Loughborough University

Developing Digital Transformative Capabilities of Industrial Businesses by Leveraging the Industrial Internet of Things

by
Swapan K Ghosh

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I dedicate this thesis to my wife Natalie

and to my children

Mikey, Salma and Shweta

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ABSTRACT

Industrial businesses are going through a period of digital disruption and firms are under severe pressure to undertake Digital Transformation and leverage the Industrial Internet of Things (IIoT). Yet, there is next to no scholarly guidance for such an endeavour. Most industrial firms are developing their Digital Transformation strategies, however, they are not sure what kind of capabilities they should develop for such transformation.

Though there is limited academic literature about Digital Transformation and how firms are developing digital transformative capabilities, a systematic literature review was performed to disentangle capability transformation processes and how firms are developing dynamic capabilities to remain competitive in a high-velocity environment. The current study extended dynamic capability theory and proposed digital transformative capabilities (DTCs) for Digital Transformation. To understand the IIoT landscape and how it influences Digital Transformation, an industry review was performed.

The research was conducted in two phases. Based on the literature review and industry review, in the first phase, two qualitative exploratory studies were performed. The preliminary exploratory study was conducted to get an understanding of the IIoT landscape and how firms were developing capabilities for transformation. Based on the insights from preliminary exploratory study, a detailed exploratory study was performed which revealed critical themes for Digital Transformation and, based on these themes, a conceptual framework for Digital Transformation was derived. The conceptual framework was divided into two models. The front-end model

identified three DTCs (Business Model Transformation, Operating Model Transformation and Cultural Transformation), three inputs (Digital Twin, Digital Thread and Digital Mindset) and the factors influencing the DTCs. The back-end model examined the influence of DTCs on dynamic capabilities, which may be indicative of digital transformation in a company.

In the second phase, these two models were tested through a quantitative analysis, utilizing data generated from 107 respondents from 87 industrial companies via a self-reported online questionnaire and the application of multiple linear regression analysis.

The Digital Twin is widely touted as an important input for DTC but the result did not support that. Digital Thread as an input for DTC was supported and Digital Mindset as an input for DTC was partially supported. Using moderator analysis, important insights were identified. The moderators, Technology Turbulence, Market Turbulence, Competitor Turbulence and Path Dependency had some positive moderation effects. The positive influence of 'DTC – Business Model Transformation' on dynamic capabilities which may be indicative of digital transformation in a company was not supported. However, the positive influence of 'DTC – Operating Model Transformation' was supported and 'DTC – Cultural Transformation' was partially supported. The moderation effects of ecosystem partnership and resource scarcity and constraints were partially supported, and the moderation effects of customer and market demands and digital commitment were not supported or refuted.

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1.0: Introduction

This thesis reports a study of capabilities required for Digital Transformation. The fundamental aim of this thesis is to empirically examine the development of digital transformative capabilities, contingent factors involved and offer a new measurement system for capturing data on Digital Transformation, by leveraging the Industrial Internet of Things (IIoT). This chapter presents the background of the research and research gaps (theoretical and empirical) for digital transformative capabilities and Digital Transformation first, followed by discussions about research aims, objectives, research questions and the significance of the study. Lastly, the organization of the chapters is presented.

1.1 Background of Research

Industrial businesses are going through Digital Transformation. The Industrial Internet of Things (IIoT), or Industrial Internet, is a common terminology for industrial managers across industries. Industrial managers are starting Digital Transformation initiatives rapidly and leveraging IIoT for transformation. However, these two concepts and their interactions are still not clear to many industrial managers.

The academic definition of Digital Transformation is still evolving and, according to Matt et al. (2015), Digital Transformation is the transformations of key business operations, processes, products and its impact on organization structures by using digital technologies. Other researchers (Zhu et al., 2006) suggest that Digital Transformation is responsible for technology-based innovations, whereas, Kane et al. (2015) argue that enterprise strategy and not technology drives Digital Transformation. Researchers such as Bygstad et al. (2017) have taken an information technology (IT) related view of Digital Transformation. Based on their study on Scandinavian businesses, the researchers suggest that Digital Transformation deals with the redesign of business processes by innovative usage of IT.

Industrial businesses have embraced Digital Transformation for the last four to five years. The World Economic Forum (WEF) launched Digital Transformation initiative research in 2015. According to the WEF (2018) Digital Transformation is redefining customer expectations and enabling businesses to meet those expectations by using new and advanced technologies. Digital transformation has immense potential to change our lives, create tremendous value for businesses and will have a strong impact on society. According to Gruman (2016), Digital Transformation is the application of digital technologies which can fundamentally impact all businesses and society;, Edmead (2016) suggests that Digital Transformation is the acceleration of business processes, capabilities and competencies to leverage digital technologies and their impacts in a strategic and prioritized way.

The term "Industrial Internet", or IIoT, was coined by GE in 2012. The Industrial Internet[1] is the network of diverse industrial devices, connected by communication technologies such that the systems can monitor, collect, exchange and analyse business insights which can help in driving smarter and faster business decisions for industrial companies. According to Jeschke et al. (2016), IIoT is an industrial information network of physical objects (sensors, cars,

[1] https://www.ge.com/digital/blog/everything-you-need-know-about-industrial-internet-things

machines, buildings, and other items) which allows interactions and cooperation of these objects for common industrial goals. Another term, "Industry 4.0", is synonymous with Industrial Internet. In 2011, this term was proposed by German businesses and industries[2]. Industry 4.0 is referred to as the fourth industrial revolution. Lasi et al. (2014) suggest that technological advances have led to paradigm shifts in industrial businesses, starting from mechanization (the first industrial revolution), to the usage of electrical energy (the second industrial revolution), to extensive use of machine-to-machine communication and digitization (the third industrial revolution) and finally to advanced digitization in factories by combining the internet with emerging connected technologies (the fourth industrial revolution).

Though industrial businesses are scrambling to develop their Digital Transformation strategies by leveraging the Industrial Internet, to my knowledge there is no conceptual framework among academics to illustrate and unpack the nomological network of Digital Transformation. This study has extended dynamic capability theory to understand the capability requirements for Digital Transformation. In strategic management, dynamic capability research is rapidly expanding to explain how firms are developing sustained competitive advantages (Teece, Pisano and Shuen, 1997; Teece, 2007; Augier et al., 2009; Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Zott, 2003). Though researchers are showing great interest in dynamic capabilities, there is no generic purpose dynamic capability for all situations (Ethiraj et al., 2005) and researchers have studied specific purpose dynamic capabilities, such as project management capabilities (Ethiraj et al., 2005), new product

[2] https://www.cleverism.com/industry-4-0/

development capabilities (Deeds et al., 2000; Winter, 2003; Mu et al., 2009), product innovation capability (Slater et al., 2014; Teece, et al.,2016) and alliance management capability (Schilke, 2014; Wang and Rajagopalan, 2015).

Digital transformation is disrupting industrial businesses, however, to the best of my knowledge, there is no study related to digital transformative capabilities (DTC) which can influence Digital Transformation. As a practitioner, I have been involved in Digital Transformation projects for the last couple of years and I could not find any academic or systematic business guidance to deal with Digital Transformation and how firms should develop these capabilities, such that they can remain competitive during this turbulent time. This study is an attempt to address this shortfall by defining DTCs, the inputs and contingencies for DTCs and how DTCs influence Digital Transformation.

My interest in this study started by observing Digital Transformation initiatives in industrial businesses and how firms are not well equipped to deal with Digital Transformation challenges in their organizations. There are limited academic studies related to Digital Transformation and yet businesses are making big claims about Digital Transformation. GE[3] suggested that saving one percent ("power of one") from industrial businesses can save more than $200B in the next fifteen years from five major businesses. Time and again, leading business journals cited big economic impacts of Digital Transformation. According to Marketwatch[4], the market size of Digital Transformation is projected to be around $462B by 2023. The leading market research

[3] https://www.ge.com/docs/chapters/Industrial_Internet.pdf
[4] https://www.marketwatch.com/press-release/digital-transformation-market-size-is-projected-to-be-around-us-462-billion-by-2023-2018-08-23

firm IDC[5] has projected that businesses will spend $662B in 2018 on Digital Transformation. Though leading business journals believe that Digital Transformation will change the industrial landscape, in reality, industrial managers are cautiously optimistic about this transformation. All industrial businesses have started Digital Transformation projects with much fanfare, but due to lack of guidance, managers are not clear how to harness Digital Transformation.

To address this problem, this study reviewed the existing literature related to Porter's view, the resource-based view (RBV) and dynamic capability view of competition. Based on this review, it was realized that the dynamic capability framework would be appropriate to understand digital transformative capabilities for a firm and Teece's standpoint of sense, seize and reconfigure transformation is adopted as the perspective on dynamic capability.

1.2 Research Aims, Gaps and Objectives

In this section, research aims, gaps and objectives are discussed. A detailed discussion of the research focus is presented in the literature review (section 2.7).

As discussed in the previous section, there is limited academic study in the Digital Transformation area and firms need academic and managerial guidance to face Digital Transformation challenges. Firms are developing new dynamic capabilities and reconfiguring existing operational capabilities for competitive advantages (Teece, 2007; Eisenhardt and Martin, 2000, Winter, 2003), however, firms need specific guidance for developing dynamic capabilities for Digital Transformation. So, the aim of the research is to develop a conceptual model for

[5] https://www.idc.com/getdoc.jsp?containerId=prUS43381817

Digital Transformation and to guide industrial businesses in their Digital Transformation journeys.

The research study plans to look at Digital Transformation through the dynamic capability lens and identify capabilities needed for Digital Transformation. To fulfil the research aims, the study has identified the **first research gap** related to identification of DTCs for Digital Transformation.

Though firms are discussing different Digital Transformation initiatives, such as Digital Twin (Tao et al., 2018; Boschert et al., 2016; Glaessgen et al., 2012) and Digital Thread (Helu, et al., 2017; Hedberg et al., 2016; Nassar et al., 2013), these initiatives are more fragmented and used in certain aspects of industrial manufacturing and they are not well connected with Digital Transformation initiatives. Similarly, businesses have been discussing Digital Twin[6] and Digital Thread[7] for the last couple of years. However, there is limited discussion about the influence of these initiatives and inputs for developing DTCs. There is also limited discussion about the internal and external contingencies affecting DTCs. Thus, the **second research gap** is related to the inputs, contingencies and factors affecting DTCs.

Most of the measurements of the dynamic capabilities are related to firm performance, especially financial performance or related to specific aspects of business, such as productivity

[6] https://www.ge.com/digital/applications/digital-twin; https://www.ibm.com/blogs/internet-of-things/iot-cheat-sheet-digital-twin/

[7] https://www.nist.gov/sites/default/files/documents/el/msid/1Kraft_DigitalThread.pdf; https://go.oracle.com/LP=67651

improvements. Macher et al. (2009) studied the influence of new process improvement dynamic capabilities in semiconductor manufacturing. Pavlou et al. (2006) have studied NPD capabilities and developed measurement models based on improvements in product quality, process efficiency and also financial measures such as increase in revenue and percentage sales spent on R&D activities. Xinchun et al. (2006) studied 29 Chinese firms and measured dynamic capabilities based on marketing potential, organizational flexibility, strategic isolation, organizational learning and organizational innovation. Since Digital Transformation initiatives are relatively new to industrial businesses, there is limited financial performance data available for research and the study has identified the development of a measurement framework for DTCs as the **third research gap**.

Based on these research gaps, the study has identified three research objectives including extending dynamic capability for Digital Transformation and conceptualizing and developing DTCs, identifying inputs, contingencies and influence of internal and external factors affecting DTCs, and developing a measurement framework for Digital Transformation.

As firms are going through digital disruption and businesses are developing Industrial Internet/Industry 4.0 strategies, they should develop dynamic capabilities for Digital Transformation, so the first research objective is:

To conceptualize and develop digital transformative capabilities for Digital Transformation *by leveraging the Industrial Internet.*

As mentioned in the previous section, Digital Twin and Digital Thread related Digital Transformation projects are being funded in a rapid manner in industrial businesses and managers are discussing cultural aspects of Digital Transformation [8]. Thus, the second objective of the study is:

To identify the inputs and contingencies for DTCs and to access the influence of external and internal factors on DTCs.

Measuring the effects of dynamic capability is difficult and most often direct measures are not available. Since Digital Transformation initiatives are relatively new to organizations, measuring the effects of dynamic capability on Digital Transformation is further complicated. So, the third objective of this study is:

To develop a measurement framework for Digital Transformation *and the internal and external factors which could affect the transformation.*

1.3 Nature and Significance of the Study

This study adopts a mixed methods approach, and initially a preliminary exploratory study (qualitative) is conducted to understand the Digital Transformation landscape and capabilities required for Digital Transformation, followed by a detailed exploratory study (qualitative) to

[8] https://www.bcg.com/en-us/publications/2018/not-digital-transformation-without-digital-culture.aspx; https://go.forrester.com/blogs/prioritize-culture-change-to-accelerate-digital-transformation/

conceptualize the research questions and come up with a set of hypotheses, and finally a survey based quantitative study is performed to test and analyse the hypotheses.

In addressing the research gaps, the study intends to make key contributions to the academic literature and provides guidance to practitioners who are engaged in Digital Transformation.

To the best of the author's knowledge, this study is pioneering academic study to unpack the nomological networks of Digital Transformation and aims to advance the knowledge of dynamic capabilities and its effect on Digital Transformation. The study plans to develop a conceptual framework for DTC and to explain how it can affect Digital Transformation. The study aims to conceptualize DTCs, develop a digitalization profile for an organization and identify contingencies for DTCs. The study also plans to identify external and internal factors which could influence the digitalization profile and DTCs. Thus, this study aims to extend the body of knowledge in strategic management related to Digital Transformation. Lastly, the development of a management framework to understand the degree of Digital Transformation in an organization is a methodical contribution to the body of knowledge related to Digital Transformation. The similar measurement framework can be applied to other management studies where direct measurements are not available.

The study aims to contribute significantly to the work of industrial managers. Industrial managers can use the conceptual framework and develop necessary dynamic capabilities needed for Digital Transformation. Managers can evaluate their digitalization profile and develop strategies to enhance their profile for successful Digital Transformation. The study aims to highlight internal and external factors which can have significant impacts on DTCs and Digital Transformation and managers should be aware of those factors and plan mitigation strategies to overcome the challenges.

1.4 Thesis Structure

To fulfil the research objectives identified in the previous sections, the research is implemented in a sequential manner (Figure 1). The thesis is organized in ten chapters and each chapter has its individual focus; chapters are connected with each other in a logical manner.

Chapter one presents the background of the research, research gaps and objectives, the significance of the research and its overall contribution for academicians and practitioners.

Chapter two reviews important strategic management literature related to the resource-based view (RBV), the dynamic capability view (DC) and competitive strategy. The study aims to develop DTC as an extension of dynamic capability, so all relevant literature of DC, including operational capability and RBV, are reviewed. Teece's (2007) DC framework of sensing, seizing and reconfiguration, has been identified to conceptualize DTCs. Finally, after reviewing all related literature, research gaps are identified and conclusions are drawn for moving forward towards the conceptual model.

Chapter three represents the current definition and landscape of the industrial internet. It also describes the different components of the Industrial Internet, leading Industrial Internet software platforms and finally introduces Digital Transformation, different phases of Digital Transformation and how Digital Transformation leverages the Industrial Internet.

Chapters four and five describe the qualitative study. Chapter four presents the preliminary exploratory study. Based on the literature review and industry review, the preliminary study investigates how industrial managers are treating capabilities including dynamic and operational capabilities and how new transformative capabilities are generated during digital disruption. Chapter five describes the detailed exploratory study. Based on the findings from the preliminary exploratory study, the detailed exploratory study explores the formation of digital transformative capabilities and the factors which influence these capabilities. This study intends to bridge the gap between literature survey, industry review, conceptualization and the hypotheses development phase. It identifies a series of themes that are interrelated in depicting the challenges and conditions for dynamic capability transformation.

Chapter six provides a conceptualization framework of DTC and illustrates different hypotheses for DTCs and DCs which help in Digital Transformation. The conceptual model of Digital Transformation has been divided into two parts: the front-end model, which represents DTCs, inputs, contingencies and factors affecting DTCs, and the back-end model, which represents a measurement framework based on the importance, improvements and comparison of DCs which conceptualizes the degree of Digital Transformation in a company.

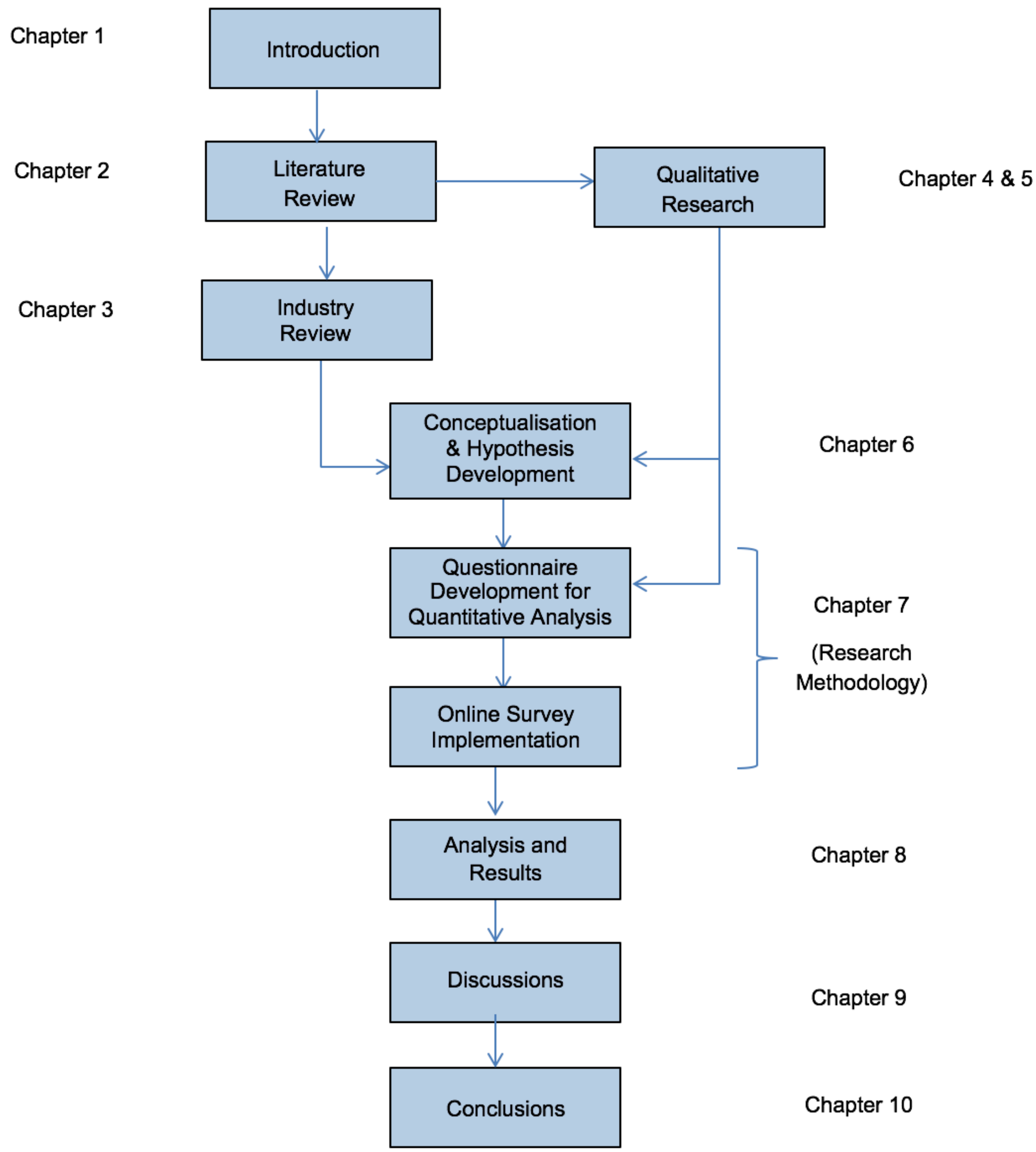
Based on the conceptual framework, preliminary exploratory analysis and detailed exploratory analysis, chapter seven deals with the research methodology including research designs, data collection methods and sampling issues. The chapter also discusses the questionnaire design, construct measurements, survey design and analytical procedures to test the hypotheses for this study. I have applied mixed research method for this study where I have applied qualitative study to understand the formation and development of digital transformative capabilities and developed a conceptual framework for Digital Transformation. I have applied quantitative analysis to test the hypotheses developed in the conceptual framework. The quantitative study is discussed in chapter seven.

Chapter eight provides a data analysis process and the results of the data analysis. The chapter describes the exploratory factor analyses (EFA) for front-end and back-end models. After EFA, reliability and collinearity analyses are discussed and finally conceptual model tests using linear regression analyses (using SPSS) are presented.

Chapter nine presents the discussion of the hypotheses based on the interpretations of regression analysis models. These discussions focus on the comparison of the results from this study with the relevant management theories related to DTCs and Digital Transformation.

Finally, chapter ten presents the conclusion of the study. The chapter discusses the summary of the research, theoretical and managerial contributions, limitations and the scope for future research directions.

Figure 1: Structure of the Thesis



2.0: Literature Review

After reviewing important strategic management literature in dynamic capability and competitive strategy, I present my review and views based on my critical assessment of the important theories in this area. I have identified problems and research gaps in the current literature and formulate my research questions for investigation in the subsequent chapters. This literature review is the conceptual foundation of my research work.

2.1 Competitive Advantage in a Changing Market

Strategic management research scholars are always thinking about competitive advantage. It is an important matter because generating and maintaining competitive advantage creates potentially sustainable performance differences between a firm and its rivals. It is that performance heterogeneity that is fundamental cornerstone of strategic management and its study (Teece et al., 1994).

In a high-velocity environment, demand, competition and technology change rapidly and those changes are typically disruptive. The information about the changes taking place is typically inaccurate, unavailable or obsolete (Bourgeois and Eisenhardt, 1988). When allied to innovation, such disruptions can cause further complexity in which patterns and expectations about markets, events, competitors and consumers change in non-deterministic ways (Sargut and McGrath, 2011).

Within these circumstances, strategy scholars are interested to know how and why some firms can develop and maintain persistent performance difference over and above their competitors during this kind of market environment. Whether these advantages are sustainable (Teece et al., 1994) or temporary (D'Aveni, Dagino and Smith, 2010) would determine the competitive strategy of a firm. D'Aveni et al. (2010) suggest that the temporary natures of competitive advantage are attributed to globalization, technological changes, industry convergence, competitive behaviour, deregulation and privatization.

