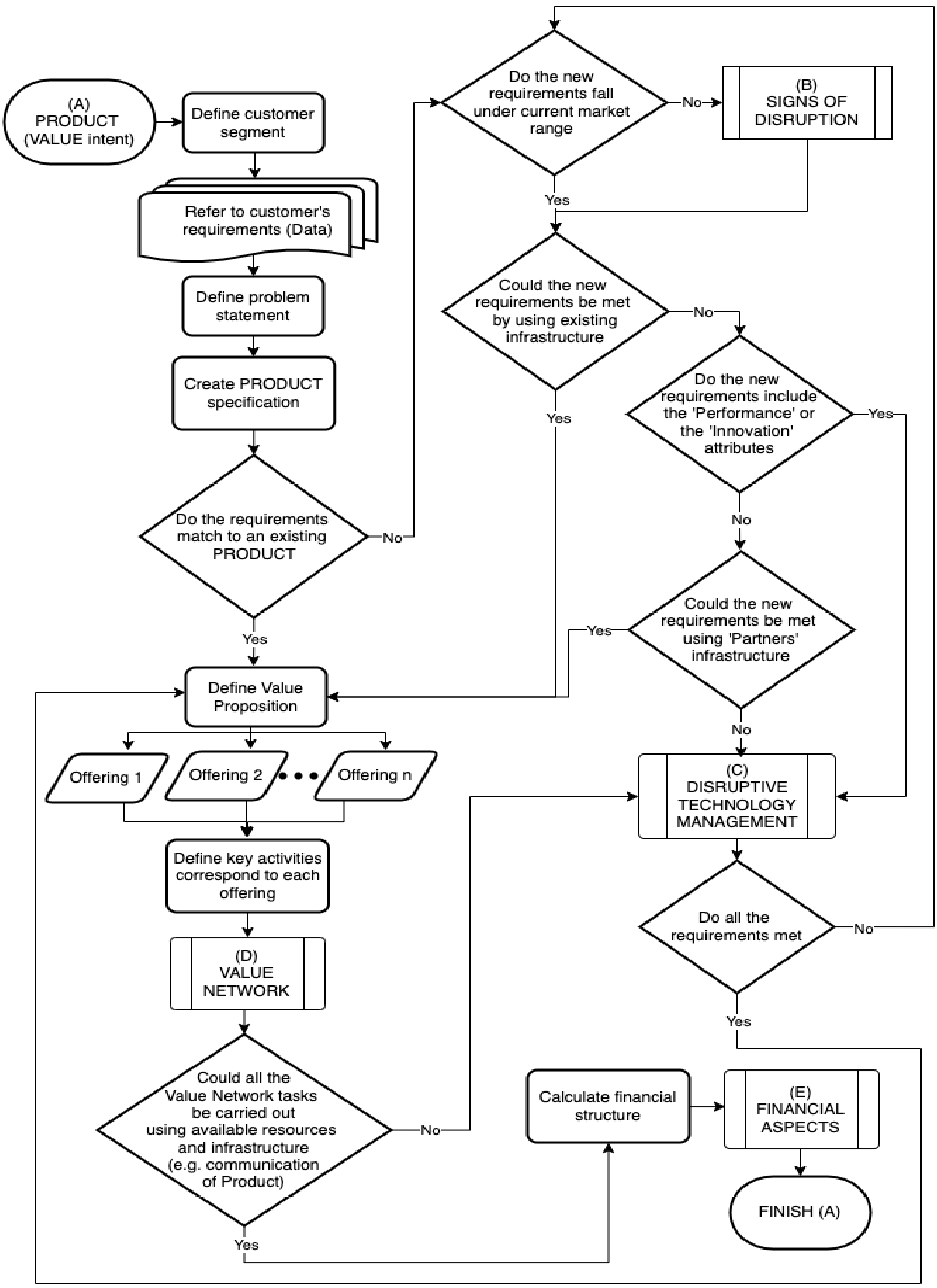


Figure 7.2 Flow diagram for ‘PRODUCT’

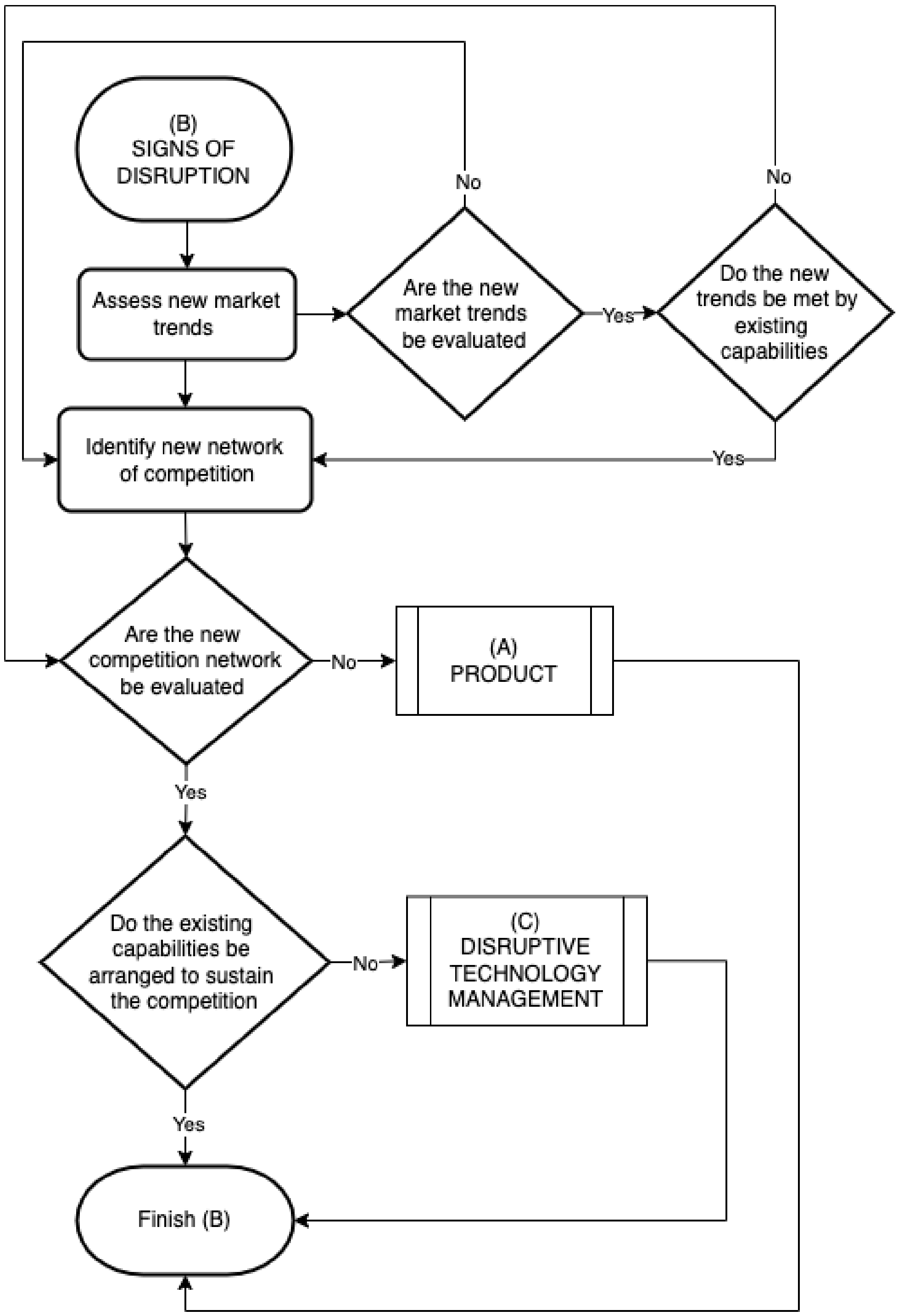


Figure 7.3 Flow diagram for ‘SIGNS OF DISRUPTION’