Early strategy scholars (Teece et al., 1994) suggest that sustainable competitive advantage exists as they assume the relative stability of the market environment. However, in an emerging and evolving high technology industry, continuous strategic changes are essential for their existence as their environments are unpredictable (Christensen, 1997). Christensen suggests that the industry never reaches maturity such that firms must innovate, implement, cannibalize and re-innovate their products and services in a changing environment. Business leaders in technology industries are continually trying to re-invent their products and services to remain competitive. For example, a company like Apple introduces new products or services in a six- to twelve-month time frame and Intel brings new microprocessors in 12 to 18 months. Though a firm may develop some core capabilities in these dynamic environments and gain some competitive advantages, contemporary arguments in the field of strategic management hold that those advantages are at best temporary (D'Aveni et al., 2010; McGrath, 2013), Nevertheless, the pathway to competitive advantage comes from a firm's competitive strategy.

To explain competitive strategy, I present two important strategy frameworks for competitive advantage. First, Porter (1980, 2008) developed an industry-centric view of sustained competitive advantage. According to his work, a firm can develop a sustained competitive advantage if it can effectively manage supplier and buyer powers, has marginal threat from substitutes, less rivalry from competitors and high barrier(s) to entry such that new entrants do not (or cannot) enter the market on a regular basis. His theory also suggests that economic rents are created at the industry level and not at the firm level.

However, in a rapidly changing uncertain market, industry structures change frequently and the lines separating industries get blurred. A modern example of this problem is the Internet of Things (IoT) and the cloud-computing ecosystem. In both cases, it is difficult to cleanly identify and isolate who are buyers, suppliers or rivals. For example, General Electric (GE) is developing an industrial internet platform, Predix™ (https://www.ge.com/digital/iiot-platform), and industry-specific Predictivity™ solutions. GE is working with partners such as Intel, Cisco and AT&T and they in turn are developing their own IoT platforms and solutions for the same industries. Are these firms buyers, suppliers, or rivals? In this IoT ecosystem, a firm cannot necessarily position itself in an 'industry' because the definition of the industry is vague and frequently subject to change or evolution (i.e., it is amorphous and without a clearly defined form, boundaries or structure) such that major participants are competing, cooperating and co-existing with each other. This is further complicated by industry convergence and blurring of industry boundaries being driven by technological disruptions.

The second theory about competitive advantage, the resource-based view (RBV) (Barney, 1991, Penrose, 1959 and Wernerfelt, 1984) has emerged as one of, if not the most, dominant theory of sustained competitive advantage. The RBV suggests that a firm can gain sustained competitive advantage when the firm creates more economic values for its products or services than the marginal firm in the same industry and other firms in the industry cannot duplicate and provide similar values to their customers. Importantly, the RBV suggests that a firm could develop such a sustained competitive advantage if its resources or capabilities are valuable, rare, non-imitable and non-substitutable such that an organization can use these resources or capabilities to create defendable economic values (VRIO Framework, Barney et al., 1991). Although resources and capabilities are important, RBV does not explain the consistent performance differences between rivals in the same industry because rivals in the same industry have similar resources and capabilities.

In a high-velocity market (Eisenhardt et al., 1989), such as in the technology industry, it is difficult for a firm to hold onto its valuable resources and competitors can imitate each other's technologies and business processes quickly or find ways to circumvent them. So, it is difficult to hold on to a sustainable competitive advantage based on RBV alone because it neglects the need to manage the resource portfolio actively and appreciate the interplay between resource strengths and weaknesses (Sirmon, Hitt and Ireland, 2007, Sirmon, Hitt and Campbell, 2010*)*.

Some scholars have taken the topic of sustained competitive advantage one step further and suggest the end of sustained competitive advantages (McGrath, 2013). According to McGrath, sustained competitive advantage creates a sense of stability and it is dangerous for a firm. A prime example of this is BlackBerry. Once it was a default mobile phone for business users but when Apple introduced iPhone and related consumer services around iPhone on iTunes, BlackBerry could not adapt as demands, needs and wants moved away from their core proposition (McNish and Silcoff, 2015). Focusing on their core business and technology, they could not re-invent themselves and within only a few years lost their market share to competitors such as Apple and Samsung.

D'Aveni et al. (2010) argue that *sustained* competitive advantage does not exist for a firm; only *temporary* ones do. However, dynamic capability and organizational flexibility may create a sustained competitive advantage but it may not last for as long a period of time as one might associate with the normative meaning of the term 'sustained'. As the environment becomes more dynamic, the velocity of changes is rapid and disruptions occur through exogenous and endogenous change. Competitive strategy should be more dynamic and it may not be able to depend on the static positioning of the resources, capabilities and routines alone. In turn, competitive advantages are temporary and transient appearing sustainable only when a firm is able to dynamically refresh its resources and capabilities to create a stream of new temporary advantages. Strategic decisions need to be quick and the firms must formulate strategic initiatives to take advantage of windows for transient competitive advantage (McGrath, 2013). In such states, a firm can launch a new or revised product, but must organize teams and allocate resources to exploit several opportunities. This is because the transient advantages of business will be challenged by new entrants and competitors and the firm needs to reconfigure its capabilities and resources to re-adjust with the changing market and industry situations before those initial temporary advantages are exhausted. A firm must then be able to disengage and dispose of resources and capabilities which are not required for the existing business.

2.2 Resource-based View of a Firm

The resource-based view (RBV) is an important strategy framework for competitive advantage (Barney, 1991, Penrose 1959. As mentioned in the previous section, the valuable-rare-imperfectly-imitable-organization (VRIO) framework explains the competitiveness of a firm against its rivals in an industry under the RBV. To understand this framework, each attribute is explained in detail:

Valuable resources: A firm can gain competitive advantage or sustained competitive advantage, if its resources are valuable. A valuable resource increases the efficiency and effectiveness of a firm (Barney, 1991). However, the resources are valuable when a firm utilizes these resources for available opportunities and neutralizes its threats.

Rare: Only valuable resources are not enough for competitive advantage, as the competitors will copy those valuable resources. If a firm's resources are completely unique, those resources will generate competitive and sustained competitive resources. For example, Google has some unique, rare and valuable search algorithms and distinct competitive advantage against its rivals in the internet search area for this reason.

Imperfectly imitable resources: Valuable and rare resources give a firm first movers advantage in an industry, however, the rivals may copy these resources and a firm may not be able to hold onto its competitive advantage. However, if the resource is imperfectly imitable or costly to imitate then it will create sustainable competitive advantage. Firms' resources are imperfectly imitable for three reasons: unique historical condition, causal ambiguity and social complexity. A unique historical condition like the starting of a company in a particular place with a particular management team may be imperfectly imitable. For example, a group of engineers working in the semiconductor company in Silicon Valley (Gordon Moore, Andy Grove, Robert Noyce all worked at Fairchild semiconductors in 1950–60s and then they started Intel corporation in 1968) gained unique knowledge and started other flagship semiconductor companies. Causal ambiguity is another factor for imperfectly imitable resource. A firm, which has the resource and competitive advantage, may not publicize its advantage to the market and an imitating firm may not understand the resources properly as it is ambiguous and, in this case, the firm with the resource enjoys competitive advantage for some time. However, the imitating firm may steal core employees and may like to clear the ambiguity.

The third factor for imperfectly imitable resource is social complexity. Some types of resources, such as a highly motivated research and development team, loyal customers of a firm, culture of a firm etc., are examples of social complexity and it cannot be imitated easily. Barney (1991) argued that firm resources and capabilities can be "imperfectly imitable for one or a combination of three reasons: (a) the ability of a firm to obtain a resource is dependent upon unique historical conditions, (b) the link between the resources possessed by a firm and a firm's sustained competitive advantage is causally ambiguous, or (c) the resource generating a firm's advantage is socially complex" (Barney, 1991). These conditions propose circumstances in which a resource or capability might be hard to replicate but also hold the potential to cause problems for the owing firm itself. For example, when a capability is causally ambiguous, socially complex (normally the case for capabilities which by their very nature depends on knowledge, routines and their functions (Winter, 2003)) and developed from historical investments and circumstances, the ability for the firm to change those capabilities (and create new ones urgently) is made difficult and challenging.

The following chart (Table 1) illustrates the interactions of different parameters and their implications for the VRIO framework.

Table 1: VRIO Framework

Resource-based View – VRIO Framework

Valuable (Y/N)	Rare (Y/N)	Imitation cost (H/L)	Organization (Y/N)	Competitive Advantage	Firm Performance
No	**-**	**-**	**No**	**Competitive disadvantage**	**Poor**
Yes	**No**	**-**	**Yes**	**Competitive Parity**	**Average**
Yes	**Yes**	**Low**	**Yes**	**Temporary Competitive Advantage**	**Above Average**
Yes	**Yes**	**High**	**Yes**	**Sustained Competitive Advantage**	**Above Average for a longer duration**

Source: Barney (1991)

Based on this framework, if a firm does not have valuable or rare resources it cannot maintain competitive advantage. If a firm has valuable resources but those resources are not rare, then the firm could have competitive parity with its rivals if the firm could exploit those resources effectively. Therefore, valuable but not rare resources can still have merit for a firm but are unlikely to allow it to surpass its rivals. If a firm has valuable and rare resources but one or more rivals can imitate those resources, then the firm will have a temporary competitive advantage because the rivals will likely catch up with the firm quickly. However, the firm may be able to gain significant market share by the time rivals can copy those resources and capabilities if it is able to benefit from first-mover advantage. For example, Apple's iTunes marketplace was the first of its kind for digital music distribution and it secured a substantive market lead over its rivals. Apple was able to duplicate this mode for its App Store initiative, but now all other key competitors, such as Samsung and other Android mobile phone providers, have an application marketplace. On the other hand, if a firm has valuable, rare and non-imitable resources with a proper organization structure it can have sustained competitive advantage.

The RBV based on the VRIO framework has developed propositions which seek to explain a firm's performance based on its resources and capabilities. However, any such measurements are difficult in practice (Lockett, Thompson, and Morgenstern, 2009). According to the RBV, valuable and rare resources generate competitive advantage; however, the rarity and value depend on the usage of the resources. The problem of tautology within the RBV lies in the general and specific usage of resources. The firm-specific works may generate competitive advantage and it may not be directly observable. It is difficult to identify and measure the specific resources that are responsible for competitive advantage. Researchers often used commonly observable resources (Ambrosini & Bowman, 2001) and it is not clear whether these resources could generate competitive advantage. Firm heterogeneity causes problems for the researchers, as they cannot get a homogeneous sample to understand the impact of heterogeneity. In a large organization, it is difficult to identify and measure the impact of some key resources in the performance of the organization, as multiple factors are responsible for the organization's performance. So far, all the empirical work on RBV has used data sets which are unbalanced and do not reduce the selection biases.

2.3 The Dynamic Capability View (DCV) of a Firm

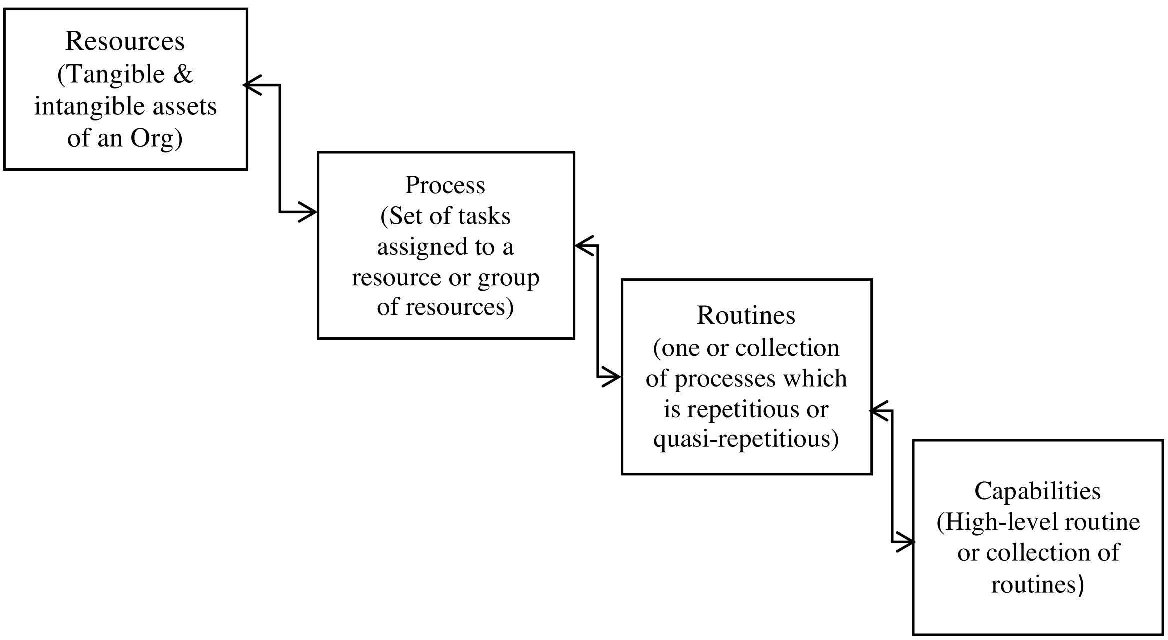
The RBV suggests a VRIO framework for sustained competitive advantage; however, it does not sufficiently explain how a firm can gain competitive advantage when the market is dynamic and unpredictable. Strategy scholars (Teece, Pisano & Shuen, 1997; Teece, 2007; and Winter, 2003). extended the RBV as they felt that the RBV was too static and did not explain the situations in a high-velocity market. So, scholars proposed a dynamic capability view (DCV) of the firm. According to proponents of the DCV, RBV does not explain why a firm maintains competitive advantage in a volatile, continuously changing high-velocity market (Eisenhardt & Martin, 2000). A high-velocity environment is characterized by rapid and discontinuous changes in technology, fluctuations in demand and supply and future prediction of the market is difficult due to lack or shortage of information (Bourgeois and Eisenhardt, 1988). In dynamic capability, capabilities are acquired by the firm, then integrated as well as reconfigured such that these capabilities can create economic rents for the firm (Teece et al., 1997; Eisenhardt et al., 2000).

According to the RBV, the heterogeneity of resources and capabilities held by a firm create sustained competitive advantage. However, the RBV does not explain how the heterogeneity arises across different firms. In the subsequent section, I will explain the basic constructs and definition of DCV and how it advances upon the RBV.

2.3.1 Basic Constructs of Dynamic Capability

Before I discuss some key definitions of dynamic capability, I explain the key elements of capability development process: resource, process, routine and capability (Figure 2)

Figure 2: Key Elements of Capability Development



Resource: This refers to the tangible or intangible assets of a firm that it owns, controls and has access to on a semi-permanent basis (Helfat et al., 2003). For example, the existing employees of a firm are an important resource of the firm in this respect.

Process: Organizational process is a set of tasks assigned to a resource or group of resources to perform a particular outcome. For example, a software development process delivers a specific objective of the firm.

Routine: The routine is a process or collection of processes of the firm, which can be learned and it is patterned, repetitious or quasi-repetitious in nature (Winter, 2000). For example, a technology firm often has a well-defined routine for developing a new product for a particular market. A firm develops competitive advantages with its well-defined routines for different business functions.

Capability: Based on hierarchies, capabilities are lower-level or higher-level routines, which work on specific inputs and produce significant outputs of a particular type (Winter, 2003). The capability follows a hierarchy in which zero-level capabilities are operational capabilities for the firm for its business activity and dynamic capabilities are higher-order capabilities, which involve long-term commitments to specialized resources. However, there is no guarantee that the higher-order capabilities will only produce positive outcomes. Operational capability and dynamic capability have significant differences as operational capability helps a firm to earn its living in the current state, whereas dynamic capability helps a firm to position itself to earn a living in uncertain times (Eisenhardt et al., 2000).

2.3.2 Definition of Dynamic Capability

Strategic scholars have defined dynamic capability differently and here I present some key definitions from some leading strategic scholars.

Table 2 : Definitions of Dynamic Capability

Author(s)	**Type**	**Development Process**	**Definition**
Teece, Pisano and Shuen (1997)	Ability or capacity of a firm	Capabilities are developed by utilizing three types of organizational processes, namely, Coordination/Integration (static concept), Learning (Dynamic concept) and Reconfiguration (Transformational concepts)	*"Dynamic capability is the ability of the firm to integrate, build and reconfigure internal and external competencies to address rapidly changing environments."*
Eisenhardt and Martin, 2000	Process of the firm (routines which are interchangeable, transferable and having some results	Specific strategic and organizational routines, which show commonality across multiple firms, varies based on market dynamism and can be developed through well-defined learning mechanisms.	*"Dynamic capabilities are organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve and die."*
Zollo and Winter, 2002	Evolution of dynamic capabilities by deliberate learning	Dynamic capabilities emerge by experience accumulation, knowledge articulation and codification activities. A firm applies a system learning process such that it can transform operational capabilities and gain organizational efficiencies.	*"Dynamic capability is a collective routine by which a firm systematically generates and modifies its operating routines for improved effectiveness".*
Winter, 2003	Routines and capabilities	Dynamic capabilities extend, modify or create zero-level ordinary capabilities. However, creating high-level routines are expensive and do not guarantee sustained competitive advantages. Ad-hoc capabilities might be sufficient to solve the firm's problems.	*"The ordinary or zero-level capabilities are those, which help a firm to make a living in the short term. The dynamic capabilities are those that operate to extend, modify or create ordinary capabilities."*
Zahra, Sapienza and Davidson, 2006	Introduced substantive capability and	The author introduces three elements about a firm's ability to change its	*"The dynamic capabilities are abilities to reconfigure a firm's resources and*

	explained its difference from dynamic capability.	capabilities: the ability to solve a problem (substantive capability), the presence of rapidly changing environments, the ability to change the way a firm solves its problems (a higher-order dynamic capability to alter capabilities).	*routines in the manner envisioned and deemed appropriate by the firm's principal decision maker(s)."*
Wang and Ahmed, 2007	Resources and capabilities in a changing environment	The authors define three types of dynamic capabilities: adaptive, absorptive and innovative.	The firm's resources and capabilities follow a hierarchy. The resources are zero order element, capabilities are first order, core capabilities are second order element and dynamic capabilities are third order element, by which firm renew, reconfigure and recreate resources, capabilities and core capabilities to address environmental changes.
Teece, 2007	Micro foundation of dynamic capability and how firms develop organizational assets, processes (routines), procedures for sustained competitive advantage	The dynamic capability is a three-step process: sensing, seizing and reconfiguring tangible and intangible assets	The processes are as follows: **Sensing:** analytical systems and processes to learn and discover opportunities in technology, markets, customer needs and supplier capabilities. **Seizing:** organization structure, procedure, processes and capabilities to seize opportunities with focus on new products and services, decision-making processes, customer loyalty and co-specialization. **Reconfiguration**: continuous alignment and re-alignment of tangible and intangible assets, using a proper governance framework, knowledge management and decentralization of the decision-making processes.

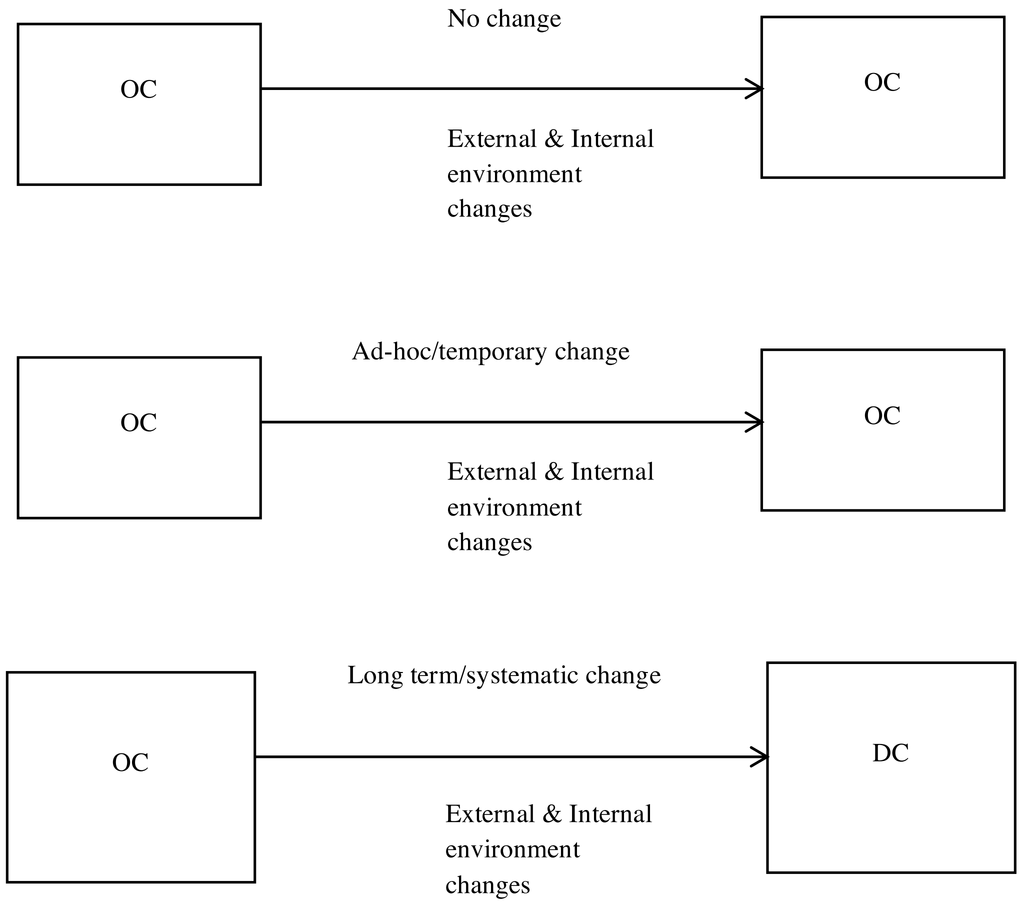
Barreto, 2010	Based on multiple research streams, author suggests a new conceptualization of dynamic capability	The dynamic capability is a multidimensional construct and it has four distinct dimensions, the ability to sense the environment, to make timely decisions, to make market-oriented decisions and to change its resource base.	*"The dynamic capability is the firm's potential to systematically solve problems, formed by its propensity to sense opportunity and threats, to make timely and market-oriented decisions and to change its resource base."*
Ambrosini, Bowman and Collier, 2009	Three levels of dynamic capability based on environmental dynamism	The three levels of dynamic capabilities: incremental, renewing and regenerative dynamic capability	The dynamic capabilities are comprised of four main processes: reconfiguration, leveraging, learning and integration

2.3.3 Operational (OC) versus Dynamic Capability (DC)

The capabilities are either operational or dynamic. The operational capabilities are a collection of routines which follow implementation workflows of the organization and produce a desired outcome for the firm (Winter, 2000). The routine consists of repetitive activities of a firm. Dynamic capability (Teece et al., 1997) builds, integrates or reconfigures operational capability. Similar to operational capability, dynamic capability consists of one or a set of routines, which impacts the operational capability.