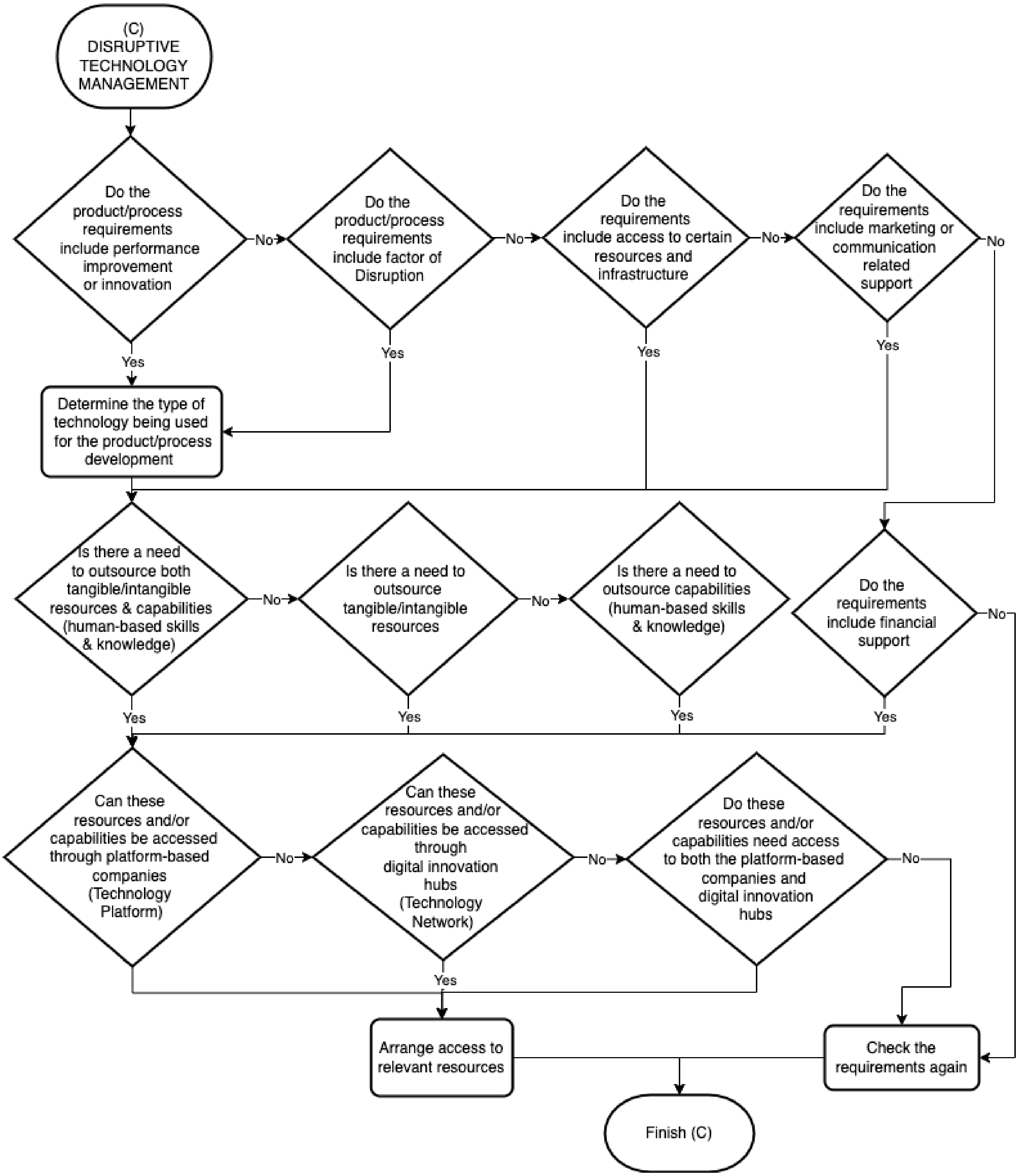


Figure 7.4 Flow diagram for ‘DISRUPTIVE TECHNOLOGY MANAGEMENT’

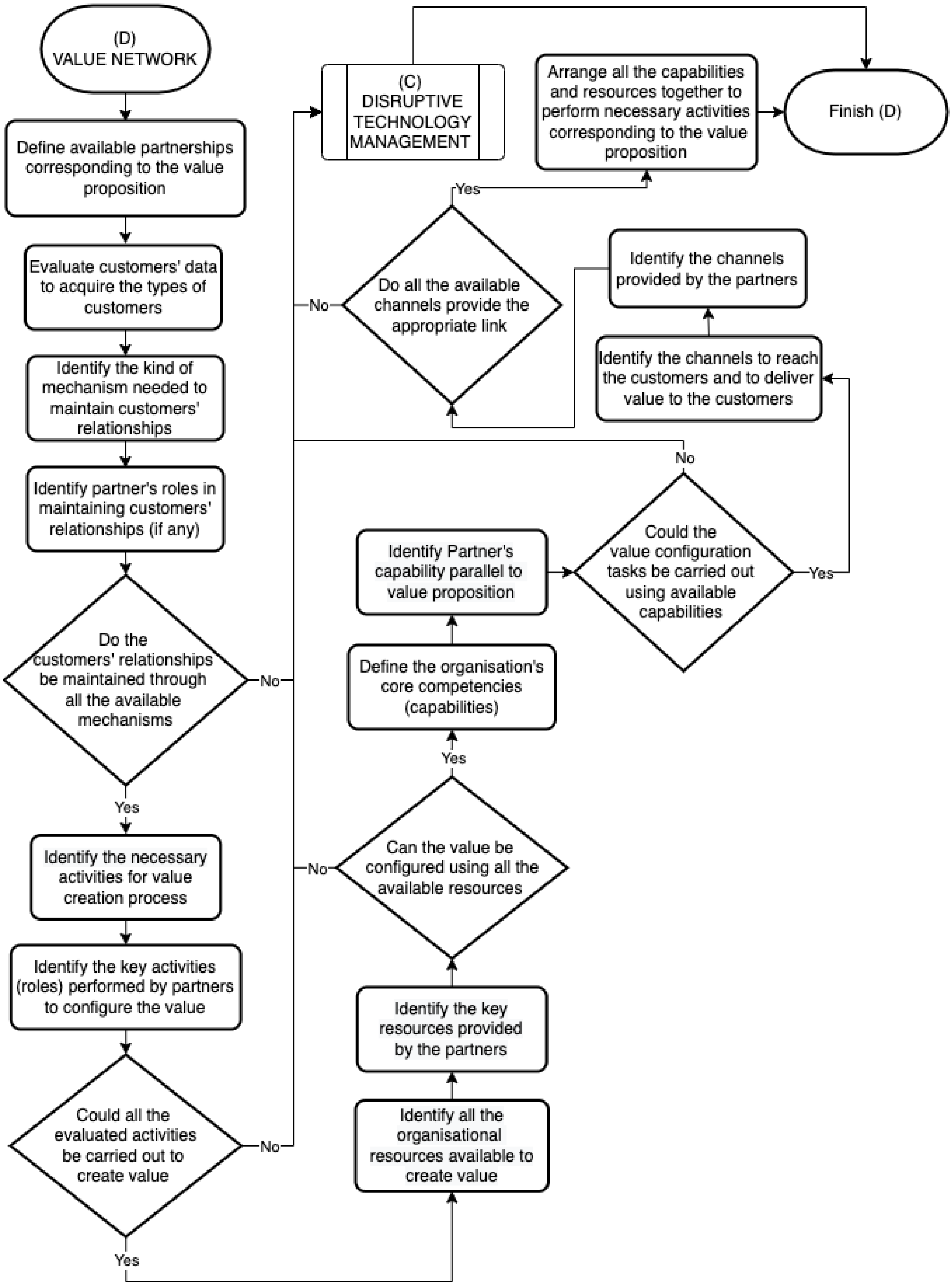


Figure 7.5 Flow diagram for ‘VALUE NETWORK’

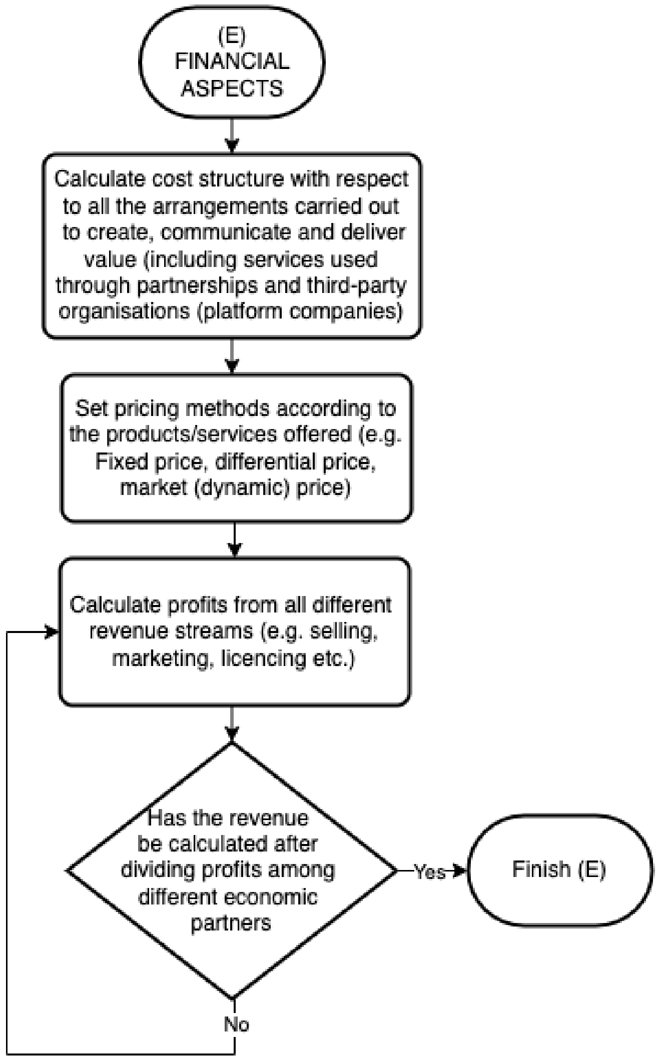


Figure 7.6 Flow diagram for 'FINANCIAL ASPECTS'

7.2.2 Use case (5) for Optimising the Process of Manufacturing Solar Panel (CloudiFacturing, no date)

To test the methodology and its associated flow charts, I select use case 5 (randomly) to analyse its business model elements. In the original experiment, the ISV 5 conducted its business analysis through the lean canvas model. I identified from companies' representatives that many of them used lean canvas model because it is popular (Appendix B). While making this business analysis, I found the main three vital elements (Competition, Partners, and Customer relationship) are not described within the business analysis and some elements are not given due consideration. I found those elements outside the business analysis, or by conducting independent research from the company's website and completed the business analysis shown in figure 7.7.

Capability Requirements Against New Trends
1. Cloud-HPC resources to integrate CFD simulation
2. Optimisation algorithm to run multiple CFD simulation and optimise the production of solar hybrid panels
3. Capability to integrate the algorithm and CFD to Cloud-HPC environment
4. Cloud-HPC tools and expertise to improve lamination process (a step in the production of solar hybrid panel)

Network of Competition (New Trends)
1. Cloud and HPC based Simulation and Modelling
2. Growing market in solar energy systems for commercial installations
3. Growing market of innovative Hybrid Solar Technologyl
4. Already established competitive simulation software products in Computational Fluid Dynamics (CFD) simulation market

Infrastructure and New Capabilities
1. OpenFOAM toolkit for simulation software
2. SALOME for pre-process execution
3. ParaView for post-processing
4. HPC resources to maintain approximately 10,000 CPU/hour are required to optimise the oven
5. Cloud resources for output files

Value Proposition
1. A cloud-based CFD simulation to optimise manufacturing of solar hybrid panels
2. A cloud-HPC based simulation to improve the lamination process for oven's heat distribution and identify the oven's hot points

Customer Segment
1. Multinational companies in energy and industrial sectors
2. Small and medium Manufacturing companies in energy sector
3. Glass and Metallurgy industrial sector

Platform Access
1. CloudiFacturing Platform and other technology platforms to access HaaS (HPC as a Service), IaaS (Infrastructure as a Service), Authentication and Visualisation
2. CloudiFacturing Digital Marketplace to access competence centres and DIHs (for support related to relevant skills and knowledge)

Partners
1. Research and Technology organisations
2. Energy Companies
3. Collaboration in different projects

Competency (internal capability)
1. Specialised in consulting and services based on fluid simulation to address problems related to fluid flow, heat transfer and chemical reaction
2. ICT skills and knowledge to create numerical model and algorithms

Resources (internal capability)
1. Linux Operating System and suitable hardware platform to create algorithm and simulation software
2. Hardware of 20 cores, 40 GB RAM and 200GB space for temporary storage
2. Consultants (staff) to support end-users (customers)
3. Financial, legal and other administrative resources

Channels
1. CloudiFacturing Digital Marketplaces
2. B2B industrial fairs and events
3. Digital Innovation Hubs
4. Direct Communication with Customers

Technology Network
1. CloudiFacturing Digital Marketplace
2. Digital Innovation Hubs
3. Competence Centres (Technology Organisations, R&D, Research Institutions)

Customer Relationship
1. CloudiFacturing Digital Marketplace
2. Digital Innovation Hub (DIH 5)
3. End-user training and consultacy services

Value Configuration Tasks
1. To obtain an optimised configuration of the lamination oven, to configure the variables of heating rate program, air mass flow rate, number of active electric heat resistance, the open/closed air enterances and the panel positions
2. Process optimisation and improved production capacity by adapting the CFD toolkit for end user
3. Cost reduction by reducing the total number of trail and error tests, decreasing design cost and wastage
4. Increased affordability by lowering investment cost on in-house infrastructure
5. Improved competitivness by reducing time-to-market

Cost Structure
1. Personal costs
2. Staff costs
3.. Marketing costs
4. Open-source software cost
5. Costs from the adaptation of CFD software through Cloud-HPC

Revenue Stream
1. Pay as a Service
2. Sharing CFD software
3. Cloud resources
4. Executing projects as a consultant or to customize software to meet specific demands

Figure 7.7 Business Analysis of ISV 5 (CloudiFacturing use case) through Dynamic Canvas Model

Evaluation of business elements of use case 5 using Dynamic Model Canvas and Flow charts

I provided background information about ISV 5 in chapter 5 (§5.2.4), where I explained that ISV 5 provides services related to computational fluid dynamics and develop tailored-made fluid flow simulation for their end users. I, therefore, start directly with their business analysis and requirements. Using flow charts, the first and foremost step for a business analyst is to evaluate product specification (flow chart 'PRODUCT'). This can be created through knowing their target customers according to their industrial specialisation. Once the customer segment is founded (can be existing customers or new), then they create product specifications by referring to the customers' requirements. By following customers' requirements, the process (solution) requirements can be established to address the problem to be resolved. In use case 5, the customer (end-user), Manufacturer 6 struggles to automate their current processes of manufacturing hybrid solar panels. The information regarding the number of challenges Manufacturer 6 faces and the possible solution specification is also stated in chapter 5 (§5.2.2). This section of the flow chart supports examining the capabilities requirements, technology requirements, knowledge requirements and other competencies required for the value creation process.

Next, if the capabilities match the already established product and arrangements can be made internally, then the flow chart directs the analyst towards the value creation activities (flow chart 'VALUE NETWORK'), and finally to calculate cost and revenue structures (flow chart 'FINANCIAL ASPECTS'). If the requirements are new or cannot be met through internal resources and capabilities, then there are further questions that lead an analyst to select whether the market search is necessary (flow chart 'SIGNS OF DISRUPTION'), or the capabilities are identified and can be arranged through collaboration and third-party companies (flow chart 'DISRUPTIVE TECHNOLOGY MANAGEMENT). Once all the business elements are collected then these can be mapped to the Dynamic Model Canvas for visualisation and understanding of the whole business plan.

In the case of ISV 5, some **Internal Capabilities (resources and competencies)** can be used such as (through VALUE NETWORK):

- CFD simulation to address problems related to fluid flow
- ICT skills and knowledge to create numerical models and algorithms
- Available software: Linux Operating System and suitable hardware platform to create algorithm and simulation software
- The hardware of 20 cores, 40 GB RAM and 200GB space for temporary storage
- Consultants (staff) to support end-users (customers)
- Required financial, legal, and other administrative resources

In addition to the internal capabilities, ISV 5 also required some external capabilities to optimise the process for end-user, without having to buy expensive infrastructure and resources for both end-user and them. To arrange external capabilities, ISV 5 can analyse the number of competitive solutions already established by their competitors, and by end-user's competitors, or any other industry with advanced solutions (e.g., Research and Development). This analysis was conducted in the project outside of business analysis (through the Lean Canvas Model), and therefore enabled me to evaluate these elements. Please note that CloudiFacturing is an immense platform involving approximately 60 significant companies in total (during the project for leading 21 experiments). The business analysis sections are prepared in iterations and the business planning is created by several experts mutually. I identified that it is significantly essential to conduct a competition and market analysis to an advanced level, during my time at the CloudiFacturing project (Appendix B). Therefore, a firm which requires external capabilities, especially the firm that serves its customers with advanced technological products, is required to seize new market and competition trends. The dynamic model canvas and the flow charts 'SIGNS OF DISRUPTION' prompt a business analyst to create this analysis. Therefore, the following elements related to new technology trends and capabilities are found for ISV 5 to develop solutions for Manufacturer 6:

New Technology Trends:

- Cloud and HPC-based Simulation and Modelling
- The growing market in solar energy systems for commercial installations
- The growing market for innovative Hybrid Solar Technology

- Already established competitive simulation software products in Computational Fluid Dynamics (CFD) simulation market

To compete against these trends, the **External Capabilities required** are:

- Cloud-HPC resources to integrate CFD simulation
- Optimisation algorithm to run multiple CFD simulations and optimise the production of solar hybrid panels
- Capability to integrate the algorithm and CFD into a Cloud-HPC environment
- Cloud-HPC tools and expertise to improve the lamination process (a step in the production of the solar hybrid panel)

Once the requirements of new capabilities are evaluated, the business analyst can go to the next step identifying the ways to acquire these new capabilities from 'DISRUPTIVE TECHNOLOGY MANAGEMENT' and define the exact capabilities to be used. For use case 5, these steps allow identifying the following business elements:

Infrastructure and New Capabilities

- OpenFOAM toolkit for simulation software
- SALOME for pre-processing execution
- ParaView for post-processing
- HPC resources to maintain approximately 10,000 CPU/hour are required to optimise the oven
- Cloud resources for output files

Platform Access (Cloud/HPC Platform)

- CloudiFacturing Platform and other technology platforms to access HaaS (HPC as a Service), IaaS (Infrastructure as a Service), Authentication and Visualisation
- CloudiFacturing Digital Marketplace to access competence centres and DIHs (for support related to relevant skills and knowledge)

Technology Network (New Collaborations)

- CloudiFacturing Digital Marketplace
- Digital Innovation Hubs
- Competence Centres
- (Technology Organisations, R&D, Research Institutions)

Once all internal and external capabilities are arranged, these can be integrated to create **Value Configuration** tasks through VALUE NETWORK, which include:

- To obtain an optimised configuration of the lamination oven, to configure the variables of the heating rate program, air mass flow rate,
- number of active electric heat resistance, the open/closed air entrances, and the panel positions
- Process optimisation and improved production capacity by adapting the CFD toolkit for the end-user
- Cost reduction by reducing the total number of trial-and-error tests, decreasing design cost and wastage
- Increased affordability by lowering investment costs on in-house infrastructure
- Improved competitiveness by reducing time-to-market

In addition to the value configuration tasks, the VALUE NETWORK flow chart also allows for identifying other necessary business activities such as:

Internal Capabilities (resource/competency, that is already identified above)

Partners (these are not identified in the project document at all neither within the methodology (lean canvas model) nor outside the business analysis. I identified these elements through the company’s website.)

- Research and Technology organisations
- Energy companies
- Collaboration in different projects

Channels

- CloudiFacturing Digital Marketplaces
- B2B industrial fairs and events
- Digital Innovation Hubs
- Direct Communication with Customers

Customer Relationships (these are also not identified in the project document at all neither within the methodology (lean canvas model) nor outside the business analysis. I identified these elements through reading the project document, understanding the concept of CloudiFacturing platform and, eventually worked out how ISV 5 maintain relationships with ISV 6. For ISV themselves, it is easy to evaluate how they maintain customer relationships.