The operational capability maintains the status quo, whereas, dynamic capability initiates change. So, in the mathematical equation form, operational capability is a zero-order capability, whereas, dynamic capability is a higher-order capability. For example, on a hypothetical basis, if a firm sells similar products to a similar set of customers in the same market, then those manufacturing or selling capabilities would be a zero-order capability or operational capability (Winter, 2003). Also, operational capability is firm specific, for example, if a firm has a channel partner management capability, but the firm does not change the capability when faced with technological changes, then that capability is an operational capability. However, the same firm could change that capability when faced with external factors and make that operational capability a dynamic capability. However, change in capability does not always make it dynamic. The firm may like to change on an ad-hoc basis and may not have a long-term plan in place for change. Then that ad-hoc change may not make that capability dynamic, as dynamic capability is a long-term engagement for a firm and it deploys specialized resources to achieve positive outcomes. The following paragraph depicts these propositions.

Figure 3 : How OC Changes to DC



For example, the IoT and cloud business is different from traditional businesses for industrial manufacturing companies. In the pre-IoT time, these companies had service contracts for providing services for their machines. Providing after sales service is an operational capability, however, the new way of providing proactive service by using machine analytics is a dynamic capability.

According to a senior marketing executive of an industrial conglomerate (who was interviewed for this study), "IoT business is different than their current businesses as IoT business is in the intersection of physical machines and analytical world of data. The confluence of those two makes business different than traditional business. It is not a break-fix model of service but it has transformed our service business to predict-prevent-optimize your service model". This type of new service development is a dynamic transformative capability for a firm as it has developed a new service business model.

Some empirical studies about operational and dynamic capability and their influence on relative firm performance do exist (Drnevich & Kriauciunas, 2011). According to Drnevich et al. (2011), OC and DC influence relative firm performance positively, but the contribution of DC is higher in a high-velocity environment than OC and heterogeneity has minimal influence on the OC and firm performance, whereas, heterogeneity has significant influence on DC and relative firm performance. Drnevich et al. (2011) have selected relative firm performance at two levels: process level (RFPP) and firm level (RFPF). The RFPP level measures productivity, quality of products and services and business process performance and the RFPF measures profits as a percentage of sales.). Dynamic capabilities may have direct impact on resource access and resource development (Stadler, Helfat & Verona, 2013). According to them, the impact of resource access versus resource development in the oil & gas industry has a greater degree of unpredictability. According to their analysis, the firm with more sophisticated dynamic capabilities undertakes resource access activities more and develops resources before making it commercial. For measurement, the authors use annual expenditure of oil exploration for measuring resource access and annual expenditure of oil field development as a measure of resource development, successful exploratory wells drilled as a result of the resource activity and successful development wells drilled as a measure of the success of resource development. To develop a proxy measure of dynamic capability, the technological sophistication of oil exploration using seismic imaging and well drill technology, including imaging technologies and types of drilling (vertical, horizontal, multi-lateral), are used across various firms. This is an example of measuring the impact of dynamic capabilities for a very specific industry, such as oil & gas.

2.4 Dynamic Capability View – Theoretical Foundations

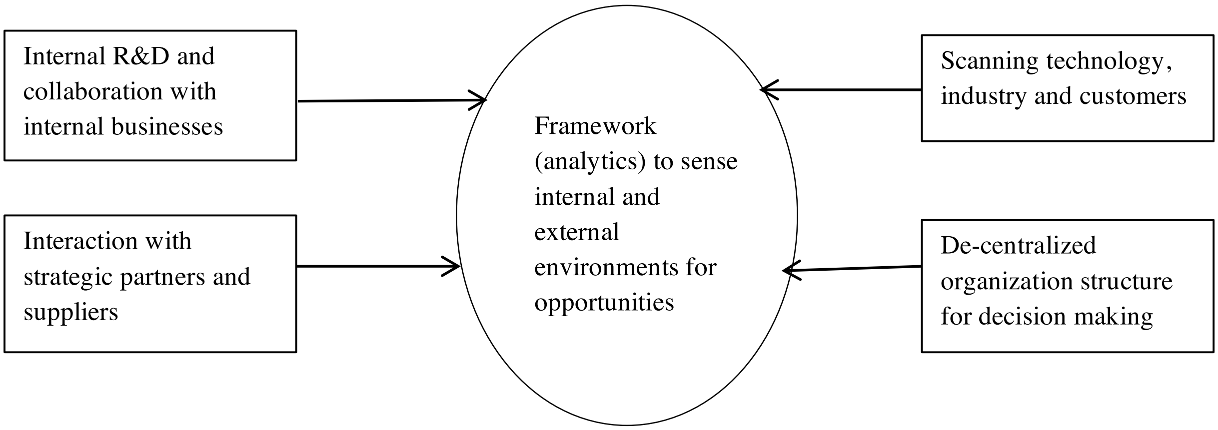
2.4.1 Teece et al. (1997 & 2007)

Teece et al. developed a dynamic capability framework to explain the competitive advantages of certain firms in a high-velocity environment. They observed the growth of high technology firms in the late 90s, and came to the conclusion that the ability of a firm to remain competitive is based on its dynamic capabilities. The term 'dynamic' refers to the development of competencies in a changing business environment and 'capability' "is the ability of a firm to adapt, integrate and reconfigure internal and external organizational skills, resources and functional competences to meet the organizational objectives in a changing environment" (Teece, 2007). Teece developed micro-foundation of dynamic capabilities, which are necessary to develop sustained competitive advantage and get superior firm performance. The micro-foundation of dynamic capabilities consists of processes and procedures which are required for enterprise level sensing, seizing and reconfiguring capabilities in a high-velocity environment.

Teece argues that the dynamic capability creates a change in operational capability through the activities of sensing, seizing and reconfiguring tangible and intangible assets.

2.4.1.1 Sensing opportunities

Figure 4: Micro-Foundations of DC: Sensing Market and Technological Opportunities



Source: Micro-foundation of dynamic capabilities, Teece (2007)

Entrepreneurs in the technology industry are capable of sensing opportunities, technological changes and their impact on the business. However, the sensing process should be embedded in the organization. An organization can develop specific processes and structures to deal with internal and external requirements. An established firm such as General Electric[9] has global research centres deal with external environments and opportunities and develop new and innovative technologies such that GE can remain leaders in its businesses. Other than research and development (R&D) groups, organizations have strategic marketing functions for collecting customer and market information, competitors' information and overall growth of the market. Sometimes, in a large organization, information flow might be slow and not so effective due to multiple layers of management. In that case, a de-centralized organization structure might be useful to sense and react to the opportunities. The dynamic capability framework looks at the environment as the ecosystem of the business for sensing purposes. This is a substantial departure from Porter's five forces of competitive advantage because Porter looks at the industry

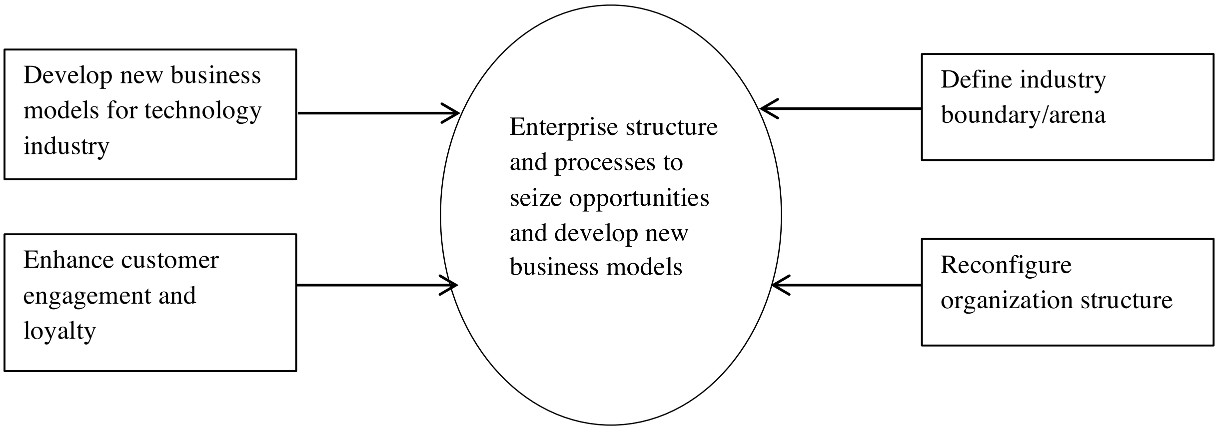
[9] www.ge.com/research

and not at the ecosystem (Teece, 2007). Even if an organization looks at the ecosystem, it is difficult to assimilate the information and to take proper corrective action on a proactive basis. Though entrepreneurship is supported by the individual(s) in the organization with their experience and risk-taking abilities, organization processes and routines help a firm in their R&D efforts to develop new products and services. The scanning of internal and external environments should be embedded in the firm's processes such that it could monitor the environments on a regular basis. A firm which had a better scanning process would develop more dynamic capabilities and economic outcomes for itself. Lack of sensing capability not only makes a firm vulnerable, but may destroy a firm completely. When Steve Jobs, Apple's former CEO, announced iPhone in 2007, the mobile phone leader at that time, Research in Motion's (RIM) mobile phone, the BlackBerry, did not pay serious attention to iPhone. RIM's chief told his colleagues that iPhone would only be popular with casual customers (McNish et al., 2015). RIM could not sense the competitor and its products properly and in the next five years, RIM lost its business completely.

It is critical to a firm's success to incorporate open innovation, and the firm should engage with external partners including universities and educational institutions such that innovation by the universities could be brought to the commercial market. Success of the start-up companies in the Silicon Valley, are the examples of firms and universities collaboration.

2.4.1.2 Seizing opportunities

Figure 5: Micro-Foundations of DC: Seizing Market and Technological Opportunities



Source: Micro-foundation of dynamic capabilities, Teece (2007)

After sensing the market and identifying opportunities, a firm should develop new products, processes and services to gain market share. The firm needs to have an investment strategy to develop technology, market and related resources and capabilities to seize the opportunity. Teece (2007) suggests four different parameters to seize the opportunity, as discussed below.

A firm develops product and services strategies and corresponding business models to find new customers and retain existing customers. A business model is the organizational and functional architecture of an organization (Chesbrough & Rosenbloom, 2002). In a high-velocity environment, the business model is changing. An organization is moving from a product-centric model to an outcome-centric model. This is more evident in the technology industry and this model is known as servitization. Due to advancement of technology and information gathering and analysis, technology companies are shifting their business models. Servitization is the process when a firm moves from its product-centric approach to service-centric approach (Baines et al., 2014). To develop this outcome-centric model, a firm needs to redesign its business, including product and services architecture, sales and distribution models and specifically its strategic alliance strategy. In my research, I have analysed digital transformative capabilities which influence business transition from product-centric to outcome-centric business models.

In a high-velocity environment, selecting an industry boundary will be a key success factor to implement the business plan. Chesbrough and Teece (2002) and Teece (1996) give guidelines about the selection of the industry boundary and its effect on innovators and imitators. They suggest four factors: 1) the appropriate market segment and region for legal protection to the innovators, 2) the nature of the co-specialized assets of the innovators in that region, 3) the relative market positions of innovators and the imitators in that region, and 4) the development of the industry in that region. Also, innovators' upstream and downstream capabilities will influence the boundary selection.

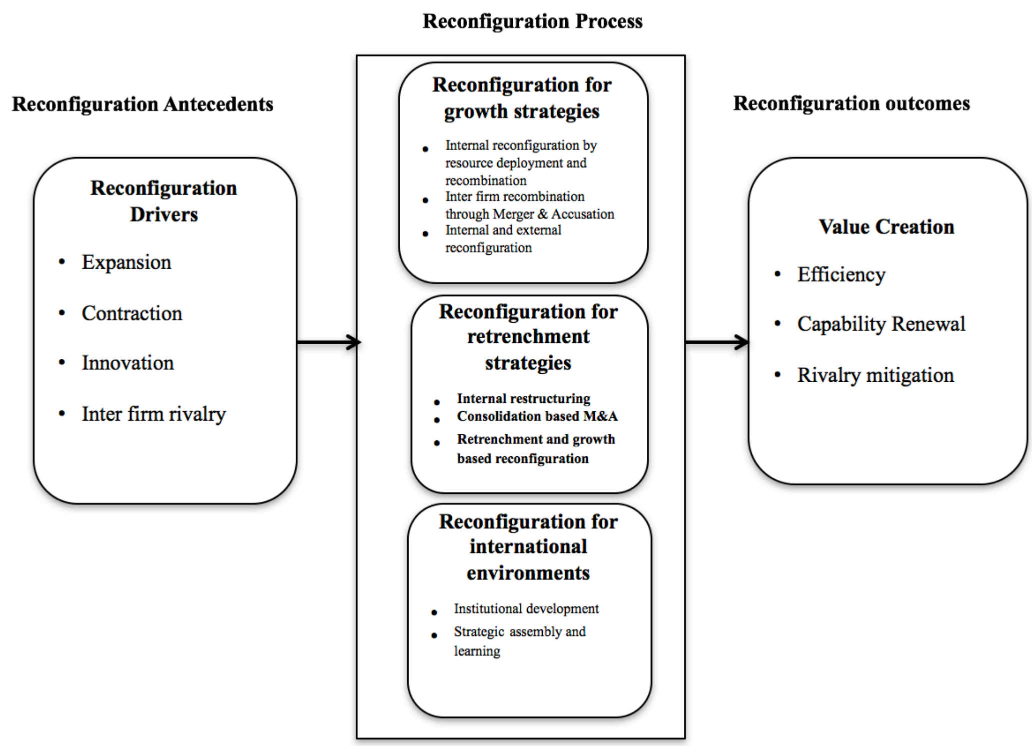
However, if we focus our attention towards the industry-specific boundary, we may face serious challenges in the high-velocity environment. Industry-specific positioning assumes some stability in the environment. McGrath (2013) suggests that within-industry competition is the most significant competitive threat. Companies define competitors in the same industry which provides similar products and services. However, the landscape is changing and in the technology industry the industry line is blurred (Porter & Heppelmann, 2014).

As discussed in my previous section, the industry-specific competition has moved to an arena-specific competition, where an arena is characterized by the connections between customers and solutions. For example, in the home healthcare solutions business, established companies like General Electric Healthcare and Phillips Healthcare and new providers like Apple and Google are also looking into this arena. Two other factors are customer loyalty and retention and proper organizational structure to support the seizing processes.

2.4.1.3 Reconfiguration of resources

Reconfiguration is the third leg of the dynamic capability (Helfat & Peteraf, 2015). Reconfiguration is a dynamic capability, by which a firm aligns its resource base to expand, contract or innovate its business based on the internal and external environment (Karim & Capron, 2016).

Figure 6: Micro-Foundations of DC: Reconfiguration Process



Source: Reconfiguration Strategy (Karim and Capron, 2016)

The reconfiguration process has three broad strategies: strategies for **growth,** strategies for **retrenchment** and strategies for **international environments**. The drivers are economic and these include drivers for expansion, contraction, new products and services development through innovation and internal frictions between firms. These strategies create value by increasing efficiency, developing new capabilities by renewing existing capabilities or creating new capabilities and developing mitigation plans for inter-firm rivalry.

Reconfiguration for growth strategy: A firm develops its growth strategy by expanding its products and services in multiple markets. This is an internal growth strategy. A firm also deploys successful M&A strategy to accelerate growth and develop of strategic partnerships to reach markets where it may not be able to grow as a standalone entity. Redeployment of resources is commonly used during M&A activities and resources are deployed from and to target firms (Capron, Dussauge & Mitchell, 1998). The acquisition also plays a significant role in deploying resources. The resources are reconfigured in both the source and target firms based on the values of the resources for the combined organization (Karim, 2006). A firm may follow, ambidexterity, where the firm explores certain business activities and exploits other business activities such that it can meet the market expectations in terms of revenue and profits and at the same time develop new products and solutions to remain competitive in the market. The balance across these two modes of operation improves the firm's performance (Capron & Mitchell, 2012).

Reconfiguration for retrenchment strategies: Reconfiguration is also achieved through retrenchment and divestiture. A firm normally sheds away underperforming assets and capabilities, which are misaligned with corporate goals and objectives (Bowman & Singh, 1993); Vidal & Mitchell, 2015). A firm may get rid of a business or a part of a business through divestiture. A firm may adopt one or many divestiture processes including sale, exchange, closure or bankruptcy. Asset redeployment could be done through merger and acquisition strategies and it depends on the effectiveness of market interfaces in utilizing the redeployed assets (Anand & Singh, 1997).

Reconfiguration for international environments: A firm may adapt different reconfiguration strategies in an emerging market where law and governance are not well implemented. The growth reconfiguration cost may be higher in the emerging market and a firm may develop a different reconfiguration strategy in a less developed market (Chakrabarti, Vidal & Mitchell, 2011).

Reconfiguration outcome: Value creation is the ultimate outcome for a reconfiguration process. Combining resources and making resources and capabilities relevant for the current and future markets creates value for a firm. However, the benefits of the reconfiguration should be weighed against the transaction cost of the reconfiguration (Karim, 2009). The efficiency of reconfiguration is achieved from growth and diversification strategies. The empirical studies in the reconfiguration research show that the reconfiguration resources taking part in internal development and M&A activities can influence firm performance (Karim & Mitchell, 2000; Moliterno & Wierseman, 2007).

As firm renew their assets and capabilities to remain competitive in the high-velocity environment, the reconfiguration capability is an important dynamic capability for value creation.

2.4.2 Eisenhardt & Martin (2000)

Eisenhardt & Martin extend the resource-based view (RBV) for competitive advantage and define dynamic capability as organizational and strategic routines to form new resource configuration as the market goes through the transformation process. Eisenhardt et al. (2000) argue that dynamic capabilities are identifiable routines in a firm such as product development, strategic decision making and alliancing, which help a firm to develop revenue-producing products and services. Dynamic capabilities are common across firms and not unique to any firm. These are best practices adopted by a firm. For example, product development capabilities follow a common set of routines, which are similar across many firms in an industry. Dynamic capability shows equifinality, which means firms could reach the same dynamic capability via different paths. Since these capabilities demonstrate commonality and equifinality, these are substitutable and fungible. So, according to Eisenhardt et al. (2000), dynamic capabilities by themselves are not sources of sustained competitive advantage. Though Teece (1997) suggests that the high-velocity market is required for dynamic capability, Eisenhardt et al. (2000) argue that the dynamic capabilities exist in high and moderate velocity markets and long-term competitive advantages are achieved by resource configuration and not by dynamic capabilities.

2.4.3 Winter et al. (2002 - 2003)

Winter defines organization capability as a routine or a collection of routines, which takes some inputs and develops multiple options for the management of the firm such that they can select multiple options for a desirable outcome. Routine is a learned behaviour and it is repetitive or quasi-repetitive in nature. The author also distinguishes between ordinary or operational capability and dynamic capability. Operational capability is a zero-order capability and it is necessary for the firm's survival. Zero-level capabilities are locally defined. So, for an independent R&D firm, developing new products might be a zero-level capability but for a normal firm R&D activities and associated routines might be higher-order capability. So, based on the business, the same capability may be ordinary for some firms and dynamic for others. Dynamic capability relates to change; however, change might come on an ad-hoc basis. Sometimes, managers need to make ad-hoc decisions based on the current situation of the products and services. This type of strategy may be more cost effective than dynamic capability. The higher order capability may need continuous investment by the firm such that resources can be optimized by learning, experimentation etc. However, this higher order dynamic capability does not guarantee better performance or sustained competitive advantage.

The managers of a form need to have tactic knowledge of the business processes within the organization, such that they can understand how to influence some of these tactical capabilities and change them to dynamic capabilities.

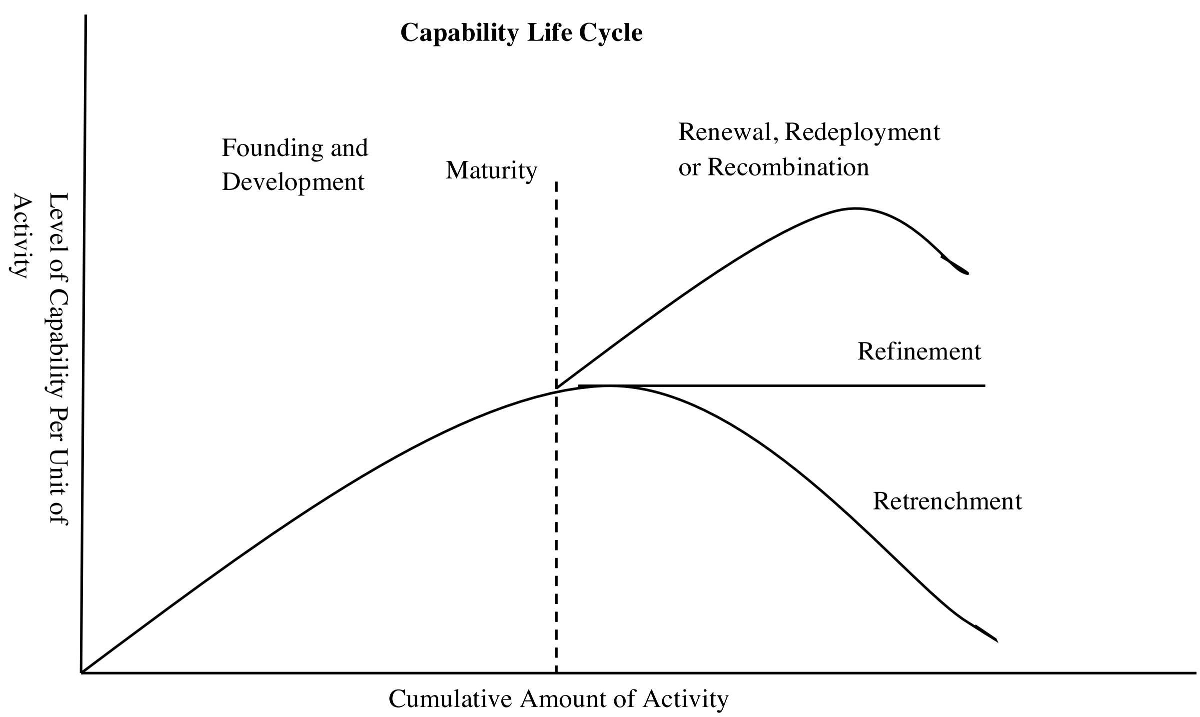
Both Zahra et al. and Winter suggest a hierarchy of capabilities, where a firm starts with a zero-order or operational capability for running the business and gradually changes the operational capability to a higher-order dynamic capability.

2.4.4 Helfat & Peteraf (2003, 2009)

The capability concept as a set of routines implies that the capability must have reached a threshold and its behaviour is predictable. The capability initially starts with a level of maturity and then gradually it moves through a capability life cycle.