- CloudiFacturing Digital Marketplace
- Digital Innovation Hub (DIH 5)
- End-user training and consultancy services

After the evaluation of ‘VALUE NETWORK’, the final analysis is to calculate the firm’s finances, through the flow chart of ‘FINANCIAL ASPECTS’ and as below:

Cost Structure

- Personal costs
- Staff costs
- Marketing costs
- Open-source software cost
- Costs from the adaptation of CFD software through Cloud-HPC

Revenue Streams

- Pay as a Service
- Sharing CFD software
- Cloud resources
- Executing projects as a consultant or customizing software to meet specific demands

After financial analysis, the main value elements can be defined through PRODUCT flow chart. The **Value Proposition** elements for ISV 5 are defined as:

- A cloud-based CFD simulation to optimise the manufacturing of solar hybrid panels
- A cloud/HPC-based simulation to improve the lamination process for the oven's heat distribution and identify the oven's hot points

Finally, when all the business elements are identified, they can simply be mapped to the dynamic model canvas as a well-developed disruptive business model.

7.3 Summary

This chapter provides detailed information about the new business model development methodology, i.e., dynamic model canvas (coupled with 5 flow charts) to develop disruptive business models. Besides, thorough business analysis, along with technical, social, and external analysis, is conducted using one of the seven CloudiFacturing use cases. I randomly selected the real business elements of use case 5 and tested the working of Dynamic Model Canvas and its associated flow charts. The flow chart usage is significant here to guide precisely which business model element is to analyse next. Using a single tool, Dynamic Model Canvas is proven to be effective in evaluating all major elements of an organisation, including business, technical, social, and external dynamic elements, that were not conceptualised together previously.

Chapter 8 Conclusions and Future work

8.1 Overview

This chapter provides a conclusive summary of the thesis and future research avenues. It delivers a verdict of how the research questions are answered and the objectives are achieved. It briefly explains the research findings and contributions. It also offers future research directions that may lead to further progress in this critical area of research.

8.2 Conclusion

The research aimed to build a framework to develop a methodology to create disruptive business models corresponding to the utilisation of disruptive technologies. To achieve this aim, the research revolves around answering the research questions and achieving research objectives. To find the answer to my first research question, first and foremost, I studied interdisciplinary domains of disruptive technology (§3.2) and business modelling (§3.3), showing that an organisation goes through an inevitable business model change while employing disruptive technologies for commercial use. Second, the literature on disruptive technology further leads me to investigate social sciences studies (§3.2.3, §3.2.4) to understand the interconnection of social and technical (sociomaterial) aspects of an organisation for the development of a new technological product. Furthermore, I reviewed a connected theory of dynamic capabilities, dynamic technologies, and changing external environments (§3.3.1) for an organisation causing the change of business model.

While reviewing the literature, I evaluated that there is a gap in theories of business modelling. First, the sociomaterial view has not been shown completely in the context of the business model change. Second, the most prominent business model development methodologies do not include the dynamic factors of disruption and disruptive technologies. Although a few theories embrace these dynamic elements in the context of business modelling, they are not being conceptualised (§3.3.2.6, table 3.1). Since all these studies I reviewed are yet to be conceptualised together in a unified framework, I merged all these interdisciplinary concepts together and created an initial conceptual framework (figure 3.8). The elements of the framework answered the first research question (§1.4, Q1(a), Q1(b)). Nevertheless, they further need verification in the means of evaluation of actual elements of the originally proposed framework.

Thereafter, to answer the second and third research questions, I created a framework to conduct a systematic comparison (§4.4) between the five most relevant business model methodologies (§3.3.2). This comparison I created using business model elements of two actual business use cases (from the Cloud SME project (§2.2.3.1)) that offer high-tech products/services (simulation solution) utilising cloud/HPC resources. I mapped these business elements and created thirteen large matrices comparing business elements of these five business model methodologies, one by one with each other (§1.5, objective 2a). Overall, this comparison framework was found ineffective, since the matrices can be very complex and unreliable, especially if an increased number of business processes are required to be evaluated. Further, this framework did not support discovering an effective methodology that can be used to develop disruptive business models. In addition to the similarities and differences, the comparison results show that these business model development methodologies provide the same level of static analysis since the technical aspects cannot be clearly decomposed. Nevertheless, this framework can be significant in developing a generic business model for general business analysis.

Although this methodical (comparison) framework did not provide disruptive and technical elements for my proposed methodology, it offered general business model elements that meet the partial requirement of my proposed framework (part of objective 2(b)). Most of these general business model elements are selected from the elements from the business model canvas (Osterwalder, Pigneur and Clark, 2010) in addition to the important external elements of “competition analysis” and the “market analysis” (§4.6) that are evaluated as a result of the systematic comparison (partially answered Q3). Therefore, it was considered to extend Osterwalder’s Business Model Ontology (Osterwalder, 2004) effectively tailored for the firms that commercialise disruptive technology (precisely for cloud-based solutions). This ontology can be created by conducting further in-depth analysis and finding technological and all other relevant elements (Q2).

Thereafter, to find the remaining elements of the intended ontological framework, the research conducts an empirical analysis to identify social, technological, and disruption-related factors and their interrelation, and influence on an organisation's business model. The empirical analysis is carried out on the data collected from CloudiFacturing Project (§2.2.3.2). The data was collected in two forms, reviewing the project's documents, and conducting direct observations on the participants (Part of Objective 1). The analysis was conducted on data collected from 30 companies comprising 7 application experiments (which I call seven business use cases). These seven use cases involve 8 end-user companies (manufacturing companies), 7 ISV companies (Independent Software Vendors) that acquire access to the CloudiFacturing platform, and 15 other technological/competence organisations.

The research carries out a thematic analysis by reviewing organisations' data to find patterns through the generated codes (§2.2.5.2), which are subsequently arranged, and re-arranged into main themes. The codes are generated and managed through NVivo software, which is specifically designed for qualitative researchers. The themes generated through these codes reflected clearly on the interdependency of sociomaterialty (in the essence of disruptive technologies) for the development of technological products and how these technological products affect the arrangement of value elements of organisations (further verification on Q1(a), Q1(b), objective 1). The analysis also showed the contradictory views of end-user companies and technology companies about introducing new technological solutions, and how this affect ISVs to change their business models. Finally, this analysis resulted in the main elements of technological, social, and disruption to consider for the proposed ontological framework (§5.4), which also answered the main research question (Q3), and contributed to achieving key objectives (3(a), 3(b)).

Subsequently, all the research findings are combined to form an ontological framework (all elements through a conceptual framework (derived from the literature, figure 3.8), identified business elements (business element identified from systematic comparison, §4.4, §4.4.2.9, §4.6), and identified social and technology elements (from empirical analysis, figures 5.2, 5.3, and 5.4, §5.4). For the new ontology, I extended Business Model Ontology (Osterwalder, 2004), by adding dimensions of disruption, socio-material and other related elements (figure 6.2, §6.4) to manage the introduction of disruptive technology in the organisations' value chain (objective 4(a)). This new ontological framework can further be used to construct an analytical tool to develop disruptive business models. I explained all these newly introduced dimensions of ontology and the roles of individual elements in the development of disruptive business models (§6.3).

Finally, aligned with the new ontological framework, I created a business modelling tool, which I call Dynamic Model Canvas (figure 7.1), coupled with five flow diagrams (figures 7.2, 7.3, 7.4, 7.5, and 7.6) that represent logical questionnaire for business analysts to develop customised disruptive business models (objective 4(b)). I then use a case study analysis ('use case 5' from CloudiFacturing Project) using the dynamic model canvas and flow diagrams to validate its usage and usefulness for ISV 5 (§7.2.2, figure 7.7). I also made a point-to-point discussion for identifying business elements for ISV 5 (Q4, objective 5). Although the dynamic model canvas is prototyped for the cloud technology at the moment, the way ontology structure is created, can be easily generalised towards less specific cases, and can be used with other types of disruptive technologies. Hence, it's clear how the research developed and successfully reached its aim by addressing all the research questions and achieving all objectives.

8.3 Research Contributions

The research made three main contributions to the field of business modelling and offered conceptually unifying key concepts of sociomateriality, disruption, disruptive technologies, and business models in a single model.

First, I created a framework to compare different business model development methodologies by systematically comparing their core business elements (chapter 4), which can help a business analyst to evaluate the best business development methodology for their business case. This comparison framework may be effective for business analysts that are not looking to analyse technical factors along with the business factors for their business case analysis. In my case, I was required to analyse business elements along with the technical elements of the organisation that offer high-end solutions to their customer for the commercial use of disruptive technologies. Nonetheless, this comparison analysis helped me discover two major external elements, i.e., “competition analysis”, and “market analysis”, that are required to be associated with the “technological” elements to develop disruptive business models. Further, the analysis offered general business elements for the projected framework, which are, “value proposition”, “target customer”, “partnership”, “resource”, “value configuration”, “channel”, “relationship”, “cost structure”, and “revenue stream”.

As a second contribution, I evaluated and defined the exact social and technological and disruption-related elements needed to create a new business model ontology by conducting an empirical analysis. The analysis involved the cases that engaged the development of high-tech products/services (simulation and analytics solution) utilising cloud/HPC resources (chapter 5). In some cases, however, additional technologies are also used, such as Big Data, Artificial intelligence, Solar technology etc., combined with cloud/HPC tools. This analysis helped me understand how technologies, social and disruption factors interact with each other and cause a business model change in organisations. I evaluated that the driving forces (socio-material and disruption elements) are primary factors to be addressed to develop disruptive business models. These factors include the analysis of “market & competition”, “key performance factors”, “disruptive Innovation”, and “dynamic capability”, etc. Besides, it also enabled me to decompose technological elements such as “technology type”, “technology infrastructure”, “technology platform”, and “technology network”; which are needed to create a new business model methodology. I also identified central dynamic elements for my framework as “data”, and “actor”, which enabled the interaction of other elements together.