The following figure explains the capability life cycle:

Table 3 : Capability Life Cycle



Source: Helfat and Peteraf (2003)

Heterogeneity of capabilities creates competitive advantages among the firms in an industry and the capabilities go through a life cycle, which is similar to the product life cycle (Helfat & Peteraf, 2003). The capability life cycle somewhat explains the heterogeneity of resources and capabilities. The capabilities go through a life cycle, starting with the founding stage. At this stage, the team is formed with specific objective(s), and resources are allocated such that the team can deliver the expected outcome. At the development stage, the team might go through alternatives and select a particular routine or group of routines, and follow the learning by doing process. At this phase, the firm might develop sustained productivity gain including worker management relations. At some point, capability development ceases and the team enters the maturity phase, where the capabilities are maintained and might become embedded into the firm's routines, possibly becoming a habitual routine for future use. From the maturity phase, the capability enters the decline phase and may branch out to one of the six paths: renewal, redeployment, recombination, replication, retrenchment, and retirement. Since a capability goes through a life cycle and it may eventually retire or renew based on the firm's ability, this creates heterogeneity across the firms and in turn it might be an important contributor for competitive advantage. If a firm can renew, redeploy and reconfigure its capability based on market demands, that firm would be more successful than others who could not do it so effectively.

2.5 Major Themes of Dynamic Capability

Based on my literature survey, I have derived the following themes for DC which are described below:

1. **Resources and firm performance:** Resources and capabilities are at the core of dynamic capability. The success of a firm depends on its ability to work on the resource base and change it for better firm performance. I explain that in the subsequent section.

2. **Origin and intent:** The origin of dynamic capability is of great interest to scholars. The effect of the external environment on the resource base changes the capabilities of the firm. However, it is still not clear whether environment velocity has any major impacts on dynamic capability development. I highlight some of my observations in this area.

3. **Entrepreneurial action:** Though dynamic capabilities are higher-order routines, entrepreneurial actions by senior executives and managers are strategic and non-routine in nature, but we can classify these actions as dynamic capabilities. Organization routines are related to execution of projects but they do not necessary include how these projects are identified (Teece, 2012). So, project identification through active sensing, and resource orchestration, which includes identifying resource requirements and missing assets and then actively buying or building these assets, are non-routine in nature. The senior executives are responsible for executing these projects. For example, at Apple Inc., CEO Steve Jobs had the vision and orchestration skills to identify new electronic equipment and commercialize that before its competitors.

These themes are now discussed in detail.

Resources and firm performance

Dynamic capability works on a firm's resource base. The dynamic capability is the ability of a firm to create, extend and modify its resource base (Helfat et al., 2009). The resource base includes a firm's tangible and intangible assets, human assets and other intellectual properties, as well as capabilities which it owns or controls or has influence on a preferential basis. For example, strong strategic alliance relationships with a firm's partners are the firm's capabilities and these are included in its resource base. Leading scholars also support the resource view of dynamic capability. Teece et al. (1997) suggest that dynamic capability operates on organizational skills, resources and competences. Eisenhardt and Martin (2000) suggest that the dynamic capability works on the firm's resource base. Zahra et al. (2006) focus on the reconfiguration of the resources and routines, whereas Wang et al. (2007) highlight the resources and capability hierarchy.

Stability of the environment plays an important role for the managers in strategic decision-making processes. Based on the analysis of the RBV literature, RBV assumes relative stability of the environment. However, DCV assumes relative instability and disruption in the environment. Based on these environmental criteria, Ambrosini et.al. (2009) suggest three levels of dynamic capability: incremental, renewing and rejuvenating.

Incremental dynamic capability: During the stable environment, a firm may readjust its capabilities and routines based on the internal and external environments. These changes are not innovative or disruptive but are more incremental and extend the current capabilities. For example, a software company has an incremental product enhancement capability and it releases new versions of the software periodically. This capability is to keep up existing customers and hold on to the existing market share.

Renewing dynamic capability: A firm needs to reconfigure its existing capabilities for internal and external factors and gain knowledge it acquires from various sources. If these capabilities are not reconfigured, then the firm will have distinct disadvantages, so it is essential that the firm has well developed organization processes to assess the market conditions and reconfigure these capabilities. Though current literature does not distinguish between incremental and renewing dynamic capabilities, Ambrosini et al. (2009) suggest that incremental dynamic capabilities deal with the current resource base, but renewing capabilities deal with existing and new resource bases such that the firm can remain competitive with the changing environments. For example, in the software technology business, Salesforce.com introduced a cloud-based software-as-a-service business model (SaaS) in the early 2000s. Gradually SaaS became the default business software distribution model and other big players, such as Oracle, SAP type of companies are forced to create, extend or modify their resource bases to offer SaaS services. So, for Oracle and SAP, the current cloud-based deployment capabilities are renewal-based dynamic capabilities.

Regenerative dynamic capability: Sometimes the existing dynamic capability of a firm may not be sufficient to sustain competitive advantage and remain successful in business. In this circumstance, a firm needs to change and renew its dynamic capabilities and develop capabilities such that it can be effective in a changing environment. The managers develop the regenerative dynamic capabilities when they perceive that the business situation is disruptive and business visibility is blurred. The technology industry goes through this disruption on a regular basis and managers in this industry need to be vigilant all the time. IoT is a disruptive technology and it has changed the business model.

2.6 My Research Focus Area

In high-velocity environments, with the introduction of new disruptive technologies, firms must develop digital transformative capabilities such that they readjust their business routines for favourable Digital Transformation. **I define digital transformative capability (DTC) as *the ability of a firm to systematically identify and coordinate digital changes for the digitalization***

of core business routines. The digital transformative capability is an extension of dynamic capability and explains the Digital Transformation process. From the point of view of dynamic capability theory, digital transformative capabilities do not fit cleanly into existing the theoretical apparatus because they are not simply about the renewal of existing capabilities or about making existing capabilities malleable; Digital Transformation involves the replacement of long-standing business activity and long-held assumptions and views of products and trading with digital versions (or replacements) that involve fundamentally different technologies and working practices.

For my research, I plan to use Teece's et al. (2007) framework. This framework allows me to look into the digital transformative capability development process as a three-stage process consisting of sensing, seizing and reconfiguring stages. Though other dynamic capability theories are equally important, I believe that the industrial businesses are going through a high velocity environment and more evolutionary / entrepreneurship approaches are necessary to develop digital transformative capabilities and thus Teece's framework is an appropriate framework for my research area.

The following are the research questions for this study:

1. *How are firms developing digital transformative capabilities for Digital Transformation by leveraging the Industrial Internet?*

The firms are going through a technology disruption and they must find a way to develop new dynamic capabilities or reconfigure existing operational capabilities and transform them into digital transformative capabilities. It is very important to look into the key capabilities which are responsible for Digital Transformation and how internal and external factors are influencing the transformation process.

2. *What are the inputs and contingencies for digital transformative capabilities and how are internal and external factors affecting digital transformative capabilities?*

Firms are discussing different Digital Transformation initiatives and have started some of them. However, most of the initiatives are fragmented and there is limited discussion about the influence of internal and external factors including environmental factors which could influence the development or reconfiguration of dynamic capabilities for Digital Transformation.

3. *How should success and failure of Digital Transformation be compared among different industrial businesses and how can a measurement framework for Digital Transformation be developed?*

Since Digital Transformation by leveraging IIoT is a recent phenomenon and industrial businesses have faced this challenge for the last five years, it is difficult to measure the success and/or failure of Digital Transformation by comparing standard measures such as financial performance, market growth or productivity enhancements. A proper framework needs to be developed to compare Digital Transformation across different firms.

2.7 Conclusion

In this chapter, a literature review of the industry-centric view and resource-based view of competition was presented. First, the industry-centric view of competition (Porter's view) was presented and limitations were highlighted. Second, the resource-based view and dynamic capability view of the competition were presented and how firms were developing operational capabilities and dynamic capabilities was explained. Third, the major themes and criticisms of dynamic capabilities were identified and, finally, digital transformative capability was defined by extending dynamic capability theory and research questions were identified.

However, the findings from the literature review are not sufficient to develop a conceptual framework for Digital Transformation. In order to compliment the literature review, an industry review and exploratory studies were conducted. The industry review is presented in the next chapter.

3.0: Industry Review

This chapter reviews the Internet-of-Things (IoT) and Industrial Internet of Things (IIoT) and its impact on Digital Transformation. The chapter starts with the definitions of IoT and IIoT, followed by IIoT ecosystem, major IIoT software platforms and Digital Transformation. The chapter ends with the discussion of IIoT and its influence on Digital Transformation.

3.1 Internet-of-Things (IoT) and Industrial Internet of Things (IIoT)

There is no standard definition of IoT and various organizations have defined it somewhat differently. The following table presents some of the definitions from leading IIoT companies and industry groups.

Table 4 : Definition of the Industrial Internet of Things

Company / Group	Definition	Main Components
Gartner Group (www.gartner.com)	IoT is the network of physical objects, which communicate with their internal states and with outside environments, through technology embedded into those objects	Connected Physical Objects, Embedded Technology.
Cisco Systems (www.cisco.com)	IoT links product, asset, environments and other business processes of a company to generate better information and analysis and in turn increases productivity and reduce costs for a company.	Cisco defines Internet of Everything in a company.
Accenture, World Economic Forum, January, 2015 – 2017 (www.weforum.com)	Industrial internet (of things) will combine internet with physical world including machines, factories and infrastructure and will bring enormous opportunity and transform the businesses.	Industrial internet is IoT for industrial businesses.
General Electric (GE) (www.ge.com/digital)	Industrial Internet allows a company to use edge devices, software, machine-to-machine learning and other connectivity technologies to collect and analyze data from physical objects for better decisions and to provide new and improved products and services.	Integration of physical and digital worlds in industrial settings.

In summary, the IoT enables connected devices to collect data from various sources, transport the data to the cloud using a communication mechanism and to analyze the vast amount of data for making business decisions. So, IoT has four distinct components: data collection, data transport to the cloud, meaningful analytics and decision-making processes. Earlier it was difficult to collect such a vast amount of data and transport it to the cloud economically. Also, earlier it was difficult to analyse a huge amount of data economically and quickly for business decisions. The advancement in cloud, big data and analytics has paved the way for commercial deployment of IoT-enabled systems.

3.2 Overview of the Industrial Internet of Things (IIoT)

Industrial internet is a term coined by General Electric (Leber, 2012). The industrial internet comprises of connecting industrial machines to share information on a real-time or near real-time basis and to make pro-active and predictive business decisions based on machine analytics. According to GE, this can change the whole business paradigm for industrial businesses. There is a convergence of industrial systems with the power of advanced processing and analysis capabilities, emergence of a low cost cloud-based data sharing environment and low-cost sensing and machine data sharing. These business solutions will transform the industrial world and in turn will change our daily lives including the ways we do our jobs and business. It holds the promise of greater productivity, higher standards of living and a safe and secure industrial environment.

Industrial internet will bring low healthcare costs with better outcomes, substantial savings in fuel and energy costs and will prolong the lives of the industrial assets which will accelerate industrial productivity similar to the industrial revolution and the internet revolution. It can boost annual productivity growth of the US economy by 1 to 1.5 percentage points. If we continue the momentum for the next 20 years, then the average income will rise to 25 to 40%, if we consider the effects of compounding from the current level. As the innovation spreads across the globe, and if other countries could achieve half of US productivity growth, then the industrial revolution will add $10 to $15 Trillion GDP globally.

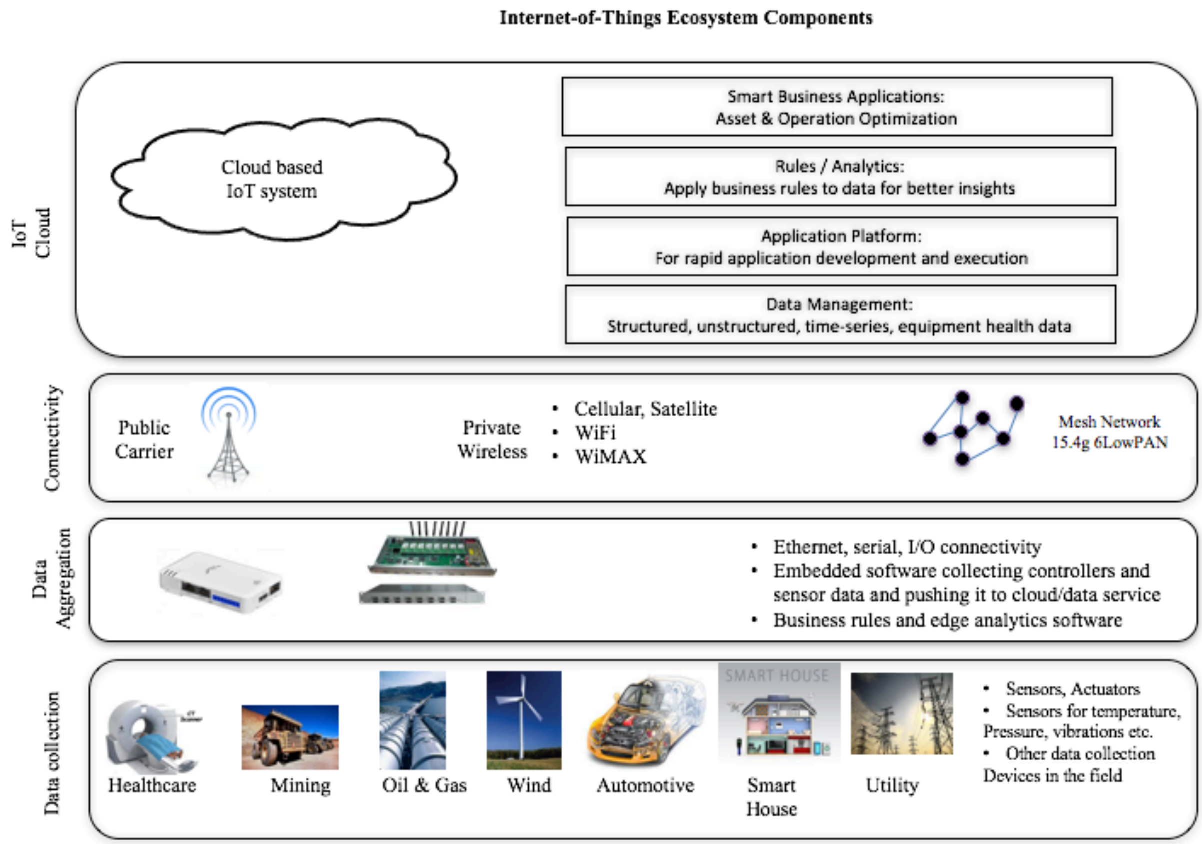
The savings from interconnected and intelligent machines will have substantial savings in the global market (Evans et al., 2012). Just by making one per cent fuel savings in the aviation industry can save $30 billion globally (over 15 years). Similarly, one per cent fuel savings in power generation equipment can save $66 billion (over 15 years). The global healthcare industry can save $63 billion (over 15 years) by reducing one per cent operation cost at the hospitals. We can improve the transportation and logistics cost of our freight movements by rail. Improving one per cent transportation efficiency could lead to $27 billion saving (over 15 years). Lastly, one per cent improvement in capital utilization in upstream and downstream oil exploration and development could save $90 billion (over 15 years). So, the power of just one per cent improvement is substantial for industrial companies and these five industries could save $276 billion globally (over 15 years).

Smart connected products have changed the product boundaries of companies. Firms are trying to figure out what businesses they are in and how they should compete in the connected ecosystems. Firms need to make strategic choices to work with current and new partners and they need to reshape their capabilities to compete in the IoT business (Porter and Heppelmann, 2014).

Thus industrial internet of things (IIoT) has the promise to transform the industrial businesses. The industrial managers should be aware of the business benefits of the IIoT such that they can take necessary steps to develop digital transformative capabilities (DTCs).

3.3 IIoT Ecosystem

Table 5 : IIoT ecosystem components



The industrial IoT ecosystem has four major components:

- Smart devices for data collection at source
- Edge (Fog) computing
- Connectivity from source to destination (cloud)
- IIoT applications in the cloud

The following paragraphs describe the ecosystem components.

Smart devices: A primary component of the IIoT ecosystem is to collect data of the assets through sensors, controllers, actuators and other data collection devices. The definition of asset includes any movable or immovable component of a business entity. Mostly these data collection devices are embedded into the asset. For example, we could put a sensor into the pump of an oil well and could get information from the pump on a continuous basis. By integrating with smart hardware and software, the asset becomes a smart device. Tesla has developed a software-defined car and all of the components of the car are smart components. So, a driver can start or stop the car from a mobile application. These smart components are redefining the business and a firm needs to sense the opportunity of developing new products and services by utilization of these smart devices.

Edge (Fog) Computing: Cisco coined the term fog computing or fog network (Bonomi and Milito, 2012). It is new paradigm of analysing the data on the edge of the device. Since we collect large amount of data on a continuous basis, it is not possible to send the data into the cloud, analyse the data and send it the management action back to the device. Instead, we may like to set up an edge device which could control a set of smart sensors/devices. The edge device could run analytics software and analyse real time data from the smart devices then take corrective actions as required. This will reduce the cost of data transfer and increase the speed of the decision-making process.

Connectivity: Connectivity is an important component for the IIoT ecosystem. The data collected from the devices needs to be transported to the gateway devices (or Fog Computing devices) and then it should be transported to the IoT cloud. We need multiple communication channels for data transfer, including Bluetooth, Wifi, 6LoPan (low power communication), Wired connections, Cellular and Satellite communication. The ecosystem needs to be developed and a common standard should be developed to transport different types of data to the cloud. Also, connectivity standards are different in the different geographical regions and the ecosystem should take care of that.

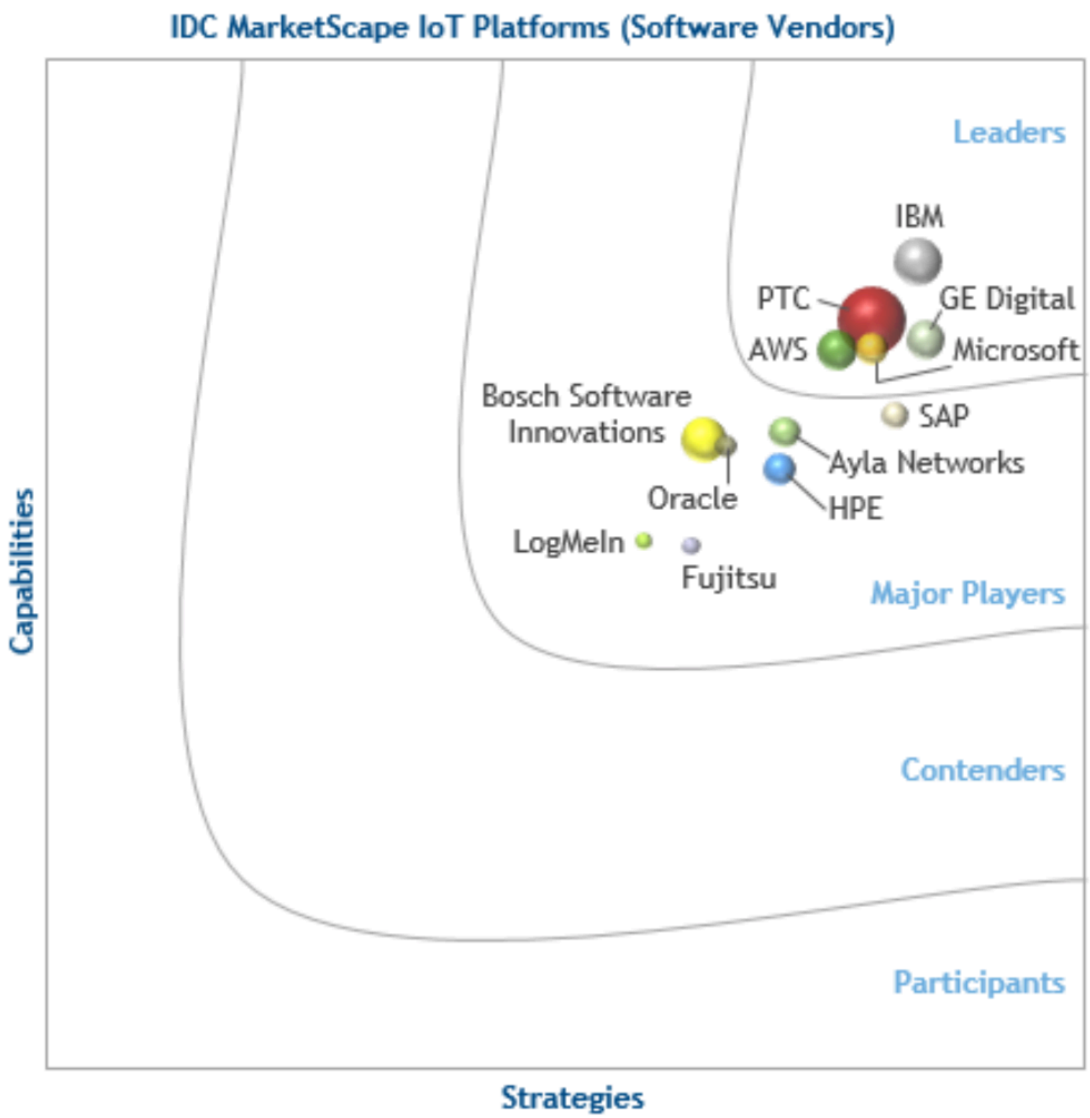
IIoT applications: Once the data is transported to the cloud, the businesses write cloud-based applications for business use. For example, GE Health Cloud collects data from various healthcare machines (MRI, CT, Ultra-sound scanners) from different hospitals, stores it in the GE Health Cloud and has different analytics and business work flows to make effective business decisions. GE Digital (a subsidiary of GE) has developed the Asset Performance Management (APM) application for industrial asset optimization and for reducing unplanned downtime in a factory. For example, GE jet engines generate terabytes of data for a single flight, which are analysed to help the maintenance crew at the terminal perform necessary maintenance such that they can reduce the unplanned downtime and this in turn increases the life cycle of the jet engine.

The industrial managers should be knowledgable about different components of IIoT infrastructure such that they can plan properly for any digital transformation initiative by leveraging IIoT.

3.4 IIoT Platforms from Leading IoT Companies

In this section, I summarize the capabilities of the IIoT platforms from leading IIoT vendors. Though all of these large enterprises are well-established companies, IIoT companies comprise start-ups, mid-size and large enterprises.

Figure 7: Leading IIoT platforms



Source: IDC, 2017

The leading market research firm IDC[10] has analysed leading IIoT software vendors and identified key vendors for IIoT platforms.

According to IDC, an IIoT software platform should have the following capabilities:

- It should be able to connect to the edges (IIoT end-points like devices).
- It should be able to manage these end-points and its identities.
- It should be able to ingest IIoT data from these devices and it should be able to analyse the data for business decision-making purposes.
- It should allow application developers to develop industry-specific IIoT applications.
- It should facilitate a seamless integration of IIoT data with existing information technology (IT) and operation technology (OT) systems.

Based on IDC, GE Digital Predix platform, IBM Watson IoT platform, PTC ThingWorx IoT platform, Microsoft Azure IoT platform and Amazon's AWS IoT platform are leading platform vendors for IIoT industry.

The industrial managers need to decide whether they should develop digital capabilities for individual businesses or they can develop a commpn capability / framework and customize it for individual businesses. According to Govondarajan and Immelt (2019), a multidivisional company like General Electric (GE) should develop digital function centrally to play a truly transformative role. The managers can leverage one of these IIoT platform to accelerate their digital capabilities.

[10] https://www.idc.com/getdoc.jsp?containerId=US42033517

3.5 Digital Transformation (DT)

Industrial businesses are going through Digital Transformation; the study that it is important to define DT at the beginning. DT is the application of digital technologies to processes, products, routines and assets such that a firm can improve efficiency, enhance customer values and uncover new business opportunities which were not available before (Schmarzo, 2017). The digital capabilities are scientific, data driven, measured and calculated and/or automated and these capabilities influence the operational and dynamic capabilities of a firm. Some scholars suggest that Digital Transformation is a significant transformation of organizational and business activities which leverages the use of digital technologies to bring changes in our businesses and ultimately to our society[11]. The wide usage and integration of digital technology for DT affects not only businesses but also their ecosystem partners and customers. DT brings new ways of doing business and helps in developing new and innovative products and services for customers. As a result of DT, current business models are reshaped or replaced (Downes and Nunes, 2013).

3.5.1 Digitization, digitalization and Digital Transformation

Industrial businesses are using these three terms interchangeably, however, there are some distinctions between them.

[11] https://www.i-scoop.eu/digital-transformation/

According to Gartner IT glossary[12], digitization is a process to change analog information into digital information and businesses have been digitizing their businesses for many decades. Digitization deals with converting the information only.

However, the definition of digitalization is not clear. According to Brenner and Kreiss (2014), digitalization is the way by which many domains of social life are restructured using digital communication and media infrastructure. So, this definition of digitalization is based on its impact on social life, for example, we have moved away from Analog communication (snail mail, telephone calls etc.) to Digital communication (email, instant chat, social media interaction). According to Gartner, digitalization is the use of digital technology to develop new business models for the enterprise and it provides revenue and value producing opportunities. Thus, Gartner views digitalization is the process of moving to a digital business. Muro, Liu, Whiton and Kulkarni (2017) define digitalization as the process of applying digital technologies and information to transform business operations.

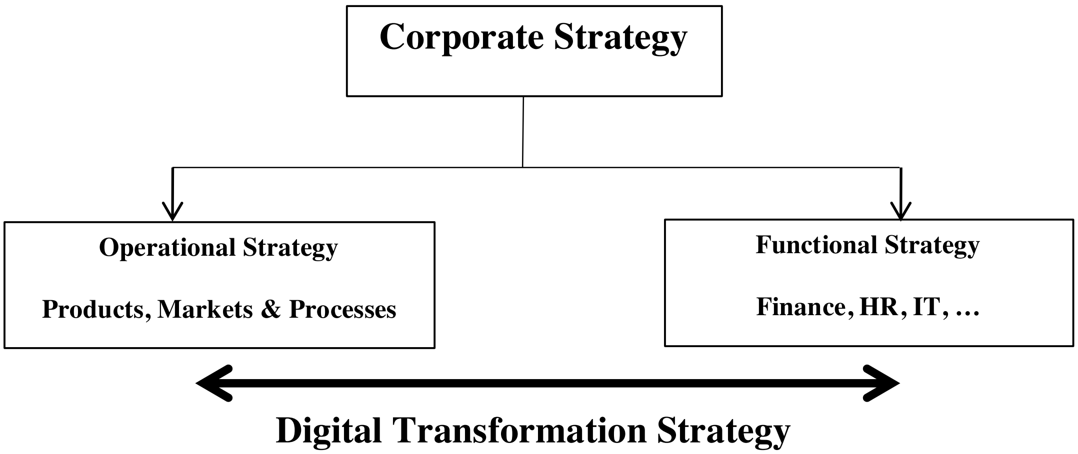
Digitalization is not Digital Transformation. An enterprise might pursue multiple digitalization initiatives related to its specific sites, manufacturing plants, service facilities etc. The enterprise can implement these initiatives as projects. DT is different and it cannot be implemented as a project. It is a customer driven, strategic business transformation that requires a holistic approach, inter- and intra-organizational changes and a new way of doing business using digital technologies.

[12] https://www.gartner.com/it-glossary/digitization/

3.5.2 Digital transformation strategy

Since the scope of Digital Transformation is not only within the organization but also includes partners ecosystem, Digital Transformation strategy coordinates and prioritizes many independent Digital Transformation initiatives within the firm (Matt, Benlian and Hess, 2015).

Figure 8: Digital Transformation Strategy



The IT strategies within a firm define the current and future operational activities, infrastructures, organizational and functional frameworks to support business operations for the firm (Teubner, 2013) and they are mostly to run daily operations of the business. It has narrow impacts on the product and service innovations within the firm. The operational strategy deals with the marketing, product and service strategies of the firm including developing or reshaping current and future businesses.

Digital transformation strategy incorporates digital technologies on the operational and functional sides of a business and helps a firm in transforming their products and services. Thus, Digital Transformation strategy includes operational technology (OT) and information technology (IT). Kristian Steenstrup, lead analyst from Gartner[13], suggests that CIO and IT leaders will be at the forefront of developing relationships and changing the culture of organizations as they will work with operational leaders for implementing Digital

[13] https://www.gartner.com/smarterwithgartner/when-it-and-operational-technology-converge/

Transformation initiatives. The author also emphasizes the importance of ecosystem partnership as organizations will need a new set of skills for such transformation and it may not be available internally.

3.6 The Industrial Internet of Things (IIoT) and Digital Transformation (DT)

We are going through an industrial revolution, the fourth industrial revolution (Industry 4.0)[14] where technology innovations are driving significant advancement in automation technologies and making machines and related infrastructure software defined. These software-defined machines are helping to create new industrial and city infrastructure. The fourth industrial revolution presents tremendous opportunities for growth by leveraging IIoT. According to industry experts, by 2020, the IIoT will deliver $1.9 Trillion in productivity gains globally[15].

According to Deborah Sherry, Chief Digital Officer (CDO), GE Europe, "IIoT powers Digital Transformation for Industry 4.0 and it is the digital technology which connects machines, data and processes that makes it possible to create smart technologies, smart manufacturing and connected city infrastructure".

Other scholars, such as Rathmann (2017), suggests that IIoT is a specific thing whereas Digital Transformation is a concept; currently industrial businesses are using IIoT technologies for cost avoidance. However, IIoT has greater potential to accelerate business growth through Digital Transformation.

[14] https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/
[15] https://www.forbes.com/sites/louiscolumbus/2016/11/27/roundup-of-internet-of-things-forecasts-and-market-estimates-2016/#569f87c0292d

3.7 Conclusion

In this chapter, the overview of IIoT and Digital Transformation definitions was presented. Since IIOT and DT definitions are still evolving, multiple definitions from leading organizations were presented. DT initiatives are gaining momentum with industrial businesses and these definitions will evolve further in the coming years. Next the overview of IIOT was discussed and major components of IIoT ecosystems were presented. Since the IIoT market is evolving rapidly, most industrial businesses are developing their own IIoT strategies and platforms. Based on the IDC report, four top IIoT platforms were presented. Finally, DT and factors affecting DT by leveraging IIoT were presented. This chapter, along with the literature review became a good foundation for the qualitative study.

4.0: Preliminary Exploratory Study

In this chapter, I discuss the preliminary study adopted as part of this research. A key conclusion from the literature review chapter is the apparent confusion and inconsistency in the literature about how capabilities, dynamic or substantive, are treated and conceptualized. This confusion warrants a preliminary investigation to understand how companies and their senior managers treat Digital Transformation initiatives, particularly when faced with complex environmental upheaval, such as that rendered by the emergence and disruption of IIoT. The purpose of the preliminary exploratory study is to understand the IIoT landscapes in the firms which are going through Digital Transformation.

In the first section, I identify the research gaps and the objectives of the preliminary study. In the second section, I explain the qualitative research design for my work. In the third section, I describe the unit of analysis of the case study and its relevance for the research. In the fourth section, I describe the case study and initial set of interviews. In the fifth section, I present the compliance of the research with ethical procedures. In the final section, I describe the findings and next steps.

4.1 Research Gaps and Objectives

Dynamic capability theory has drawn great interest from strategic management scholars. A simple search of "dynamic capability" in Google Scholar yields 23,200 results. If we narrow the search to studies since 2012, it gives 9,650 search results. So, it is a rapidly growing research matter among strategic management scholars. However, there is no standard definition of dynamic capability; the effect of environment, both external and internal, is not very clear or well documented and the evolution of dynamic capability is not well understood. I focus on the IIoT industry and since IIoT is creating a disruption in the markets, I focus on the effect of disruptive technologies for the formation of digital transformative capability. The sequence of transformation may be relevant in this respect. The transformation may take place during the sensing and seizing phases of dynamic capability or transformation takes place during the reconfiguration phase. The ambiguity surrounding this process warrants an investigation of its own since our ability to theorize a set of expectations about the process are so far confounded by alternative and competing theoretical frameworks surrounding dynamic capability and an absence of sufficient conceptualization within each part of such a process. This study plans to elaborate on this and helps in defining 'digital transformative capability'. Thus, appreciating capability formation and transformation needs a holistic approach by understanding how practising managers take necessary steps for transforming their capabilities for organizational success.

To summarize, the three main research objectives are:

- To conceptualize and develop digital transformative capabilities for Digital Transformation by leveraging the Industrial Internet.

- To identify the inputs and contingencies for DTCs and to access the influence of external and internal factors on DTCs.
- To develop a measurement framework for Digital Transformation and the internal and external factors which could affect the transformation.

4.2 Research Design

The exploratory study consists of two sets of studies. The initial study (Preliminary Exploratory Study, Chapter 4) has been conducted to understand the research problem and scope of the work and the second study (Detailed Exploratory Study, Chapter 5) has been conducted to develop a hypothetical framework for the research questions. For both preliminary and detailed exploratory study, I have chosen qualitative research methodology to gain insights into the four objectives mentioned in the previous section. The research methodology has been discussed in detail in Chapter 7.

The choice of research methodology is dependent on the research problem (Morgan and Smircich, 1980). Whether to choose qualitative, quantitative or mixed method of research methodology is dependent on the research questions and contexts. For my preliminary study, I have limited information about my subject or phenomenon of interest, so a qualitative study is more appropriate. The Digital Transformation process is ambiguous and not well documented. The managers understand the need for dynamic capability; however, they do not have clear steps to transform a substantive capability to digital transformative capability (dynamic capability). Since the relationship is not known, it is imperative to have a qualitative analysis to understand the intricacies of these capabilities (Denzin and Lincoln, 2000). To understand the digital transformative capability, I would like to have a holistic approach to understand the evolution, formation, continuation and termination of dynamic capability. A quantitative study may not be appropriate to understand these relationships from multiple angles. A qualitative study can provide a richness and holism (Miles, Huberman and Saldana, 1994).

Apart from qualitative methodology, for my preliminary study, I have chosen case study research method to conduct the preliminary research. The reasons for the chosen method are as follows:

The type of research method suitable for a particular type of research is dependent on the research questions (Shavelson and Towne, 2002). Case study research is suitable for descriptive (what is happening or what has happened?) or explanatory questions (How or why did something happen?). Experiment or quasi-experiment are suitable for outcome oriented questions, and the survey method is relevant to understand the occurrence of particular outcome(s) (Yin, 1994).

The case study research is a good methodology to understand the impact of technology disruption on the Digital Transformation process and it will give more visibility on the formation of digital transformative capabilities.

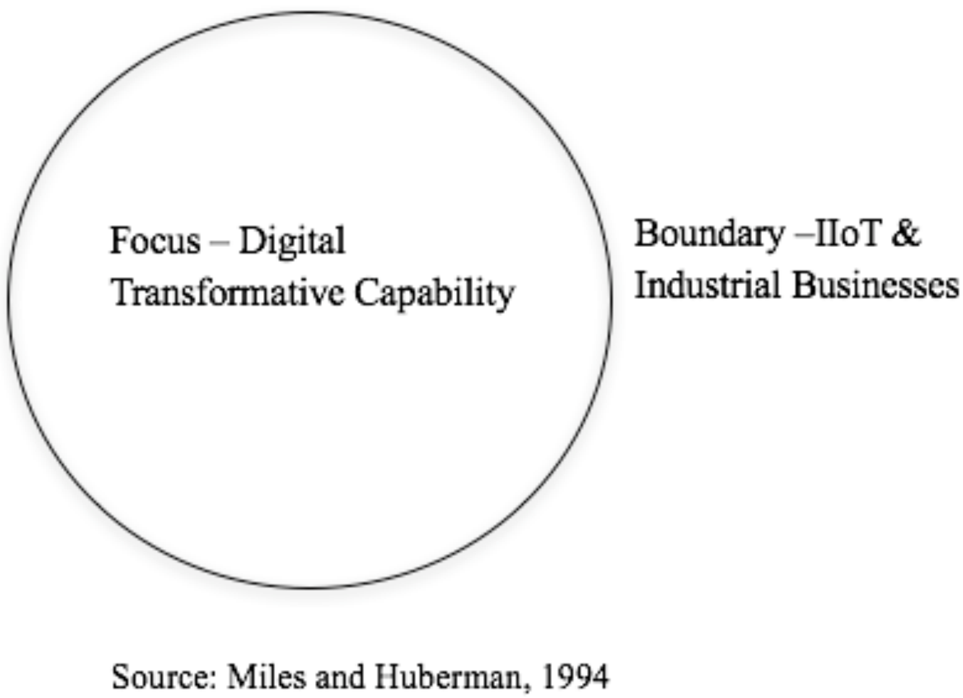
Within the qualitative research, if the research questions seek to explain the present circumstances (the "how" and "why" of some social phenomenon), then the case study research is more relevant (Yin, 1994). This can be extended in strategic management research questions. This method is more relevant when research questions require in-depth understanding of the phenomenon. Case study is not the study of an entire organization but to select specific functional areas, groups, departments and key employees who have good understanding of the research questions. Case study research methods are defined in two ways (Yin, 1981): the scope and features of the case study. The scope is related to the empirical enquiry where a researcher investigates in depth about a “case” (a social or organizational phenomenon) in the real world, where contexts are not very clear. For example, the IIoT is not new and machine-to-machine (M2M) communication has existed for the last four decades. However, real world contexts, such as improvement in communication technology, cheaper and affordable computing resources and cloud-based software deployment has created a new IIoT phenomenon and the firms are scrambling to address this phenomenon by developing new transformative capabilities or reconfiguring existing dynamic capabilities. The features of the case study deal with a technically distinctive situation with more variables of interest, rely on multiple sources of evidence and have developed prior theoretical propositions, which could guide the data collection and analysis.

There are three types of case study research, such as exploratory, descriptive and explanatory research (Yin, 1994). The purpose of the exploratory case study is to identify the research questions and procedures, which could be used for subsequent research methods including case study research. Descriptive case study describes a “case” in a real-world context, whereas explanatory case study highlights the reasons (why or how) for a particular sequence of events related to a “case” (Yin, 1994). I plan to choose the exploratory case study method, as I like to explore the research questions in detail and develop the hypothesis based on my case studies.

4.2.1 Unit of Analysis

In case study research, the definition of "case" is very important. A case is a phenomenon which occurs in a bounded context (Miles, Huberman, Saldana, 1994). The case is also the "Unit of Analysis". For my research work, my unit of analysis is the digital capability transformation and it is bounded by IIoT (a disruptive technology) and focuses on industrial businesses.

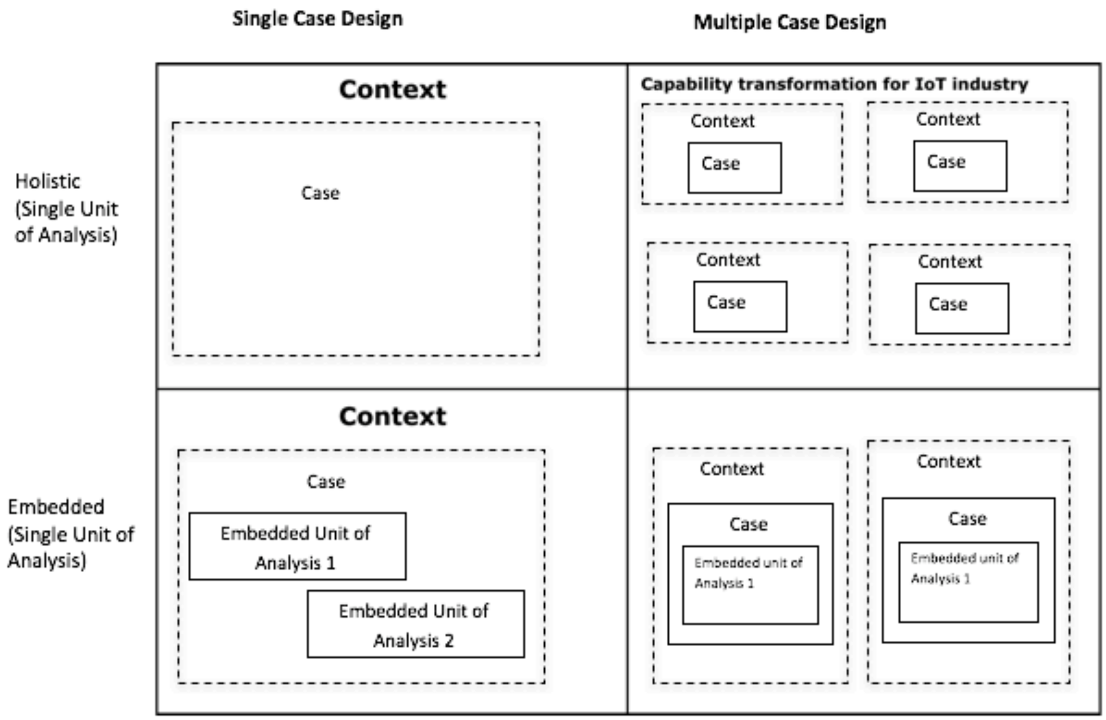
Figure 9: Unit of Analysis



4.2.2 Case Study Design

There are different types of case studies and the following figure illustrates that.

Figure 10: Types of designs of case study



Source: Yin, 2014

There are two types of case study design: one is single case study design and the other is multiple case study design (Yin, 1994, 2014; Miles, Huberman and Saldana, 2014). Within a type, there are two different categories: holistic and embedded case studies.

Single case study design deals with a single case and it is appropriate in certain circumstances. These circumstances are critical, unusual, common, revelatory and longitudinal. Critical case is critical to the author's theory or theoretical propositions and the theory should have a clear set of circumstances within which propositions will be correct and the case tests whether these propositions are true or not. Some of the cases are unusual and they deviate from theoretical norms. These types of cases are common in clinical psychology. The third type of case is a common case and the objective is to capture the circumstances and conditions for everyday situations. The revelatory case deals with a case not known to the research earlier and single case reveals that phenomenon. The fifth type of single case is longitudinal and in this situation the researcher studies the case at different points in time or to observe the trends over an elongated period of time. These are the five rationales to choose a single case, however, a researcher may stay with a pilot single case and later conduct multiple cases.

In a holistic single case study, the researcher concentrates on a single case for an organization, however, for an embedded single case study, the researcher concentrates on sub-units or different departments of an organization for the same case.

Multiple case designs have advantages and disadvantages in respect to single case design. Multiple case designs are more time consuming and need more resources. Multiple cases are similar to multiple experiments, which follow a replication design. The multiple cases are selected such that they predict similar results of the single case (a literal replication) or predicting contrasting results (theoretical replication). Normally two to three cases on a related topic is literal replication, whereas, six to ten cases are considered theoretical replication, which are designed to pursue two or more sets of propositions (Yin, 1994).

4.3 Sample Considerations and Study Participants

The purpose of the preliminary exploratory study is to understand the Digital Transformation initiatives in the industrial businesses and how firms are leveraging IIoT for Digital Transformation.

4.3.1 Interviews for Preliminary Exploratory Study

I conducted interviews with five senior executives from three different organizations to understand the current landscape of the IIoT industry and Digital Transformation. Since IIoT is a new and evolving market segment for a particular organization and Digital Transformation initiatives are relatively new, I interviewed the executives to understand the type of strategies and initiatives they are adopting to transform their businesses digitally by leveraging IIoT. I chose these organizations as they are the leaders of the IIoT business and the executives are developing and managing the strategies and initiatives for Digital Transformation. They are also the primary members of the Industrial Internet Consortium (www.iiconsortium.org) and participating in the overall direction of the Industrial Internet. Also, I have access to these executives and they agreed to answer my research questions.

I have selected the study participants based on their knowledge and experience in the IoT industry. These participants have significant experience in industrial software businesses and they have gone through several technological disruptions in their careers. The details of the participants are listed below.

Table 6 : Initial Interview Participants

Sl. No.	Type of industry	Respondent's position	Number of Employee	Annual Turnover	IOT Products
1	Industrial business conglomerate	Director, Marketing, 20 years experience in industrial businesses	300,000+	$117B	Leading Industrial Internet Platform. Businesses are developing applications using the platform
2	Industrial business conglomerate	Global Head, New Market Strategy and Development, 18 years experience in various executive capacities	300,000+	$117B	Leading Industrial Internet Platform. Businesses are developing applications using the platform
3	Enterprise Software	Vice President IOT, 30 years experience in software industry	130,000+	$38B	IOT Cloud, Gateway, Embedded Database
4	Enterprise Software	Sr. Director, IOT, 18 years experience in enterprise software	130,000+	$38B	IOT Cloud, Gateway, Embedded Database
5	Semiconductor chip manufacturing & software	Sr. Director, Market & Channels, IOT business, 20 years experience in Industrial automation and hardware business	85,000	$59B	IOT cloud gateway, Security-on-chip, IOT analytics

4.3.2 Data Collection Method

I have used the holistic multiple case study research method, which allows me to study the same unit of analysis, digital capability transformation process, across multiple organizations. Single case study research may not highlight the challenges and differences in digital capability transformation as the organizations are at different stages of Digital Transformation.

I have used the in-depth semi-structured interview format, such that I can gain good understanding of the point of interest (Rapley, 2004). The questions in the interview are broad and descriptive such that it gives a holistic picture of the processes (Dunsmuir and Williams, 1991). The semi-structured interviews allow open discussions and create semi-formal, flexible environments between interviewers and interviewee. The interviewer can ask follow-up questions and may wish to discuss some of the replies in detail to gain insights about the phenomenon. The semi-structured interview allows the interviewer to engage in model building and model testing and both theory construction and theory verification in the same session or in multiple sessions (Wengraf, 2001). The in-depth structured interview is more formal, well defined and the interviewer does not have any flexibility in the interview process. This type of interview is more relevant for aggregating the responses of the interviews (Bryman, 2008). This is not appropriate for my research work as I intend to gain insight into my research questions and aggregation will not yield the desired result.