Consequently, by enfolding the above-evaluated elements in a framework, the project reached its major contribution and accomplished its proposed goal. I arranged these elements/factors and reflected in two new dimensions of “SIGNS OF DISRUPTION”, and “DISRUPTIVE TECHNOLOGY Management” in an ontological framework (chapter 6). These new dimensions are created to allow a business analyst to identify changing factors of disruption, i.e., new competition and new requirements of dynamic capabilities. The new framework proved to be effective for a business analyst to identify which technologies and their related capabilities can be accessed through building new collaborations. I defined all these newly identified technological elements (related to social and disruption) by providing descriptions, and graphical representations in chapter 6.

Finally, to make the analysis easier and simpler, I created a methodology, named “Dynamic Model Canvas” (elements based on the new ontological framework), along with five flow diagrams (chapter 7). The dynamic model canvas is effective in creating disruptive business models for high-tech organisations. The methodology is significant in analysing the dynamic interaction of disruption, and its associated disruptive technologies (including sociomateriality); with the help of logical questions prepared for the analysis in 5 flow diagrams. I subsequently selected a case study (Use-case 5 from CloudiFacturing Project) to validate the effectiveness of the dynamic model canvas and the flow diagrams (figure 7.7). The guidance through flow charts is important here to clearly understand the sequence of the business model elements to be analysed and mapped into the dynamic model canvas. As explained earlier, the dynamic model canvas is tested for cloud technology at the moment; however, the way ontology structure is created, can be easily generalised towards other disruptive technologies.

8.4 Effectiveness of Dynamic Model Canvas over Business Model Canvas:

Dynamic model canvas, as the name suggested, is created to capture the volatility of disruptive technologies and their dynamic interaction with the disruption and social factors, in a single methodology, which can be used by high-tech firms to develop tailor-made business models. While creating my first comparison framework (§4.4), I selected five key business model methodologies (§3.3.2) by keeping a strong focus on the research context (§4.3). Each identified business model methodology has some pros and cons, including Business Model Canvas; nevertheless, they were found to be ineffective for developing disruptive business models. The elements of the business model canvas were found to be most prominent in analysing the business factors. I also evaluated the Business Model Ontology (Osterwalder, 2004) from which the business model canvas was derived. Therefore, I decided to extend the 'business model ontology', and from which I derived the customised dynamic model canvas, primarily for the cloud-based solutions.

In the final analysis of the comparative framework, I evaluated that the business model canvas is currently static and provides the same general level of analysis to arrange the business elements of any business case. I identified that the methodology could not evaluate important external factors, such as market and competition. Moreover, the technology elements are subsumed in internal IT infrastructure management (such as internal IT applications). These elements are proven to be aligned with the disruptive business model framework to sustain the uncertain and volatile technological environments.

In contrast, the dynamic model canvas is a methodology paired with analytical questions, that are prepared as five flow diagrams. When a business analyst wants to develop a disruptive business model (e.g., for cloud adoption), he first goes through the flow diagrams, finding out which of the typical sociomaterial and disruption (dynamic model canvas building blocks) components characterise their business case and the problem most. Once the analyst identifies the key building blocks for their business, they can dynamically be mapped to the business model concepts using the dynamic model canvas. In most cases, the business elements remain similar for the canvas; the only variation occurs on the technical elements depending on individual business cases. The methodology aims to optimise the canvas for each business case study on an individual basis resulting in more efficiency and a better outcome. Therefore, the dynamic model canvas and its associated flow diagrams are effective in creating customised disruptive business models.

8.5 Recommendation for future work:

The future work involves further validating the effectiveness of this innovative framework to develop disruptive business models based on another disruptive technology (e.g., IoT), and arranging corresponding interviews with one or two chief business representatives to verify the efficiency and usefulness of the dynamic canvas model. Another future prospect is that the ontological framework elements can be used to show applicability, e.g., by creating semantics through Protégé tool (Protégé, 2022). Finally, the methodology aims to optimise the canvas for different case studies on an individual basis and may result in more efficiency and better outcome. Since further validation is necessary for these findings, the second wave of CloudiFacturing experiments can be used to develop alternative business models using the dynamic model canvas. These business models will then be compared to the ones developed by business experts in the CloudiFacturing project to identify the difference and the significance of the dynamic model canvas.