4.3.3 Research Instrument

The interview guide was based on the literature survey and industry review. The questions are related to the overall IIoT business and Digital Transformation. The questions were asked in a logical order, however, the format was semi-formal such that the respondents could discuss their views of the IoT business openly. Since the purpose of the interview was to find out the degree of Digital Transformation by leveraging IIoT and its strategic importance, the questions were not changed after each interview. The data collection for the first set of interviews started in July

2015 and ended in August 2015. A total of five semi-structured interviews were conducted. The copy of the preliminary exploratory interview questions is included in Appendix A-1 and the copy of the email is included in Appendix A-3.

4.4 Ethical Considerations

For the initial qualitative study, I obtained approval from Durham University. The ethics Form B (Review Checklist) is attached in the Appendix A-4. The form details the objective of the study, the researcher's personal details, and information about the methodology of the study, consent from participants, risk assessment and approval from my research guides.

Research ethics deals with the researchers and the participants and the aim is to safeguard the interests of the participants. Agreed upon standards are necessary to protect the interests and well-being of the participants. Informed consent is a mechanism to convey the inherent risks, if any, to the participants to participating in the research study such that they can decide in a conscious and deliberate way whether to participate.

The first step for informed consent is to inform the participant about the research study. The participants must understand the purpose of the research and the type of outcome the researcher is expecting from the study.

The Durham University ethics form covers the following topics for informed consent. The participants should be told:

- about the purpose of the research
- how much time the participants are expected to spend with the researcher
- expected risks and benefits associated with the research
- how confidentiality will be protected - this is very important for the respondents
- the names and contact information of the supervisors such that the participants can contact them if they wish to do so.

The purpose of the ethical considerations is to protect the interests of the participants at all times.

4.5 Findings

All the interviews were recorded (digital recording) and transcribed by the author immediately such that none of the information was lost. Because of the exploratory nature of the first set of interviews, general observations were made. The data analysis, based on the approach of Miles, Huberman and Saldana (1994), was followed in the second set of interviews. Based on the interviews, the following observations were made:

1. Current Digital Transformation initiatives by leveraging IIoT

All respondents believe that the IIoT business is a different business for them and it is strategic in nature. Respondent-1 says "IIoT business is different from our traditional businesses, as IIoT business is at the intersection of physical machines and the analytical world of data". Respondent-2 thinks that IIoT technologies could make machines "software defined". Respondent-5 believes that the IIoT business is an evolving business and it is different to their traditional Original device manufacturing (ODM) and Original equipment manufacturing (OEM) business. Due to the disruption in the market through IIoT and cloud businesses, companies need to develop digital transformative capabilities such that they can connect these two worlds and make industrial machines smarter to achieve higher productivity and to reduce the costs of operation and be successful in their Digital Transformation journey.

All of the respondents believe the IIoT business is strategic to their growth; out of three firms, only one firm formed a strategic digital business group to go after IIoT business and two other firms still consider IIoT as their traditional business. If a firm has strategic focus on IIoT business, there is a high possibility of developing new ways of developing products and services and creating a separate organization with profit and loss responsibility. The environment has some effects on the IIoT business. Due to unpredictability, managers are not aware of the digital transformative capabilities they should develop for Digital Transformation.

2. *Collaboration within the organization*

Firm 1 (Respondents 1 & 2), has formulated an industrial Internet strategy different to the other two firms (Respondents 3, 4 & 5). Firm 1 has developed an industrial Internet development software platform such that businesses can develop industrial Internet business solutions very quickly, with optimum quality at reasonable costs. This may give a strategic advantage to Firm 1. This is an example of dynamic capability for new product development. Respondents 3 & 4 (from Firm 2) consider IIoT business as an extension of their traditional software product business and follow similar collaboration initiatives across the firm. So, for Firm 2, IIoT business capabilities are substantive capabilities for the day-to-day operations of their business. As mentioned in the previous chapter, a capability could be a substantive capability for a firm and a dynamic capability for another firm. This is an example of that. Respondent-5 mentions, “IIoT requires stitching different internal technologies within the company". This shows the importance of intra-firm collaboration and developing a cohesive IIoT strategy for the business. IoT platform development is strategic to some of these firms and this is a dynamic product development capability for the IoT business.

3. Collaboration with strategic partners

All respondents agree that forming strategic alliances will be key for the success of Digital Transformation. Though all firms have strong partners and alliance management groups, they have tweaked their processes for IIoT business. According to Respondent-5, "we have created a separate tower for IIoT with a global partner and some of the processes are tweaked and reconfigured for IIoT". Respondents 1 & 2, believe that IIoT is an evolving business, and the firms should collaborate with each other through industry consortium. All three firms are members of the Industrial Internet Consortium. Collaboration capability is the key to success in a volatile environment and strategic alliance capability is critical for the IIoT business.

4. Developing transformative capabilities

Some basic questions were asked related to digital transformative capability development. All of the respondents acknowledged that new capabilities should be developed for Digital Transformation. Respondent-1 feels that though his firm has existing best practices for alliance and partner management, the firm must develop new capabilities to engage with new partners. Respondent-2 believes strongly in co-development and joint development strategies with partners to develop new products and services quickly and reduce the time to market.

Respondent-3 has different explanations and thinks that existing capabilities should be sufficient for them for the IIoT business. Some respondents consider IIoT capabilities as dynamic capabilities and one firm in particular considers IIoT capability as an operational/substantive capability.

5. *Measuring success or failure of digital transformation*

All respondents replied that they did not have a good process by which they could measure the success of their digital transformative capabilities. In terms of partnership, Respondent-1 says "joint revenues, number of customers, ease of integration, responsiveness, technical maturity, customer base, security and scalability, could be the measurement indices". Respondent-2 says "There is no quantitative assessment for partnership and most assessments are qualitative. Since we have fewer partners, we can manage it now but we need to have measurement criteria". I explored this aspect further in the detailed exploratory study. Based on these interviews, it seems, there are no clear key success factors for Digital Transformation.

6. *Why should a firm collaborate?*

Each respondent has different answers for this question. Respondent-1 and Respondent-2 think strategic factors (competitive focus, product and technology partnership) are most important, Respondent-3 and Respondent-5 think economic factors (market, cost and risk related) are more important than others. However, all respondents started that collaboration within the firm and outside the firm are important for Digital Transformation.

Summary of the findings:

- Digital transformation is a strategic initiative and firms are leveraging IIoT solutions to achieve that.
- Internal and external collaboration initiatives are critical for the success of Digital Transformation.
- The high-velocity environment with disruptive technology such as IIoT helps in developing digital transformative capabilities.
- How to measure the success or failure of Digital Transformation initiatives is not clear to industrial managers.
- Strategic and economic factors are considered for Digital Transformation

The preliminary exploratory study findings suggest that industrial businesses are developing digital transformative capabilities as emerging technologies such as IIoT are disrupting the industries. Since Digital Transformation has started recently, the key success factors are still evolving and not clear to industrial managers.

4.6 Conclusion

In this chapter, first, the research gaps and objectives were discussed, followed by research design, sample considerations, the first set of interviews, ethical considerations and the findings from the first set of interviews. In the subsequent chapter, detailed exploratory study was discussed with the second set of interviews consisting of fifteen participants from five different IIoT companies who were going through Digital Transformation.

5.0 Detailed Explorative Study

In this chapter, I discuss the detailed explorative study conducted as part of my research. Based on the insights from preliminary exploratory study, the detailed exploratory study is intended to serve as a bridge between the literature review and formal conceptualization, accepting the fact that the literature on dynamic capabilities is contradictory in its characterization of dynamic capabilities, unclear in terms of the processes by which dynamic capabilities operate and function, and inconclusive on the transformation of operational capability to dynamic capability during environmental complexity and conditions of extreme turbulence. The process of developing new or reconfiguring existing capabilities to digital transformative capabilities is not clear and the industrial managers are seeking guidance in this area.

In chapter 4 (Preliminary exploratory study), I have identified certain factors which affect digital transformative capability, including collaboration, technological disruption and the high-velocity environment. Though the preliminary exploratory study highlights some key areas affecting Digital Transformation, the detailed exploratory study gives a holistic views of digital transformative capability transformation process and the internal and external factors which influence transformation.

The detailed exploratory study is built upon the preliminary exploratory study and it seeks to accomplish two tasks. The first is to understand the implications of context for digital transformative capabilities. I achieve this by studying a set of large, famous, and well-established technology companies being directly affected by the Industrial Internet-of-Things (IIoT) and Digital Transformation. Through a qualitative investigation based on several interviews with senior managers across five large technology companies, I seek to introduce context sensitivity into the body of theory on digital transformative capability. In doing so, I reveal internal and external environment factors affecting the ability of these firms to reconfigure their capabilities and generate new ones for Digital Transformation. This contributes to insight and helps to reconcile and transcend meta-analytic findings (Karna et al., 2016) suggesting that dynamic capabilities are not inherently superior to ordinary capabilities. By understanding the organizational circumstances surrounding ordinary and dynamic capabilities, we can begin to make more sense of the processes involved.

Second, I seek to refine theory concerned with the function of, and mechanisms behind, sensing, seizing, and reconfiguring capabilities for Digital Transformation. In doing so, I reveal how managers are explicitly going about these activities and enabling the transformation of capabilities for Digital Transformation, shedding some additional light on why some capabilities are prioritized more than others. This contributes to the micro-foundations debate about dynamic capabilities (Teece, 2007; Helfat and Peteraf, 2014).

Based on the preliminary exploratory and detailed exploratory studies, I plan to conceptualize the digital transformative capability transformation process and come up with my hypothesis to research Digital Transformation in industrial businesses by leveraging IIoT.

5.1 Exploratory Research Design

Research Gaps and objectives are described in section 4.1. Section 4.2 describes the unit of analysis and case study design. The ethical consideration for the exploratory study has been discussed in section 4.4.

The main purpose of exploratory research design is to assist in formulating hypotheses for given research problems and these hypotheses can be tested in a later phase by conclusive research design (Leinhardt and Leinhardt, 1980). It is particularly helpful when the subject or object of interest is poorly understood or in which a context is fluid or new and thus the functioning of existing ideas, constructs or theories therein may be opaque or different. The exploratory research design applies to the following research situations (Elahi and Dehdashti, 2011):

- Identifying problem(s)
- Developing a more precise formulation of a vaguely defined problem(s)
- Identifying the breadth of variables, which are responsible for the outcome
- Establishing priorities related to various problems
- Identifying and formulating alternative course of action
- Gathering information on the problems associated with doing conclusive research
- Identifying problems which can be assisted through secondary sources, interviewing knowledgeable people and compiling case histories

The exploratory research design was used in the preliminary qualitative analysis (chapter 4 and 5) for the following reasons:

- Digital transformation is a relatively new concept and there are few academic articles related to digital transformative capabilities and Digital Transformation.
- Though Digital Transformation and Industrial Internet discussions have been going on in industrial businesses for the last five years, academic scholars have started giving the subject more attention and more work will be done in the near future.
- The exploratory research methodology allows the researcher to define and formulate the problems, in this case, what causes Digital Transformation, what challenges the businesses are facing and how they are handing these challenges.

The philosophical position of the research has been discussed in section 7.2.

5.2 Methodology

To understand how firms are developing digital transformative capabilities, a holistics approach has been taken. Since interview-based studies are particularly well-suited for theory building (Eisenhardt, 1989; Eisenhardt & Graebner, 2007), for detailed exploratory study, I carried out semi-structured interviews with fifteen senior executives from five different organizations to understand the aforementioned issues in the current landscape of the IIoT industry and their Digital Transformation initiatives. Since IIoT and Digital Transformation are new initiatives and evolving, I interviewed executives to understand the type of strategies and initiatives these senior managers adopt to sense, seize and reconfigure their resources for Digital Transformation and how they are leveraging IIoT to do that. I have used purposive sampling and qualitative coding methodologies for this study.

5.2.1 Purposive Sampling

I conducted purposive sampling methodology to select my samples. Purposive sampling is a non-probabilistic sampling technique which selects the sample units within the population which have the most information about the characteristic of interest (Gurate and Barios, 2006). Purposive sampling is used when the researcher has knowledge of the field of study and has a rapport with the targeted networks (Groves, 2011). I am an insider in the Industrial Internet industry as I have been working in this industry for the last five years. I have existing relationships with my colleagues in the industry and I have selected a set of organizations representing different aspects of Industrial Internet including smart device manufacturers, edge computing providers, connectivity solution providers and IIoT application providers in the cloud. (Chapter 3, Industry Survey). I chose organizations that are leaders in the IIoT business and their executives are developing and managing the strategies and initiatives for Digital Transformation. Nevertheless, despite being leaders, these firms are facing considerable challenges due to the disruptive effects of IIoT and particularly since no one standard for IIoT has emerged. The uses and pervasiveness of IIoT now and into the future range far and wide, having considerable ramifications for these firms if they get their strategy wrong.

I selected the study participants based on their knowledge and experience in IIoT and Digital Transformation. Fifteen interviews, each lasting from forty-five to sixty minutes were recorded digitally for transcription. The name of the participants and their company name were kept confidential and forward looking future strategies and proprietary information were omitted from the discussion. I have used pseudo-names for the participants and for the companies. General information about the participants and their characteristics can be found in Table 7. To validate and to ascertain the realiability of the contruct creation, I sent the interview transcripts to all fifteen participants for their approval and received reviews related to my initial incident coding (Folger et al., 1984; Van de Ven, 2007). I also followed up with the participants later with telephone calls and meetings to clarify any issues that needed explanation.

Table 7 : Participants for Detailed Exploratory Study

Pseudo Name (Company)	Title/Position	Years of Experience	Firm Size (No. of Employees)	Firm's Industry
Susan (C1)	Senior Director	15+ years	130,000+	Enterprise Software
Kelly (C1)	Senior Director	25+ years	130,000+	Enterprise Software
Carl (C1)	Group Vice President	25+ years	130,000+	Enterprise Software
Jacob (C2)	Director	25+ years	45,000+	Healthcare
Harry (C3)	Senior Director	20+ years	90,000+	Semiconductor
Paul (C3)	Senior Director	20+ years	90,000+	Semiconductor
Henry (C3)	Senior Director	20+ years	90,000+	Semiconductor
Larry (C4)	Senior Director	25+ years	300,000+	Industrial conglomerate
John (C4)	Director	25+ years	3000,000+	Industrial conglomerate
Cliff (C4)	Director	20+ years	300,000+	Industrial conglomerate
Laura (C4)	Vice President	25+ years	300,000+	Industrial conglomerate
Mark (C4)	Senior Director	20+ years	300,000+	Industrial conglomerate
Kathy (C4)	Senior Director	20+ years	300,000+	Industrial conglomerate
Mano (C1)	Vice President	25+ years	130,000+	Enterprise Software
Tim (C5)	Senior Director	20+ years	10,000+	Network Equipment

5.2.2 Qualitative Coding

I used the qualitative analysis methodology of Yin (1994) and Tracy (2013) for data analysis. This involved coding the interviews and classifying the codes into themes and patterns. This technique is further recommended by Miles and Huberman (1994).

Coding is a methodology for organizing and sorting the data. This allows the researcher to analyse and synthesize the data. Coding links data collections and interpretations and it facilitates the analysis process. Coding can be done in a number of ways, but in most cases, during the coding process, the researcher assigns a word, phrase, number or symbol to coding categories. The researcher goes through the textual data (interviews, transcripts, field notes etc.) in a systematic way to categorize concepts and themes. The process of creating codes can be pre-set or open, however, a hybrid model may be the better option (Gibbs, 2008). A list of pre-set codes was developed from the literature survey and preliminary exploratory study. For example, alliances, partnerships, and external collaboration were coded as individual codes and later on collapsed to a category as “ecosystem partnerships”.

Pre-set codes could be as little as 8 to 10 codes and as high as 40 to 50 codes. It is advisable to keep a moderate set of pre-set codes such that the researcher is not overwhelmed with a large set of codes and as a result makes mistakes during coding.

Emergent codes are ideas, concepts, relationships, meanings etc. which emerge during the coding process. The researcher may not know these codes initially. For example, the ‘business model changes’ code, “mind-set changes” code emerged while coding the transcripts from different interviews.

Coding is a systematic way of organizing the data. It is like placing the data in code categories similar to a personal filing system where we put the relevant papers in the associated files. The researcher should ask himself/herself the following questions for systematic coding:

- What are participant sayings?
- Is it consistent among all participants? Or it is an outlier?
- What is this an example of?
- What kind of events are associated with it?
- What is happening? Can I make some meaning out of it?

The words, numbers or symbols of these questions are the codes for the qualitative study. These are labels that classify the information. It is also important to refine the codes in different iterations and the researchers should write notes for each code (Lofland and Lofland, 1995).

5.2.3 nVivo Software for Qualitative Coding

The nVivo software (QSR International, www.qsrinternational.com) for qualitative data analysis was used to facilitate the coding of the interviews and to aid in coding in a systematic manner. Several themes emerged from the coding process. Table 8 lists these themes and details both their total number of occurrences and the number of interviews in which they occurred. As part of the coding process, the intention was to seek codes that recurred across interviews so that a repetitive and representative set of themes could ultimately be used to understand the dynamic capability in these firms. To this end, any initial code was considered in light of its plausible synonyms to ensure that the number of codes did not become so large as to become meaningless.

5.2.4 Detailed Exploratory Study Interview Questions

The questions are divided into six categories; they are included in Appendix A-2 and the interview email is included in Appendix A-3. The interviews started in September, 2015 and all interviews were completed by December, 2015.

The first category of questions is related to **Digital Transformation leveraging IIoT business and the organization structure** to support the transformation process. This is an important question to understand the strategic nature of the business based on the hierarchy and reporting relationships of the IIoT executives. If a business is core to an organization's function, it must have highest visibility from the board of the organization.

The second category of questions is related to **collaboration and information sharing within the organization.** Internal knowledge management and harnessing the existing capabilities are very important to gain competitive advantages and a set of processes and organization structure will influence that.

The third set of questions is related to **collaboration with external partners**. Since IoT business intersects the operational technology (OT) side of the business (technologies which are involved in running the machines) and information technology (IT) (technologies which support the business), one firm may not be able to provide all related technologies and will need to cooperate and compete for the IIoT business.

The fourth set of questions is related to **capability development** and identifying some critical substantive and dynamic capabilities for Digital Transformation in those firms. The fifth set of questions deals with **performance measurement** and how these firms measure the success of their initiatives and capabilities. The degree of Digital Transformation is not clear and the participants were asked how they could measure their transformation initiatives. The sixth and last set of questions is related to the **reasons for developing strategic alliances.** Since almost all the companies in the IIoT industry are forming strategic alliances with multiple companies, the question explored the reasoning for such partnerships.

The themes that emerged from the interviews are listed in Table 8.

Table 8 : Themes emerged from the study

Theme	Total number of Occurrences	Total number of Interviews in which occurrence were found
Ecosystem Partnership	30	10
Path Dependency	19	7
Mind-set Changes	13	6
Business Model Change	12	10
Technology Disruption	12	9
Strategic Focus and Intent	11	7
Capability Modularization	10	7
Internal Collaboration	10	7
Context Dependency	8	6
Organization Structure	8	7

The themes that emerged from this analysis are: ecosystem partners, Path Dependency, mind-set changes, business model change, technology disruption, strategic focus and intent, capability modularization, internal collaboration, context dependency and organization structure. The next section will discuss each theme in turn, presenting evidence and evaluating its meaning in light of the existing literature.

5.3 Results and Analysis

Ecosystem partnership

All participants voiced a view that ecosystems are integral to a digital transformative capability process. In a high-velocity market with significant uncertainty in the business, firms tend to form strategic alliances to serve the market and, in this process, try to hedge the risks in the business. In the IIoT business, each and every company is forming alliances with other companies. According to Larry, “Ecosystem partners play an important role in product strategy. For example, for Smart Airport, three internal C4 businesses are involved and C4 businesses are contributing 30% to 40% of the offerings and other 60% to 70% are offered by the partners”.

Jacob, from company C2 and Mano from C1 believe that ecosystem partnership is key for success in the industrial internet market and for Digital Transformation. According to Jacob, “C2 has developed a Healthcare Cloud but it won’t be successful unless other third-party solution providers are using the C2 Healthcare Cloud and develop applications on top of that. So, we see more and more strategic alliances with ecosystem partners for IIoT & Cloud. In this space, the organization, which has a good ecosystem partnership, will succeed in the business.”

Ecosystem partnerships can be difficult to manage and the partners may have competing interests. Henry highlights this point in his interview, “C4’s strategy early on was good, to have a limited number of partners like Intel, AT&T, Cisco etc. So, for IIoT, the companies need to have a limited set of partners otherwise partner management will be difficult. We should not make ourselves too thin. Get some early adoptors and go with them, develop solutions and go with a set of partners”.

Firms develop ecosystem partnership through strategic alliances, which has been used as a classic example of dynamic capability (Eisenhardt and Martin, 2000). However, strategic management scholars have mixed opinions about the effects of strategic alliances on firm performance. Some scholars (Alvarez and Barney, 2001) think it might have a negative effect; others (Golden and Dolliger, 1993; Preece, Miles and Baetz, 1999) believe it has a positive effect; and the third group (Calabrese, Baum and Silverman, 2000; Soh, 2003) suggest it might have positive and then negative effects.

Scholars have used different measurement criteria for measuring the outcomes of strategic alliances and firm performance. One group of scholars (Rothaermel and Deeds, 2006; Soh, 2003) have used new product development; Golden and Dolliger (1993) have used revenue growth; Baum et al. (2000) have used R&D spending; and Chang (2004) has used speed of IPO as measurement criteria. Most of these studies have been conducted with large enterprises (such as large pharmaceutical companies) or companies which went public in previous years. There is not enough evidence of the impact of strategic alliances on firm performance in a high-velocity environment. The IIoT industry is still evolving and it could be compared with the venture-backed pre-IPO firms where it has been shown that alliance formation positively and significantly affects the market performance of venture-backed firms in the software industry. However, forming large alliances hurts the valuations of these firms (Moghaddam, Bosse and Provance, 2016).

One could observe similar trends in the IIoT industry which is going through Digital Transformation, where more and more companies are forming strategic partnerships with each other and none of them are emerging as an industrial leader. This signifies the confusion in the industry. Thus, ecosystem partnership is a point of interest for digital transformative capability.

Another study (Schilke, 2014) suggests that strategic alliance capability and firm performance have an inverse U-shape relationship and strategic alliance has a positive impact in a moderate-velocity environment and a negative impact in a low- and high-velocity environment, though respondents in my study suggest that ecosystem partnership through strategic alliance has a positive impact for high-velocity environment such as IIoT.

Another area of interest is the scope of ecosystem partnership and its effect on digital transformative capability by leveraging emerging technology. The available literature in this area is very limited. Some strategy scholars (Anand, Oriani and Vassalo, 2007) have studied the partnership requirements of firms working with traditional technologies versus emerging technologies. They conclude that the firms with capabilities in the emerging technologies tend to work on their own through internal development, whereas, the firms without emerging technology capability tend to rely on ecosystem partners for capability development.

In my study, the nature of the partnerships between these companies (C1 through C5) indicates more non-equity-based partnership such as technology licensing, technology exchanges, research contracts and similar associations. There are few tighter integrations through merger & acquisition (GE acquired ServiceMax, Google acquired Apigee, Cisco acquired Jasper Communication) for reconfiguring their existing capabilities and developing new capabilities by integrating technologies and customers from acquiring and acquired companies. So, ecosystem partnership is a key factor for digital transformative capability and it impacts firm performance.

Path dependency

Capability transformation is path dependent. If a firm is successful in a particular path, that is, in a particular way of doing business, it is difficult to change the business when faced with technology disruption and other changes in business conditions. This view is supported by our interview participants. Paths (Ambrosini and Bowman, 2009) are about histories and acknowledging histories is important for capability transformation due to technology disruption or other external factors. For example, some scholars, like Madhoc and Osegowitsch (2000) looked into the Path Dependency of the pharmaceutical companies and concluded that the path and country of origin of the companies impacted their capability transformation.

Carl, from company C1, stated, “We are very successful in a license-based business model and due to severe market pressure, we are slowly moving towards a cloud-based business model. Still most of our customers are in traditional business models and we will try to extend it as much as we can”. Based on Carl’s commentary, company C1 is not ready to transform its business models and related capabilities to a service-based business model due to the Path Dependency of the traditional businesses. Kathy, from C4, echoed Carl’s thoughts related to Path Dependency. This in part is due to legacy effects from its customers. There is a contradiction here, according to Teece (2014) who suggested that path dependence and legacies can provide a foundation and fulcrum for future growth. Because capabilities originate in and arise from organizational histories (Teece et al., 1997), the narratives and applications for those capabilities are similarly tied. Stated differently, managers may lack foresight to envisage new uses or new forms their capabilities should take precisely because of the histories associated with those capabilities. Thus, while capabilities may be untethered from a purpose or product, they are not untethered from the past. Teece also articulated the importance of the path for dynamic capability formation (Teece, 2007). He believes that dynamic capabilities normally reside with the top management, however, due to path dependencies, the capabilities are impacted by the organization systems, processes and structures.

Jacob, from company C2, expressed a similar view to Carl, stating, “Our medical devices business is high dollar value and low volume and our manufacturing, sales, marketing and other people are experienced in this business. This business (of selling machines to hospitals) still exists and is very profitable. It is difficult for us to switch to a cloud-based software business, which is high volume and low margin and we need to transform our existing capabilities or acquire new capabilities from outside for Digital Transformation".

Tim, from C5, had a similar view to Jacob. "There is a sluggishness for the existing companies to change in the industrial automation area. Some of them are attributed to the assets of these companies which are 30 to 40 years old and it is difficult to change very quickly. It is not a challenge for software companies. Also, the customers for these companies would like to utilize these assets at the fullest extent so they are also reluctant to change. So, all together it is difficult to shift to a new paradigm."

Wang and Ahmed (2007) echoed similar views to Jacob and Tim. According to them, capability development is path-dependent and a firm's current position is not only determined by the path it has travelled but it also impacts future direction. Teece (2014) suggests that though Path Dependency may pose a constraint for future direction, the firm should pivot and take a new path when they face technology disruption and other external factors which force them to change strategy and business model and thus transform their existing capabilities or create new capabilities.

Path dependency, then, becomes an inhibitor of change despite the urgency created by technological disruption and the flexibility sought with modularity.

Mind-set change

A majority of the respondents (among the top three occurrences) expressed that a change in mind-set is an important factor in a dynamic capability transformation process for Digital

Transformation. The punctuated equilibrium theory (Gersick, 1991, Miller & Friesen, 1980; Tushman & Romanelli, 1985) of organizational transformation is the leading theory, which states that a business goes through an equilibrium phase for a certain period of time and then the transformation occurs due to external and internal factors and again it remains stable for a period of time. During the equilibrium period, the company tries to develop competitive advantages with better products and services. This process continues over a period of time. However, in the last five years, organizational transformation has moved from punctuated equilibrium to constant fast-paced changes due to Digital Transformation (Kaganer, 2016).

The leading strategy consultancy firm, McKinsey and Company[16], says that "digital is not merely an add-on; it's a way to think differently about business models, customer journeys and organizational agility". The digital mind-set refers to managerial cognitive capability which is required for strategic changes in uncertain times (Helfat and Peteraf, 2014). It is manager's ability to think and develop strategies based on data and analytics. According to Helfat and Peteraf (2014), heterogeneity of top executives' dynamic managerial capabilities creates differential firm performance under conditions of change. Sexton and Barrett (2003) suggest that a firm has two types of routines – cognitive and operational – and interaction of these routines facilitates innovation. The cognitive routines are automatic, steady state and conscious routines for problem solving and innovation (Gajendran, Brewer, Gudergan and Sankaran, 2014). The managers in a firm should be able to change these cognitive routines from automatic routines to conscious routines such that it could maintain competitive advantages.

[16] https://www.mckinsey.com/industries/high-tech/our-insights/achieving-a-digital-state-of-mind

According to Larry, from C4, "To develop multi-faced businesses, we need managers who can deal with different industries at the same time. It is not a domain-specific knowledge but 'solution-centric' knowledge. This is a new way of looking at business. So, new product development, product distribution, serviceability, after sales support and others need to converge towards the solution. Though we can learn from existing capabilities, we need to add digital mindset and modify these capabilities". Mark, from C4, said "technology is an enabler and Digital Transformation is not possible without mindset changes in the organization".

Harry, from company C3, expressed similar views. "The IIoT business is a different business and the managers must have a digital mindset for the business. One of the characteristics of the digital business is that the pace of innovation is very high, so managers should adopt agile methodology for product development, alliance, marketing, sales, customer support and all related businesses."

Digital mindset is an important factor for digital transformative capability. The definition of digital mindset is evolving as more and more physical assets and activities are being represented digitally. It is not mere duplication of physical assets to digital assets; digitization offers a new way of looking at things which was not possible in the physical world (Kaganer, 2016). According to Kaganer, the manager's cognitive capabilities should include strategic capabilities and transformative capabilities. The manager with a digital mindset (digital manager) should be able to sense the opportunities from physical and digital information and then the managers should have transformational cognitive capability to seize the opportunity in a quickly changing environment and develop new capabilities or reconfigure existing capabilities to address those changes. The managers should look into the fundamental changes in the industry and not into the trends of the industry. For example, for a manager in the retail industry, he/she looks into the buying behaviour of customers and tries to address that with mega trends like online shopping, cloud deployment and analyzing behaviour using big data. The trends/technologies are enablers and managers should use that for developing new or enhanced/reconfigured existing product development or delivery capabilities which will satisfy customers.

Based on my interviews and discussion, the mind set change is a contributing factor for digital transformative capability and a digital mindset is a necessary cognitive managerial capability for the IIoT industry.

Business model change

A successful business model has three components: **customer value proposition** (the model helps customers to perform a specific job, which others could not provide at this time), **profit formula (**revenue model, cost structure, margins etc.) and **key resources and processes** (resources: people, technology, products etc., processes: manufacturing, sales, marketing etc. and capabilities to utilize these resources and processes to generate economic outcome) (Johnson, Christensen and Kagermann, 2008). According to these scholars, the business model should be changed when managers face the following strategic circumstances:

1) The opportunity to address a large group of customers through disruptive innovations where previously it was not possible to address those customers due to cost or other complications.

2) The opportunity to market a tested technology in a new market or capitalizing on a new technology with a good brand name.
3) The job-to-be-done initiative and integrating resources and processes to achieve this initiative.
4) Need to fend off low end disrupters through a new business model.
5) Need to respond to a shifting basis of competition.

Digital transformation and IIoT have disrupted industrial businesses and created new opportunities and customers. Also, instead of industry-centric competition (Porter, 1980), the companies are facing arena-centric competition (McGrath, 2013) and the industry boundaries are blurred in the IIoT industry. To address these challenges, business models are evolving for IIoT businesses but the lack of certainty over how to monetize IIoT is leaving firms in a state of flux and drift about the conditions for their own business models and in their confidence about what might work in this new landscape. While this opens room for business model innovation, it also creates uncertainty over which models might ultimately be rewarding. The industry is moving towards a service-based model, for example, which is similar to the software-as-a-service (SaaS) model and slowly customers are asking for these models. IIoT managers need to learn this new model and incorporate it into their decision-making processes.

For example, according to Cliff, from company C4, "The industry is moving from an equipment-centric to outcome/service-centric business models. So, the managers need to develop usage patterns, peak loads, performance indices etc. to develop the new service models for the business. And service-based, pay-per-use models will be the norm of the future".

However, Carl, from company C1, thinks differently. “My personal view is that business model changes are evolutionary. The businesses are not sure how to monetize the IoT business. The businesses are thinking of IIoT businesses either horizontally or vertically. In a horizontal IIoT business, companies are developing IIoT platforms like C1, C4 and they are expecting IoT developers will use their platforms, whereas, others are developing vertical solution businesses for IIoT. The business models are different for these businesses. However, the managers need to adopt a different business model than they are used to now”.

Both of these respondents highlight the changes in their businesses, which are moving to a service-based business. Some scholars have coined the term ‘servitization’ (Baines and Lightfoot, 2014). According to these scholars, servitization is the innovation of a firm’s capabilities and processes to shift from a product-centric business model to a product-and-service-centric business model which is based on customer outcomes. Servitization (service business model innovation) is a continuum and it starts with a product-only business model (providing products and mandatory warranty services) to the product and service business model (which provides products, mandatory services and other related services like spare parts, maintenance etc.) and finally moves to a customer-oriented business model (where the customer pays for use-oriented or result-oriented services) (Visnjic, Wiengarten and Neely, 2016).

Business model change is an important factor, which will accelerate or reduce the adoption of Digital Transformation for the customers. The IIoT companies are not demanding a total service model yet but they may demand it in the near future. So, business model changes will influence managerial capability transformation in a big way.

Technology disruption

A majority of our participants highlighted technology disruption as an important factor for capability transformation. Digital transformation is changing the markets, customers, partners and products of these firms, and doing so quite dramatically. The industrial organizations are trying to transform their businesses from a traditional machine-centric business to a digital business. For example, an industrial conglomerate like General Electric (GE) is rebranding itself as a 'digital industrial company'. Strategy scholars are divided about the impact of the environment on capability transformation. The Teece (2007) position claims that dynamic capabilities are necessary for sustaining competitive advantages in a specific boundary condition of a 'high-velocity environment'. Meanwhile, Eisenhardt and Martin (2000) suggest that dynamic capabilities are best practices (contrary to Teece, 2014) and a specific boundary condition is not necessary; both ordinary and dynamic capabilities should work in both moderate-velocity and high-velocity environments.

However, all participants in our study believe that technology disruption (or a high-velocity market) accelerate the capability transformation process because it creates a high state of urgency. So they are in agreement with Teece's (2007, 2014) argument. What is problematic, however, is that while the recognition of the need to change and transform capabilities is created by this disruption, the severity of the disruption creates its own problems. The organizations in question struggled to understand 'what' capabilities were needed as a result, both now and for the future. This problem was exacerbated by trying to ensure short-to-medium term competitiveness in their markets without knowing what the future markets will look like or need of them.

A solution may come from changing the focus of the firm's knowledge base. For example, Larry, from company C4, said, "IIoT business is a disrupter to existing businesses and disrupting itself. To develop these multi-faceted businesses, we need managers who can deal with different industries at the same time. It is not a domain-specific knowledge but 'solution-centric' knowledge. Though we can learn from existing capabilities, we need to add the 'solution' mind-set and modify these capabilities." Larry felt that the existing operational capabilities in his organization should be transformed into new ways of doing business in digital businesses. Modifying and transforming current capabilities (operational) for technology disruption is a component of that.

According to Harry, from company C3, "Our Company is transforming its business strategy. C3 is trying to transform itself from a PC company to a company that connects and powers smart and connected computing devices (things) to the cloud. This is a disruption in our traditional business".

Laura, from company C4, articulates the disruptive nature of Industrial IoT. "IIoT business is different from C4's Core businesses as IIoT is about connecting machines with intelligent information or in other words, 'Software Defined Machines'. It has a game changing effect across the industry and C4 is at the forefront of this revolution. This will improve the productivity of industrial businesses and improve the lives of people. It will have significant effects across the industrial world”.

‘Technology disruption’, then, appears to be an important factor for digital transformative capability by motivating the dynamic capability process to sense, seize, and reconfigure. IIoT created the necessary sense of urgency for these companies to focus on dynamic capabilities and to pursue change but created confusion as to what the transformation was meant to achieve (i.e., what was changed and what they were changed into). The solution may rest in Teece’s (2014) notion of untethering capabilities from products and purposes.

Strategic focus and intent

Strategic focus and intent is a pre-requisite for digital capability transformation. A capability remains as an operational capability unless top executives in a firm have strategic focus for capability transformation and they have a strategy for execution. All of our participants highlighted this as a core theme of a Digital Transformation process for dynamic capability.

Paul, from company C3 said, “In the web or mobile business, the challenges were related to the software side of the business or more information technology (IT) centric. Now, we are entering the area of operational technology (OT), which is more complex, for example, we like to predict the probability of oil spills from offshore platforms and how to prevent that, we are discussing energy saving using sensors into the street lights etc. These are complex problems and these companies need to have strategic focus and intent to change the existing capabilities and develop new capabilities". On the other hand, Susan, from company C1, expressed her frustration, "C1 does not have strategic plans for the IIoT business. The managers are not clear how IIoT and cloud could change their businesses. They still think IIoT products are extension of their Middleware and Messaging products." C1 does not have a strategic focus and intent in the IIoT business and, until now, it does not have significant presence in the IIoT market.

Intentions to change, and actual change, are two very different things. One can have an intention to change but lack the resources to do so (Covin, Selvin, and Schultz, 1994) or seek to make changes but, in fact, scale these back to minor, second-order, strategic changes consistent with the existing strategic archetype (Fox-Wolfgramm, Boal, and Hunt, 1998). This latter problem is expressed by Susan because strategic change needs to occur, and there may be intent, but reinterpretation occurs in line with existing paradigms that then inhibit dynamism.

Capability modularization

Digital transformation has disrupted businesses. The customers are demanding customized products tailor-made for their businesses; competition forces a firm to be efficient in its business operations and provide highest quality products at a lower cost within a reasonable response time; and finally, IIoT products are complex and the company needs to absorb these complexities in a changing environment. Modularization is a way to handle these competing demands (Miller and Elgard, 1998). The firm should have the capability to develop products and services in modules such that it can mix and match these modules for different customer demands. Each firm has some core capabilities. These capabilities are needed for the normal survival of the firm, and are typically referred to as zero-order, operational, or ordinary capabilities. However, due to technology disruption, competition, and new markets, firms are adding additional layers of capabilities as higher order capabilities which are adjacent to their current businesses. This is in agreement with Winter's (2003) capability hierarchy theory, where zero-order capabilities are needed for daily operation of the company and higher order capabilities are needed for dynamic capabilities. However, modularization of capabilities refers to core capabilities of a firm and then adding adjacent capabilities on top of core capabilities to provide the complete solution to its customers. These multi-layer capabilities are higher order dynamic capabilities and a firm develops these capabilities to differentiate itself from competitors.

Cliff, from company C4, articulated this idea of modular capability, describing it thus, "capabilities are like concentric circles. We have some core capability and then we have multiple concentric circles, consisting of extended capabilities. In this modular capability approach, each organization needs to protect and enhance the core capabilities and add extended capabilities to expand the business."

Another way of providing capability modularization is through a platform-centric approach. As Laura, from C4, mentioned in her interview "C4 is developing an Industrial Internet platform which will have all core capabilities of an industrial business and our businesses, customers and partners will add their own layer on top of the core platform layer". Industry platforms are products, services or technologies developed by one or more firms which act as a foundation upon which others develop complementary products, services or technologies (Gawer and Cusumano, 2014). The objective of this platform is to increase efficiency and reduce cost using a modular approach. The industry platform has the following characteristics: it should be functional for a broader technological system and it should solve a business problem for many users within an industry or across multiple industries (Gawer and Cusumano, 2008). The industry platform helps the firm to establish itself as the industry leader for that technology and it also helps the partners to develop industry-specific applications at a faster pace.

Other participants expressed similar narratives. As well as C4, C1 and C2 are also developing IIoT platforms. During technology disruption, coupled with uncertainty, firms are transforming their operational capabilities to dynamic capabilities by modular approaches most likely as part of an untethering process that also hedges the value of those capabilities against the uncertainty of what IoT markets will look like and require of firms. The nature of this modularity, however, seems to be vulnerable to path dependence.

Context dependency

Like Path Dependency, capability transformation for Digital Transformation is also context-dependent. The firm develops new capabilities or transforms its existing capabilities based on the context (such as the pressure or urgency it experiences or its value chain, for example) of that firm. A capability may remain as an operational capability for a firm and the same capability may be transformed to a dynamic capability based on the context of the firm. Our participants reported this same theme. For example, Kelly, in company C1, saw new product development (NPD) capability for IoT an operational capability, stating, “The IIoT product is an extension of our middleware software products. And we do not see any difference of IIoT software than other software”. However, the same NPD capability for IoT in company C4 is dynamic, calling for a transformation of NPD capability, as explained by Laura, “We are developing an IIoT platform, which is a platform-as-a-service (PaaS) product, and our businesses and partners are developing their solutions on top of our platform. This is different than our standard NPD capability as our managers and developers need to take care of multiple businesses with different performance requirements”. So, the capabilities depend on the context of an organization, and specifically on its role in the value chain. C1’s context is different than C4’s context.

For Teece’s (2014) refinements to the dynamic capability view, this discussion suggests that context is aligned with the strategy of the firm. Teece (2014) repeatedly emphasized that good strategy determines the value and use of dynamic capability in creating or shoring advantage. The relative distance between the firm’s capabilities, its strategy and the direction of travel in its industries (e.g., resulting from the effects of IIoT) might explain why context may on the surface appear similar to two sets of firms but in fact be quite different under the surface. As mentioned in chapter 2.6, the distinction between substantive capability and dynamic capability is not clear (Zahra et al., 2006). Context dependency is an important factor which influences capability transformation. I argue that strategic focus and intent, Path Dependency and context dependency help a firm to transform their substantive capability to dynamic capability. Path dependency hinders capability transformation as managers like to maintain the paths which made them successful. Context helps a firm to make one or more business initiatives strategic and the firm develops strategies to achieve that.

Organization structure

Organization structure is the core of developing capabilities, processes and cultures within the organization to achieve its objectives. A firm's organizational capability depends on its organization structure (Teece and Pisano, 1994; Teece, 2006). The development of new capabilities or reconfiguring existing capabilities depends on the organization structure, culture, people and processes such that the organization can continue to develop and maintain existing products and develop new products and competencies in a changing environment (Verona and Ravasi, 2003). The firm needs to reconfigure assets and organization structures to adapt emerging markets and technologies (O'Reilly and Tushman, 2007).

An organization structure helps (or hinders) a firm to transform its capabilities and execute its strategy. Most of the participants in our interviews commented on the organization structure and its impact on the digital capability transformation process. For example, C4 has created a specific digital business group with its own profit and loss responsibilities and all businesses have their own chief digital officer reporting to the head of the digital business. For C4, IIoT is a priority and the organization structures reflect the strategies for Digital Transformation. Whereas, C1 does not have an IIoT-centric organization and it considers IIoT as another extension of its product portfolio and has created a group for that. In this respect, the organization structure is also influenced by context and the strategic intent of the firm.

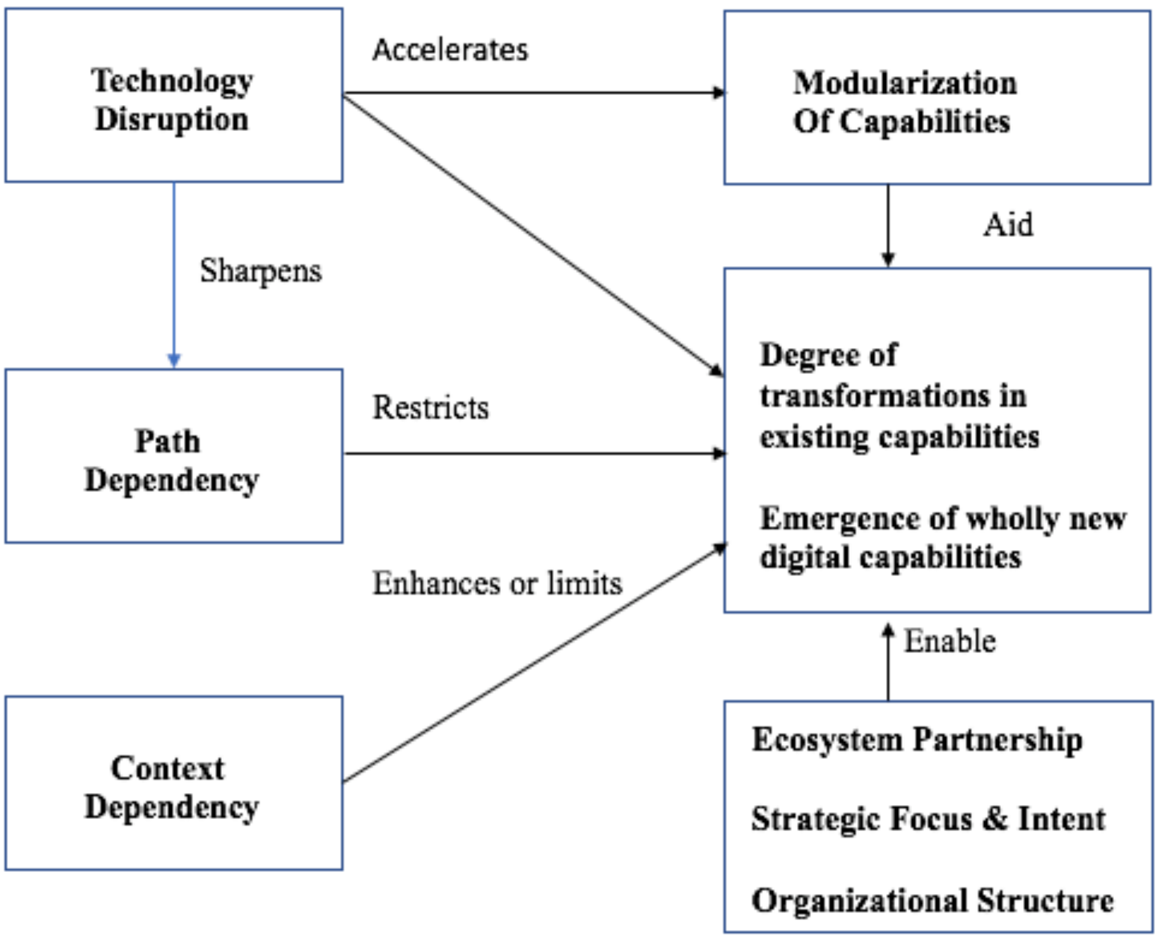
It is also dependent on the strategy of the firm. For example, a firm developing a horizontal IoT platform for its customers might have one type of organization structure and its influence on NPD capability, whereas, another firm might have a different structure as it might be developing an IoT solution for the healthcare industry, which is a vertical NPD approach. Our participants expressed the view in their interviews. For example, Larry, from company C4, stated, "The traditional business/domain-based organization structure is changing. Earlier, C4 has businesses in an industry vertical, such as Aviation, Oil & Gas, Healthcare etc. but now the structure is changing more towards a solution-based organization structure and multiple businesses are participating. So, the IIoT managers need to develop new collaborative capability or expand current capabilities to accommodate these changes". Henry, from company C3, thinks very strongly about the effect of organization structure for capability transformation and he stated, "Solution-centric organization structures are key to the IoT success. If you look at C3, they have groups such as IIoT – Solutions and Services, Core processors business groups and all of them are struggling to develop a comprehensive IIoT strategy as the groups have different charters. I have seen the same problems at other companies. Unless they have a solution-centric organization structure, they cannot develop and execute the IoT strategy. All different groups and assets must cooperate to make a good IIoT strategy".