Appendix A - Qualitative Coding on the Case Document

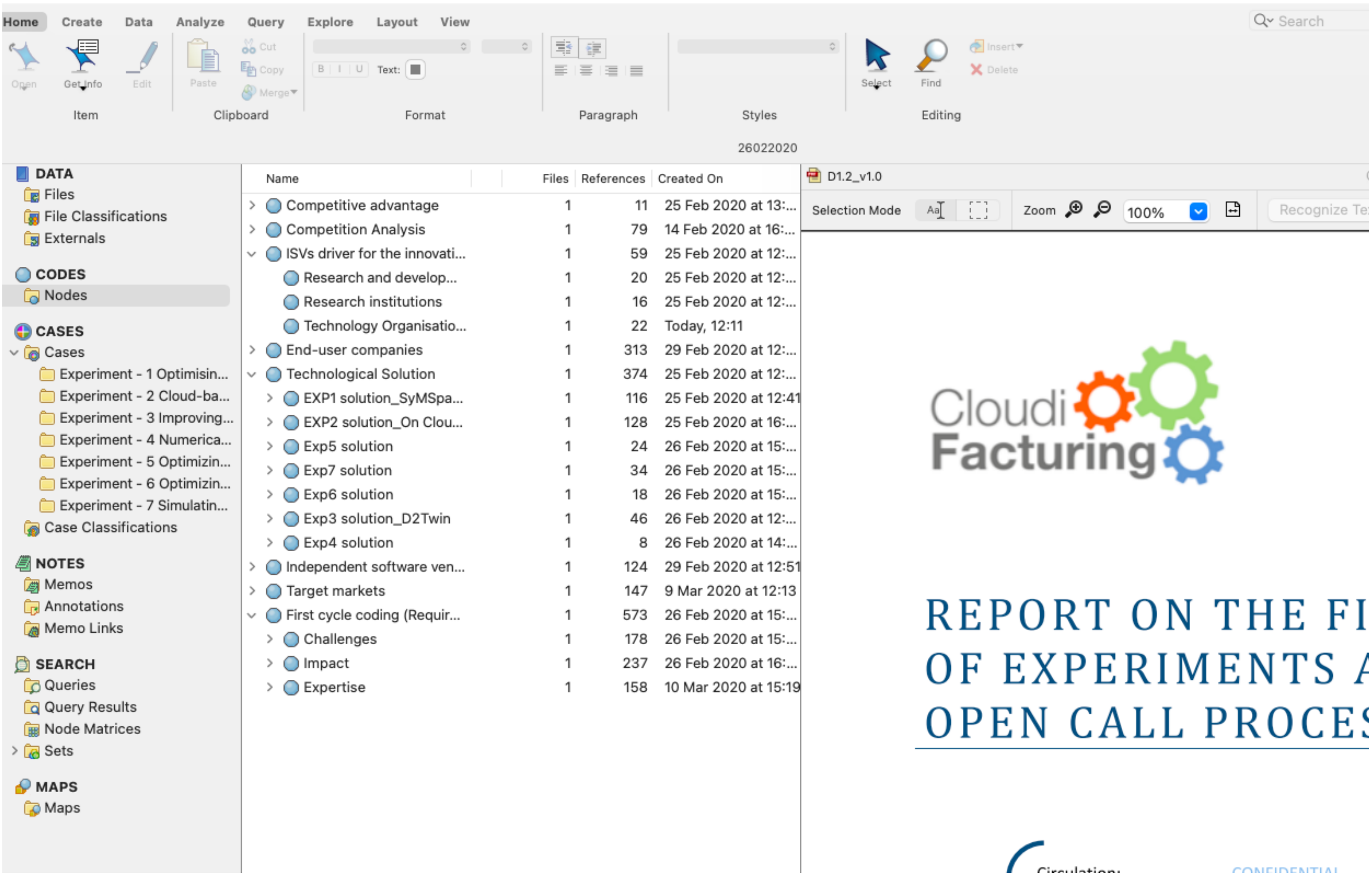


Figure A1 First Cycle Coding

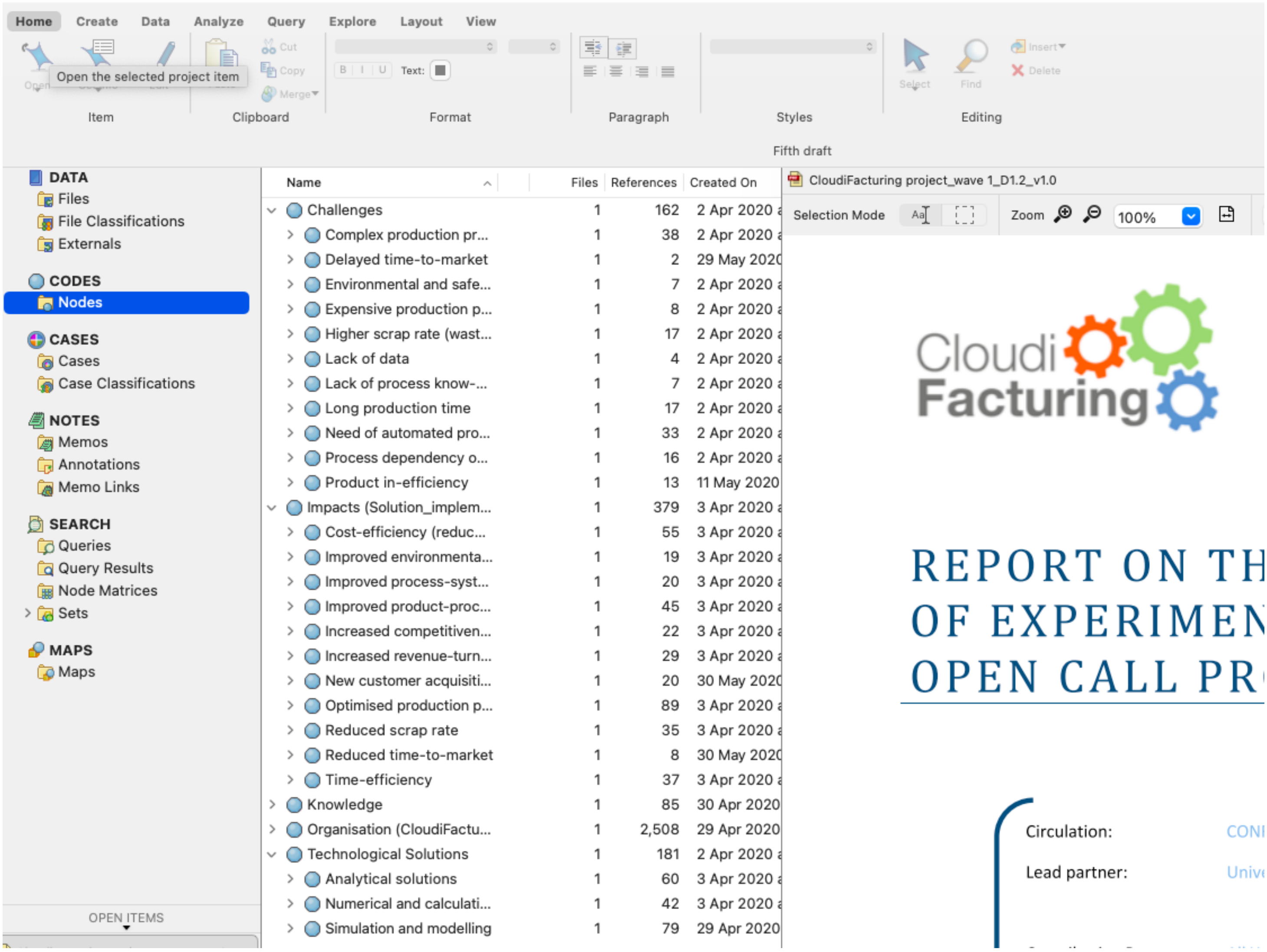


Figure A2 Second Cycle Coding

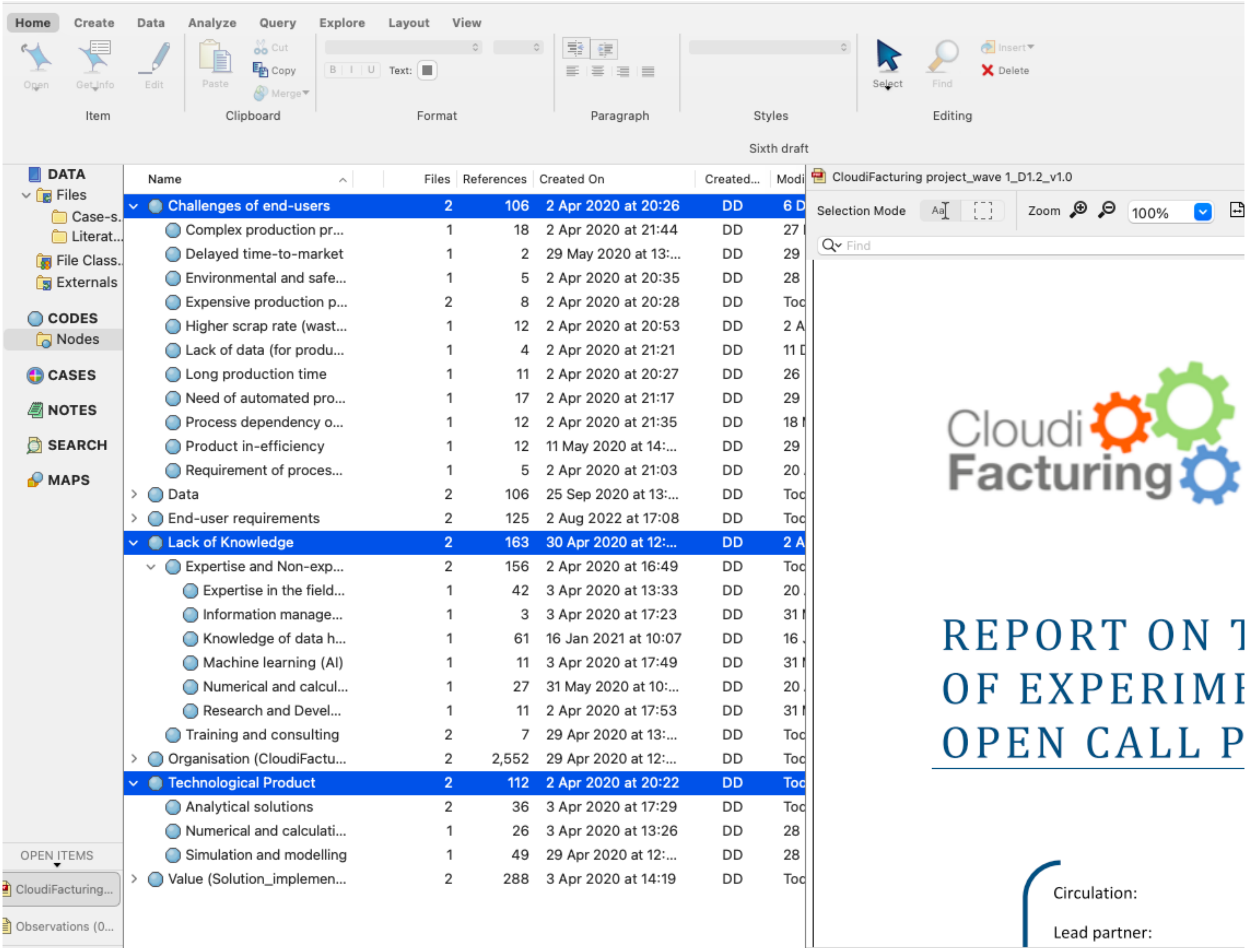


Figure A3 Sorting and Merging Codes - 1

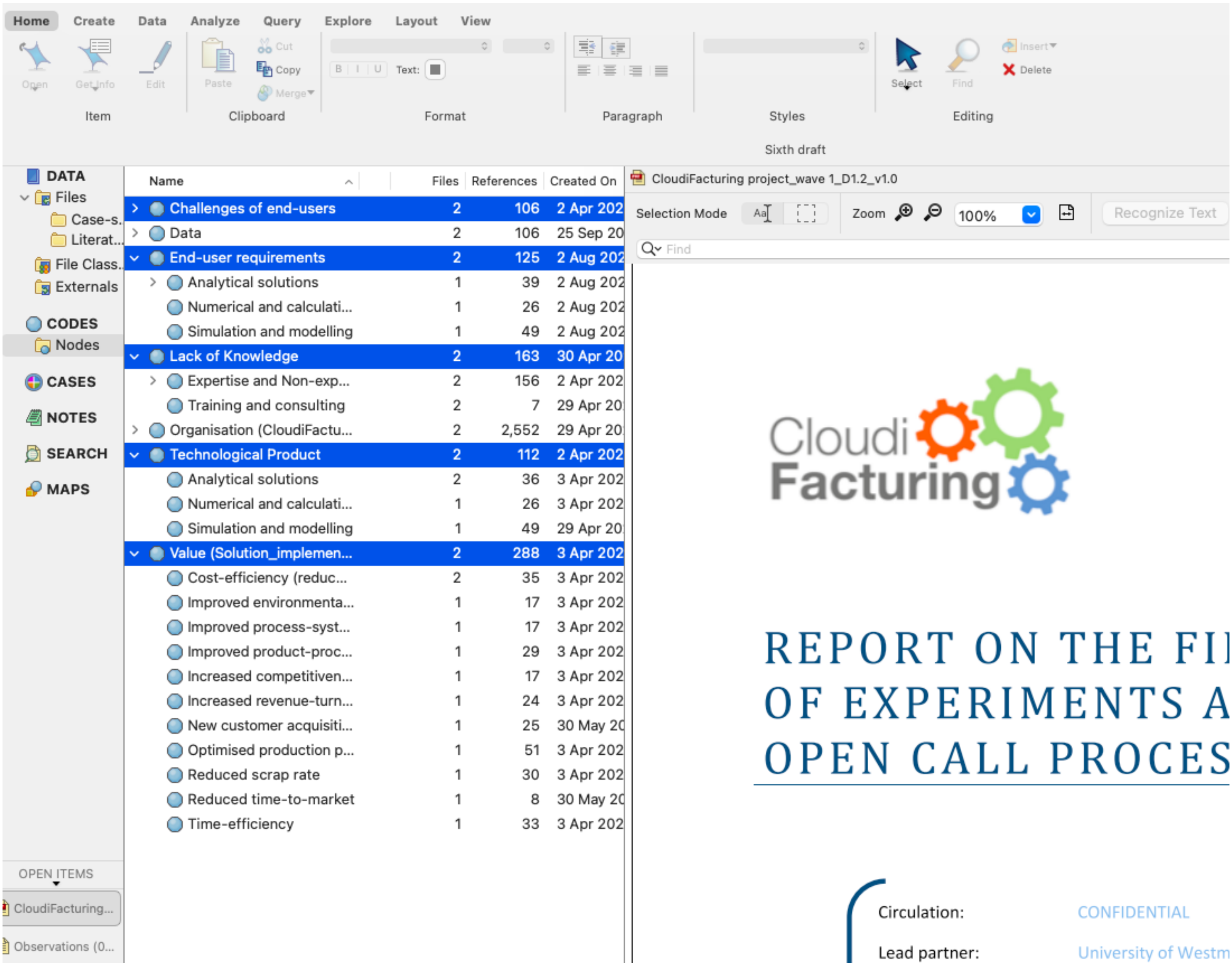


Figure A4 Sorting and Merging Codes - 2

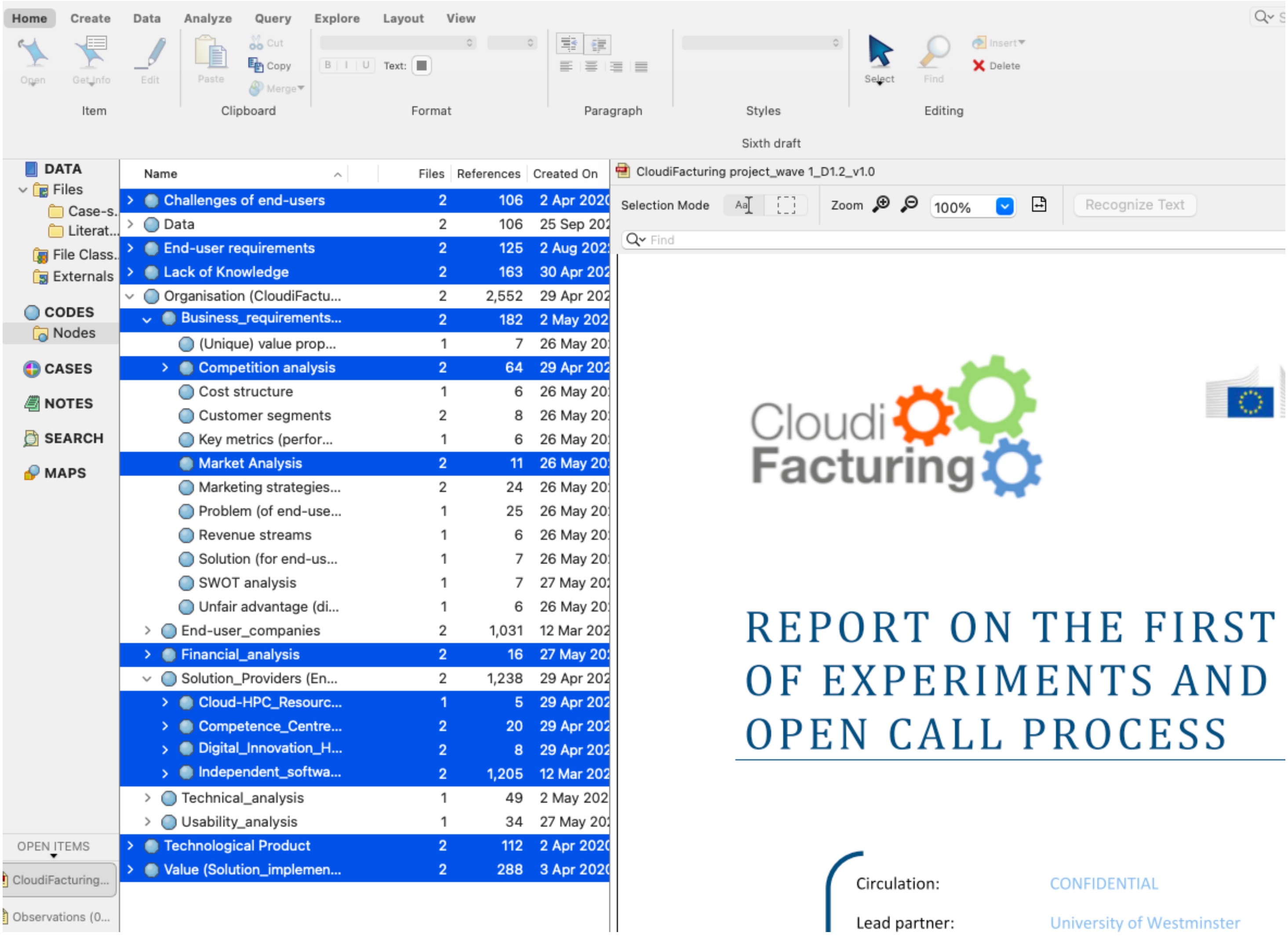


Figure A5 Sorting and Merging Codes - 3

Appendix B - A Brief and Filtered Observation to the Case

An overview of case relevance observations (approximately 12 meetings in 15 weeks):

I joined the CloudiFacturing (CFG) project as a ‘Research Associate’ for 12 weeks contract through the University of Westminster (Leader of the Project). I worked a few weeks extra to finalise the work I was given. My main role was to assist a team (competence centre specified for business modelling and technical requirements) and contribute to the development of the business model for the digital marketplace (that was under development and part of the CFG features). I got access to the various documents (related to the project), project meeting notes, and a platform to observe different companies' perceptions. Although the meetings, were organised to discuss the business model of the CFG digital marketplace during my time at CFG, a careful discussion is observed for the first wave of the experiments (CloudiFacturing, no date):

Context of the project

The CFG project organises a set of valuable Cloud and HPC-based technological services to support SMEs: both end-user companies (manufacturing) that consume the technological services and ISVs/VARs that develop those solutions exploiting the CFG platform. The project runs 21 experiments in 3 waves, where ISVs develop and deploy ICT solutions through the CFG platform for the end users. I was involved in the project particularly during the first wave of experiments when the first 7 experiments were run. In addition to the exclusive objective of developing and integrating the solution from the ISV to the end users, the experiments allow the shaping of the design of the CFG platform, and its services both from a business as well as a technical point of view.

Project’s objective and method

The aim of the consortium is to develop a viable and scalable business model for the CFG project so that the platform can successfully be running and grow past the period of the European funding. First of all, the complete analysis of the context along with the trends and market will allow deriving a proper vision and mission statement for the CFG platform. This will also include the analysis of the competition (direct, indirect, different technologies, business analysis such as methods) and different trends of business models already in place by different and/or similar value propositions on the market. Most importantly, the financial planning (i.e., profit & loss) and a roadmap of the CFG platform needs to be accessed in order to achieve the sustainability of business model chosen.

Business model choice (i.e., methodology & not revenue model)

Lean Canvas Model is chosen as a business model development methodology. It was implied by business representatives of CFG that they found through the market analysis and considered the ‘Lean Canvas Model’ as a common choice among firms these days. During a meeting, I enquired about the reason, but they did not have a conclusive answer. I also questioned the type of organisations they analysed for the business model decision. They were not sure if it really matters. The most emphasis was that the Lean Canvas Model was popular, and for them, analysis seemed to be satisfactory. Nevertheless, when I assess the previous meeting notes and other project documents, I understood that the business analysis was conducted in iterations with the input of highly experienced representatives that work in the field for several years.

Focus on market and competition analysis

While I joined a few other project meetings to discuss business model analysis for the digital marketplace, the discussion mostly covered new trends, technological competition, the use of cloud technology for innovative solutions, and revenue generation tasks. I was also involved to conduct the market and competition analysis to find the recent trends and I have also presented the direct, in-direct competition for cloud/HPC-based applications. This competition and market analysis helped in improving the set offerings for the end-users both in terms of performance and cost.

The analysis allowed us to discover new trends of collaborations and the exchange of technical information between companies to reach innovation potential. The competence centres (research institute and R&D) and technology organisations were so convinced with the fact that some selective companies (including ISVs and other technology companies that were assessed as competition and that develop innovative unique solutions can be contacted and proposed to collaborate within the CFG project.

The 3-day meeting includes all stakeholders (End-uses, ISVs and other CFG partners)

12 conference calls have been organised by the CFG consortium, where each stakeholder is involved for their input, to discuss the progress of the project, as well as any issues related to experiments and using the CFG platform. I only attended the one which was organised at the University of Westminster in October 2019. Although my contract ended in September 2019, I was involved in due tasks related to business modelling until they were finalised (such as market trends related to new cloud solutions, and competition analysis).

It is perceived that end-user companies were facing a lot of issues understanding the running of the simulation solutions through cloud-HPC resources and requiring constant communications to their respective ISVs. While research and technology organisations (like research institutes and DIHs) are involved in proving support to both ISVs and end-users, some end-users seem concerned about the working and usage of solutions in the future when they don't have close support from ISVs and DIHs beyond the project. It was explained to them these services would be provided in the same manner (for a charge) and there will be consultancy services available throughout.

I engaged in a conversation with 2 end-user companies (Manufacturer 3 and Manufacturer 8) on day 3 of the meeting, during a tea break asking how they are getting on with the experiments, as well as my colleagues that were involved in the collection and representation of business requirements and business modelling. These are two special competence centres (in addition to 30 companies I conducted empirical analysis on). I also got involved in a conversation with my colleagues regarding financial analysis (focusing mainly on generating revenue), which was carried out (during the last few weeks) to finalise the business model for digital analysis, where they specified how crucial is to conduct financial analysis in line with the competition analysis. We further discussed how the combination of disruptive technologies (e.g., cloud, AI, Big data, IoT) offers innovative technological solutions, which are also very economical, so staying sustained in terms of both technicality and economically is significant. Also, establishing new collaborations to exchange information and share competencies is highly economical. When I questioned, how they assess who to collaborate and which capabilities to share, they said they knew with the years of experience as well as continuous market and competition analysis.

The representative of Manufacturer 3 expressed that during the start of the meeting (he referred to day 1), he was concerned about the analytics modelling developed as a solution for their company. He felt the solution included a new concept and was expensive, Nevertheless, when having a group discussion with its respective ISV, DIH and Competence Centres, he was made aware of the superior functionalities of the system, available consultancy services and different usage options.

Manufacturer 8 seemed satisfied, the representative of Manufacturer 8 articulated that although they did not possess knowledge of the technicality of the cloud, however, the solution offered by ISV is significantly promising. The solution requires financial investment however, it will be still less than the cost of buying huge infrastructure and the wastage (due to the number of issues that occur in the production line), which also delay production.

After a few days of the above 3-day meeting, the business model construction was put on hold for a few days, due to the call arrangements for the second wave of experiments and, by then my journey with the CFG project was completed. Thus, I did not have the right to attend any project meetings later and had no access to the meeting notes, nevertheless, I still have the access to the comprehensive project documents.

Appendix C – Matrix Query to view the interrelationship of Sociomaterialty and Technological Solution & Business Model

Matrix - challenges against artefacts

End-user Challenges ↓ / Artefact (Solutions) →	A : Analytical solutions	B : Numerical and calculation based solutions	C : Simulation and modelling
1 : Complex production process	3	1	2
2 : Delayed time-to-market	0	0	0
3 : Environmental and safety issues	0	0	0
4 : Expensive production process	0	0	0
5 : Higher scrap rate (wastage)	1	0	0
6 : Lack of data	1	0	1
7 : Lack of process know-how using artefacts	1	1	1
8 : Long production time	0	0	0
9 : Need of automated processes	3	1	3
10 : Process dependency on human agents (experience or involvement)	2	1	2
11 : Product in-efficiency	1	0	0

Table A1: Matrix Query for Challenges against Artefacts

Matrix - knowledge against artefacts

Knowledge (Expertise) ↓ / Artefact (Solutions) →	A : Analytical solutions	B : Numerical and calculation based solutions	C : Simulation and modelling
1 : Cloud-HPC based solutions	21	18	33
2 : Data analytics (Big data)	35	16	31
3 : Information management systems	1	0	2
4 : Machine learning (AI)	1	0	8
5 : Numerical and calculation based solutions	17	26	22
6 : Research and Development	3	1	6
7 : Simulation and modelling	27	22	49
8 : Training and consulting	2	1	3

Table A2: Matrix Query for Knowledge against Artefacts

Matrix - impacts against artefacts

Solution Impact ↓ / Artefact (Solutions) →	A : Analytical solutions	B : Numerical and calculation based solutions	C : Simulation and modelling
1 : Cost-efficiency (reduced costs)	6	5	11
2 : Improved environmental impact	0	2	2
3 : Improved process-system know-how	2	3	6
4 : Improved product-process quality	9	5	12
5 : Increased competitiveness	3	1	3
6 : Increased revenue-turnover	2	3	4
7 : New customer acquisition	1	0	1
8 : Optimised production process	16	8	21
9 : Reduced scrap rate	8	2	8
10 : Reduced time-to-market	0	1	1
11 : Time-efficiency	8	3	10

Table A3: Matrix Query for Impacts against Artefacts

Matrix - organisation against artefacts

Organisation ↓ / Artefact (Solutions) →	A : Analytical solutions	B : Numerical and calculation based solutions	C : Simulation and modelling
1 : Business_requirements_analysis	20	14	27
2 : End-user_companies	27	15	36
3 : Financial_analysis	0	0	0
4 : Solution_Providers	36	26	49
5 : Technical_analysis	1	0	1
6 : Usability_analysis	2	2	2

Table A4: Matrix Query for Organisation against Artefacts

Matrix - challenges against knowledge

End-user Challenges ↓ / Knowledge (Expertise) →	A : Cloud-HPC based solutions	B : Data analytics (Big data)	C : Information management systems	D : Machine learning (AI)	E : Numerical and calculation based solutions	F : Research and Development	G : Simulation and modelling	H : Training and consulting
1 : Complex production process	1	4	0	0	1	0	2	0
2 : Delayed time-to-market	0	0	0	0	0	0	0	0
3 : Environmental and safety issues	0	0	0	0	0	0	0	0
4 : Expensive production process	0	0	0	0	0	0	0	0
5 : Higher scrap rate (wastage)	1	1	0	0	0	0	0	0
6 : Lack of data	1	1	0	0	0	0	1	0
7 : Lack of process know-how using artefacts	1	1	0	0	1	0	1	0
8 : Long production time	0	0	0	0	0	0	0	0
9 : Need of automated processes	3	4	0	0	1	0	3	0
10 : Process dependency on human agents (experience or involvement)	0	3	0	0	1	0	2	0
11 : Product in-efficiency	1	1	0	0	0	0	0	0

Table A5: Matrix Query for Challenges against Knowledge

Matrix - challenges against impacts

End-user Challenges ↓ / Impacts →	A : Cost-efficiency (reduced costs)	B : Improved environmental impact	C : Improved process-system know-how	D : Improved product-process quality	E : Increased competitiveness	F : Increased revenue-turnover	G : New customer acquisition	H : Optimised production process	I : Reduced scrap rate	J : Reduced time-to-market	K : Time-efficiency
1 : Complex production process	0	1	1	2	0	0	0	4	2	0	1
2 : Delayed time-to-market	0	0	0	0	0	0	0	0	0	0	0
3 : Environmental and safety issues	0	1	0	0	0	0	0	1	0	0	1
4 : Expensive production process	0	0	0	0	0	0	0	0	0	0	0
5 : Higher scrap rate (wastage)	0	1	1	1	0	0	0	2	2	0	1
6 : Lack of data	1	0	0	0	1	1	1	1	2	0	1
7 : Lack of process know-how using artefacts	1	0	0	1	0	0	0	1	0	0	0
8 : Long production time	0	1	1	0	0	0	0	2	1	0	1
9 : Need of automated processes	2	1	0	3	1	1	1	5	3	0	2
10 : Process dependency on human agents (experience or involvement)	0	1	0	1	0	0	0	3	0	0	1
11 : Product in-efficiency	0	0	1	1	0	0	0	1	2	0	0

Table A6: Matrix Query for Challenges against Impacts

Matrix - challenges against organisation

End-user Challenges ↓ / Organisation →	A : Business_requirements_analysis	B : End-user_companies	C : Financial_analysis	D : Solution_Providers	E : Technical_analysis	F : Usability_analysis
1 : Complex production process	18	18	0	8	0	0
2 : Delayed time-to-market	2	2	0	1	0	0
3 : Environmental and safety issues	5	5	0	2	0	0
4 : Expensive production process	7	7	0	3	0	0
5 : Higher scrap rate (wastage)	12	12	0	5	0	0
6 : Lack of data	3	3	0	2	0	0
7 : Lack of process know-how using artefacts	5	5	0	3	0	0
8 : Long production time	11	11	0	4	0	0
9 : Need of automated processes	17	17	0	9	0	0
10 : Process dependency on human agents (experience or involvement)	12	12	0	5	0	0
11 : Product in-efficiency	12	12	0	5	0	0

Table A7: Matrix Query for Challenges against Organisation

Matrix - impacts against knowledge

Impacts ↓ / Knowledge →	A : Cloud-HPC based solutions	B : Data analytics (Big data)	C : Information management systems	D : Machine learning (AI)	E : Numerical and calculation based solutions	F : Research and Development	G : Simulation and modelling	H : Training and consulting
1 : Cost-efficiency (reduced costs)	9	6	0	2	5	0	11	0
2 : Improved environmental impact	3	0	0	0	2	0	2	0
3 : Improved process-system know-how	4	2	0	2	3	2	6	0
4 : Improved product-process quality	7	12	0	2	5	1	13	0
5 : Increased competitiveness	4	3	0	0	1	0	3	0
6 : Increased revenue-turnover	5	2	0	0	3	1	4	0
7 : New customer acquisition	1	1	0	1	0	0	1	0
8 : Optimised production process	17	20	1	4	8	4	22	1
9 : Reduced scrap rate	6	8	0	1	2	0	8	0
10 : Reduced time-to-market	1	0	0	0	1	0	1	0
11 : Time-efficiency	9	9	1	1	3	1	10	1

Fig A8: Matrix Query for Impacts against Knowledge

Matrix - impacts against organisation

Impacts ↓ / Organisation →	A : Business_ requirements_ analysis	B : End-user _companies	C : Financial_ analysis	D : Solution_ Providers	E : Technical _analysis	F : Usability_ analysis
1 : Cost-efficiency (reduced costs)	13	32	0	24	0	0
2 : Improved environmental impact	7	16	0	10	0	0
3 : Improved process-system know-how	4	13	0	13	0	0
4 : Improved product-process quality	12	29	0	23	0	0
5 : Increased competitiveness	5	13	0	11	0	0
6 : Increased revenue-turnover	4	17	0	17	0	0
7 : New customer acquisition	14	11	0	19	0	0
8 : Optimised production process	17	51	0	36	1	1
9 : Reduced scrap rate	12	29	0	18	0	0
10 : Reduced time-to-market	4	8	0	5	0	0
11 : Time-efficiency	12	31	0	23	0	0

Fig A9: Matrix Query for Impacts against Organisation

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