IIoT business is a comparatively new business and firms are experimenting with multiple options for product development, pricing, sales and distribution channels. The firm needs to be ambidextrous and should have a supporting organizational structure. Ambidexterity is the ability of the firm to explore and exploit simultaneously such that it can adapt to changing business conditions (O'Rilley and Tushman, 2007). An ambidextrous strategy helps a firm to develop new or reorganize existing capabilities and it influences the organization structure.

Organization structure then appears to define the firm's readiness for change and a proper organization structure will affect digital capability transformation.

5.4 Emerging Conceptual Framework

Figure 11: Emerging conceptual framework of Digital Transformative Capabilities



Based on the discussions in the previous section, an emerging conceptual framework of digital transformative capabilities was developed (Figure 11). Though technology disruptions and technology based transformations are prevelant for decades (Henderson & Venkataraman, 1992; Brynjolfsson & Hitt, 2000, Clemons, Dewan, Kauffman and Weber, 2017), IoT and emerging technology based disruptions are accelerating digital transformation in the industrial businesses(Porter and Hepellmann, 2015; Ismail, 2017) and these businesses are developing new capabilities for business model transformation or transforming their existing capabilities to develop outcome centric, consumption based business models (Dijkman, Sprenkels, Peeters, and Janssen (2015); Metallo, Agrifoglio, Schiavone, and Mueller (2018). Thus technology disruption is a key factor which could influence a firm to develop digital transformative capabilities.

Technology disruptions and emerging technology based digital transformation are also accelerating modularization of capabilities, which in turn are helping the businesses to transform their business models to platform based business models (Muzellec, Ronteau, and Lambkin (2015). Helfat and Raubitschek (2018) argued that the companies are developing dynamic and integrative capabilities for profiting from innovation in digital platform-based ecocsystems. Also, to create a successful business model by leveraging IoT, the companies should transform their operating model (Turner, 2017; Dunbrack, Ellis, Knickle and Turner, 2016). Thus, modularization of capabilities could be an input for conceptual framework.

Though ecosystem partnership through strategic alliances have improved firm performance during high velocity market (Wassmer, Li, and Madhok, 2017), ecosystem partnership is a key success factor for digital transformation (Krishner, 2017). Digital ecosystem for industrial IoT is driving digital transformation initiatives and more and more partners are thriving from such ecosystems (Weill and Woerner, 2015). Woodhead, Stephenson and Morrey (2018) argues that IoT based digital ecosystem could help construction industry to implement Smart City and other smart infrastructure initiatives. So, based on this discussion, ecosystem partnership could play an important role for the conceptual framework.

Helfat and Martin (2015) suggested that dynamic managerial capabilities had strong influence on strategic change and firm performance. Roberts, Campbell and Vijayasarathy (2016) suggested that dynamic managerial capabilities could be augmented with proper information systems which could help a firm to sense opportunities for innovation. This dynamic managerial capabilities are important for any business transformation. However, strategic focus and intent of the senior managers are very crucial for a successful digital transformation and companies have changed the roles of Chief Information Officers (CIOs) and Chief Digital Officers (CDOs) to concentrate on digital transformation initiatives (Haffke, Kalgovas and Benlian, 2016). Hess, Matt, Benlian and Wiesböck (2016), studied successful digital transformation at three large German media companies and suggested that digital transformation is a high priority management challenge and top managers must be involved for successful digital transformation. Thus, strategic focus and intent is a key factor for digital transformative capability framework.

Teece, Peteraf and Leih (2016), suggested that strong dynamic capabilities were necessary to foster organizational agility (based on a proper organization structure), to address deep uncertainity generated by innovation and dynamic competition. However organization structure plays a pivotal role for digital transformation and Nott (2017) suggested four organization structure archetypes for digital transformation.: digital transformation special projects team, office of digital transformation, embedded digital business and digital business unit. Kiron, Kane, Palmer, Phillips, and Buckley (2016) suggested that companies should align their organizations (structure, people, process and culture) for its digital future and it could be a key component for digital transformative capability framework.

Clausen, Göll, and Tappeser (2017), observed path dependency in socio-technical regimes and how it was impeding the transformation to a green economy. Other researchers (Barnett, Evans, Gross, Kiem, Kingsford, Palutikof and Smithers, 2015) also noticed similar tendencies in the climate change area as path dependent institutions showed resistance to change. Path dependency is also impeding the digital transformation. Schmid, Recker and Brocke (2017), observed that when organizations undertook large digital transformation initiatives, these efforts were hanpered by inertia (path dependency). Kurti and Haftor (2014) observed that path dependency hindered business model changes and adaptations. Thus, path dependency is an important factor for digital transformative capability fremwork. As mentioned in the section 5.2, context dependency is also an important factor because digital transformation initiative are context dependent and for a firm industrial IoT may not be a priority whereas for another firm this is a strategic initiative (Qualitative Study).

5.5 Mapping Themes with Conceptual Framework

The table in appendix A-14, maps the themes from qualitative study with conceptual framework elements (Figure 12 & 13). Based on the qualitative case study the following conceptual framework relationships could be inferred:

- Ecosystem Partnership may influence DTCs and Digital Transformation positively, whereas Path Dependency may influence DTCs and Digital Transformatyion negatively.
- A firm should develop capabilities for cultural changes (DTC – Cultural Transformation) and business model changes (DTC – Business Model Transformation).

- A firm should develop collaborative capabilities (both internal and external collaboration capabilities which may influence firm business operations (DTC – Operating Model Transforemation). The organization structure may influence the operating models of the firm (DTC – Operating Model Transformation).
- Capability modularization may help a firm to enhance digitalization profile (Digital Twin, Digital Thread and Digital Mindset), whereas, Context dependency may or may not help a firm to enhance digitalization profile.

5.6 Conclusion

In this chapter, I have identified a series of themes that are largely interrelated in depicting the challenges and conditions supporting a digital transformative capability process. Technological disruption creates a motivation, if not demand, to change and start a transformation process. But the very nature of such disruption appears to have a double-edged consequence by creating doubt around what future capabilities are needed for Digital Transformation and into what form existing capabilities ought to be transformed. While firms realize a need to modularize their capabilities, in a way not too dissimilar to Teece's (2014) idea of untethering, Path Dependency caused by organizational histories and customer legacies causes further disruption to transformation. Context dependency appears to have a bearing on what capabilities are selected for treatment and the ultimate rate of change seems to rely on strategic focus and strategic intent allied with a supportive organization structure (though the content of that structure seems hitherto unknown but perhaps can best be described as 'readiness' for change). The transformation process appears to start at each capability development stage as we saw no apparent start point in our interview data.

Following this examination, I have developed hypotheses based on these themes and shape these themes into a theoretical framework of antecedents, mediators and moderators for digital transformative capability and its effect on Digital Transformation. I have tested these hypotheses by conducting a quantitative study with participants from industrial businesses going through Digital Transformation. The measurement model for Digital Transformation is not well-defined and represents one of the most significant on-going challenges to research on digital transformative capability and Digital Transformation.

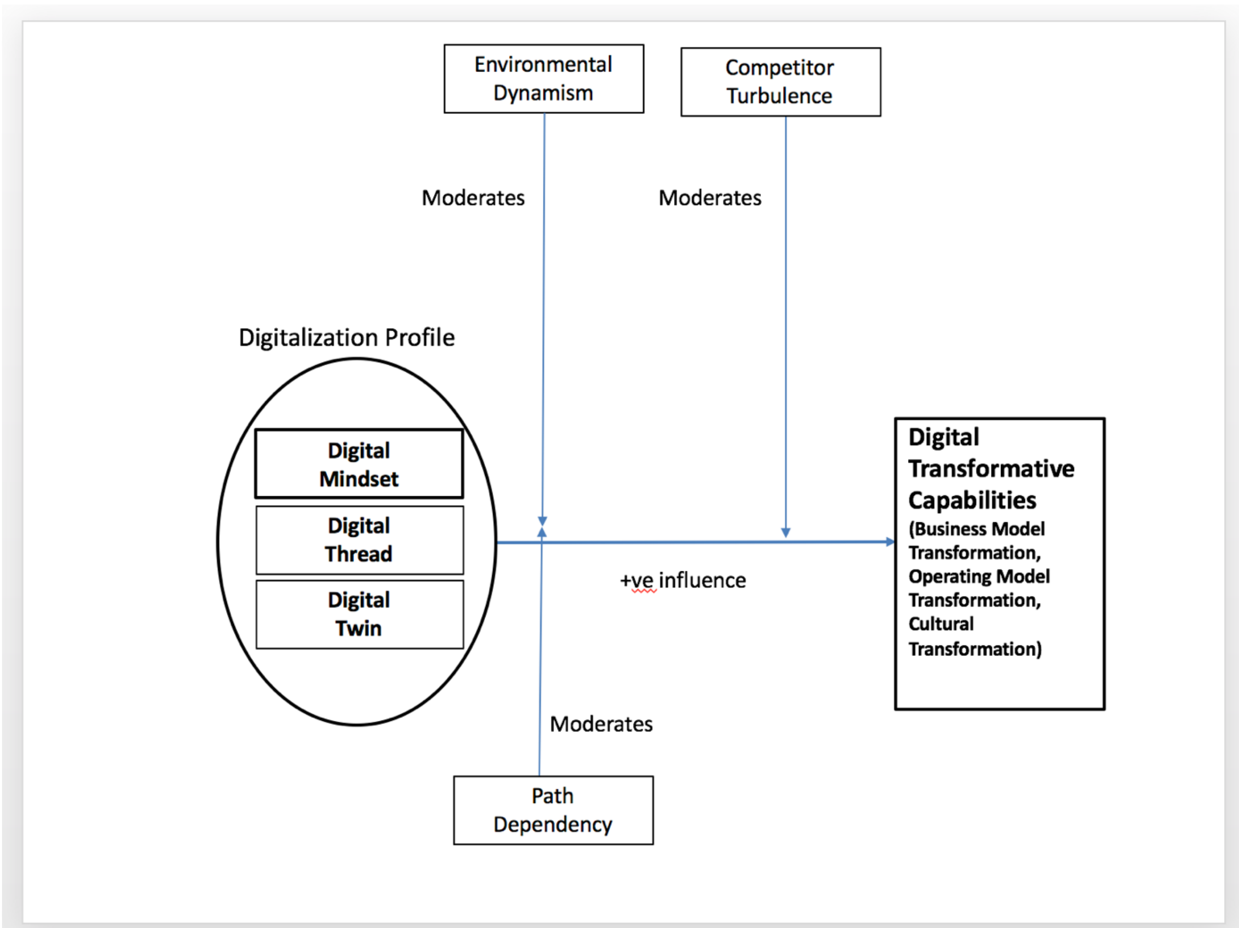
6.0: Conceptual Development

6.1 Introduction

In this chapter, the conceptualization of digital transformative capability is presented and hypotheses for its antecedents and outcomes are put forward. The conceptual framework is based on the literature survey (chapter 2), industry survey (chapter 3), preliminary exploratory study (chapter 4) and detailed exploratory study (chapter 5). The conceptual model of Digital Transformation has been divided into two parts. The front-end model describes the influence of digital profile on digital transformative capabilities and the interaction of external and internal factors which affect the relationship with digital transformative capability. The back-end model describes the influence of digital transformative capability on Digital Transformation and the factors which affect this relationship. These two models are formulated and presented in the subsequent sections.

6.2 Front-end Model: Digital Transformative Capability (DTC)

Figure 12: Conceptual Framework for Digital Transformation (Front-end model)



In a high-velocity environment, with the introduction of new disruptive technologies, companies must develop digital transformative capabilities such that they readjust their business routines for favorable Digital Transformation. We define digital transformative capability (DTC) as *the ability of a company to systematically identify and coordinate digital changes in the digitalization of core business routines.* DTC is an extension of dynamic capability and explains the Digital Transformation process. DTC is vital because, "If you can't master the idea of digital inside your business you open the door to commoditization" (Bill Ruh, CEO of GE Digital)[17]. From the point of view of dynamic capability theory, DTCs do not fit cleanly into the existing theoretical apparatus because they are not simply about the renewal of existing capabilities or about making existing capabilities malleable. Digital transformation involves the replacement of long-standing business activity and long-held assumptions and views about products and trading with digital versions or replacements that involve fundamentally different technologies and ways of working.

The Industrial Internet is accelerating Digital Transformation for industrial businesses. This transformation fundamentally alters customers' expectations about and the use of the products and services provided by industrial businesses. For example, GE used to provide aircraft engines to Boeing to manufacture their aircraft, but now GE is also providing information on the health of jet engines when in flight or at the airport terminal to the airline operators. As a result, operators such as British Airways (BA) can develop new and improved engine maintenance systems at the terminals. In addition, it is fundamentally changing the parameters and boundaries of industries, causing not just industrial integration but industries to change towards technological attributes that it did not have to face in the past. For example, in healthcare, traditional software focused on medical records and document management is being replaced by cloud computing with dynamic access to patients' data instantaneously by a range of stakeholders. In aviation, traditional maintenance contracts are being usurped by intelligent systems that routinely monitor and check airplane systems on-the-go, leading to a more on-demand and customized service delivery with smart sensors tracking a host of parameters.

[17] https://www.forbes.com/sites/maribellopez/2018/01/24/ge-digital-ceo-shares-insights-on-digital-transformation-in-industrial-markets/#4716e5ca3385

Becoming a digital business requires far more than investing in the latest software and hardware technologies; these are enablers for Digital Transformation but cannot transform a company. Companies must change their business models, work on a new operating model and create a digital workplace for their employees (WEF 2018). Some scholars are labelling this disruption a digital vortex (Bradley, Loucks, Macaulay, Noronha and Wade, 2015). Scholars suggest that industrial businesses are moving towards a digital centre, where business models, digitalization and value chains are creating this digital vortex. The components of digital values can be combined in multiple ways and can offer new and improved business models.

6.2.1 DTC for Digital Business Model

Value creation and value capture are two fundamental functions of a business model. Chesbrough (2007) suggested six distinct functions of a business models:

- To articulate the value proposition of the business such that users can understand that.
- To identify market segments where users will use the products or services or both.
- To define the structure of the value chain, including customers and partners.
- To specify the revenue generation mechanism for the firm.
- To discuss the position of the firm within the value network (ecosystem).
- To formulate a competitive strategy to compete against rivals.

A business model for connected ecosystems is a digital business model. Teece (2010) suggests that the purpose of a business model is to define how the company delivers value to its customers, entices its customers to pay for those perceived values and converts those payments to profit for the company. Teece further suggests that business model innovation can be a path to competitive advantage if it is sufficiently differentiated from its competitors and cannot be replicated easily. Teece (2012) suggests that a firm should be able to address the changing business models by developing proper sensing strategies. Hui (2014) highlights the importance of digital business model innovation for IoT business. He emphasizes that in the connected world, companies need to rethink how values are created and captured for their customers.

Value creation and capture analysis:

Hui (2014), in the Harvard Business Review article, "How the Internet of Things Changes Business Models", describes the value creation and capture model and identifies the capabilities needed to create and capture values for IoT business. Value creation is related to the offerings provided by companies to their customers such that they are encouraged to use the service and to pay for those services. Earlier competition was based on features and, since new features add incremental value to the customers, most of the business models were based on price. However, in the connected world, products are never sold once as the companies collect the usage of the products on a continuous basis and tweak the products based on customer requirements. This is a continuous improvement process and one that embraces services aligned to products.

As with value creation, Hui suggests that the value capture model is changing. Companies are not relying on one-time value of their products and services, but on recurring value captures from their customers. This is becoming possible due to real time connectivity with customers.

The table 9 in the next section (adapted from Hui (2014)), describes the model and capabilities needed for IIoT business.

Table 9 : Value Creation/Capture Analysis

Value Models	Factors for Value Creation / Capture	Traditional Business Capabilities	IIoT Business Capabilities
Value Creation	Customer needs	To solve existing problems (reactive)	To address the current and future needs proactively
	Offerings	To market products with service contracts	To market products as-a-service
	Role of Data	To maintain customers by collecting data periodically for future product enhancements	To enhance customer satisfaction by continuous monitoring of customers.
Value Capture	Path to Profit	To develop and maintain sales capabilities for one-time sale of the product & service	To enhance sales capabilities for recurring pay-per-use revenue
	Control Points	To protect using IP protection, brand values and customer support.	To protect using personalization and network effects.
	Capability Development	To leverage core competencies and existing resources and capabilities.	To work with alliance partners to develop products and fill the gaps with customers.

The capacity of a company to create, adjust, modify or replace business models is foundational to dynamic capabilities (Teece, 2009). In the internet age business models are changing, and in the information industry, the data or information are available freely so developing a revenue model is difficult. So, a lot of the internet companies have developed 'freemium" models. A business model developed by one company in one market segment can be implemented in another company in a different segment (Teece, 2009). For example, a subscription model pioneered by Salesforce.com's platform is being adopted by GE Digital in its Predix, Industrial Internet platform. Though business model studies have gained importance, some scholars (Zott, Amit and Massa, 2011) observe that: (i) the definition of a business model is not clear, (ii) the researchers are interested in business models for e-business/digital business and how business models are creating competitive advantages, and (iii) researchers are considering a business model as a new unit of analysis and partners play an important role. For industrial businesses, firms must develop value creation capabilities (such as offering service-based business models, freemium-based subscription models) and business models must include contributions from partners. Though industrial businesses are going through technology innovation, they do not guarantee business success; the new product development efforts should be coupled with new a business model to capture value for its customers (Teece, 2010).

6.2.2 DTC for Digital Operating Model

Business model transformation may not be enough for Digital Transformation, and companies need to develop capabilities to change their existing operating models or develop new operating models for operational efficiencies. Digital Operating Model is the new way of running business functions, processes and structures that combine digital technologies and operational capabilities of an organization such that it can achieve its mission (WEF 2018). Digital transformation is about operational efficiencies and competitiveness of a company and it requires deep understanding of current and emerging business processes and models and current and emerging digital technologies (Andriole, 2017). The World Economic Forum (WEF, 2018) recommends the following capabilities are needed for Digital Operating Model and has labelled these capabilities as digital capabilities for Digital Transformation.

- **To sense disruption and extend industry boundaries:** Since physical and digital worlds are converging, the companies should develop an operating model which will expand beyond their current industry. As raised in the literature survey (Chapter 2), firms now have temporary competitive advantages (McGrath, 2013) as more competitors are entering the business from multiple industries. So, firms need to have the capabilities to reconfigure and readjust their resources with changing market and industry situations.

- **To experiment with ideas and launch them faster:** Companies should launch their ideas faster and should try to get early mover's advantage with their products and services. A platform-based operating model might be appropriate for experimentation. New Product Development (NPD), which is a first order dynamic capability (Winter, 2003), is a key determinant of success for entrepreneurial high technology firms (Deeds, DeCarolis and Coombs, 2000) and the same analogy is applicable for industrial businesses who are going through DT.

- **To understand and leverage data:** Companies should understand their data and should come up with operating models to monetize data in new ways. The data monetization capability is gaining importance for DT. Data monetization is the conversion of intangible value of data into real value by selling the data and it can also be monetized in others forms, like data-driven advertising or discount and reduction in IT costs (Najjar and Kettinger, 2013). For example, GE and Pivotal created a data lake for the airline industry by storing the flight data from the aircraft and providing analytics to the airlines[18].

[18] https://www.ge.com/reports/post/94170227900/angling-in-the-data-lake-ge-and-pivotal-pioneer-4/

- **To build a competent digital team:** Companies should assess their digital capabilities and acquire or retrain their workforce in digital technologies. The managerial cognitive capability (Helfat and Peteraf, 2014) is a special form of dynamic managerial capability (Teece, 2007) and it is essential for managers who are faced with strategic changes, like DT. The key dynamic managerial capabilities, such as attention and perception for sensing, problem solving and reasoning for seizing and the role of languages, communication and social cognition in relation to reconfiguration (Helfat and Peteraf, 2014), are also applicable for digital managers.

- **To develop ecosystem partnerships:** Companies should develop ecosystem partnerships to provide comprehensive solutions to their customers. Also, companies should partner for non-core activities. The firm with stronger technological capabilities likes to enter an emerging technological field through internal development whereas the firm with weaker technological capabilities will enter through strategic alliances and it is a key dynamic capability for the firm (Anand, Oriani and Vassolo, 2010). For DT, a firm alone cannot fulfill all the requirements from the customers and alliance management capabilities are key for organizational success.

- **To organize for speed:** Companies should have digitally savvy executives who can lead Digital Transformation. A role of Chief Digital Officer (CDO) reporting to the CEO could be ideal for companies. In a hyper competitive environment (like the Industrial Internet) the mere presence of adequate resources is not enough and the firm's ability to mobilize its resources and organizational capabilities and aligning them dynamically with the changing opportunities in the environment, is vital to maintain competitive advantage (Liao, Kickul and Ma, 2009). The role of the CDO to bring changes using digital technologies is key for DT (Rickards, Smaje and Sohoni, 2015).

- **To design a user friendly experience for its customers:** Companies should design multi-channel user experiences for their customers which should include web, mobile and other digital assistants. The omnichannel marketing capabilities are gaining importance to connect with the customers and becoming a key dynamic capability for a firm (Mirsch, Lehrer and Jung, 2016).

Other than the WEF DT initiative (WEF 2018), another major industry initiative, Industry 4.0 has gained significant momentum in Europe. The leading strategy consulting firm Strategy& (formerly Booz and Company), predicts that Europe's industrial sector will spend 140 Billion Euro per year on Digital Transformation by 2020 (Geissbauer, Kuge, Schrauf and Koch, 2015). The firm surveyed two hundred and thirty-five industrial companies in Germany. According to this report, operating models for the industrial businesses are changing along with the changes in the business models. One of the significant changes in operating model is driven by digitalization across vertical and horizontal functions of an organization. Industrial businesses are digitizing and integrating their vertical value chains, from design, manufacturing, sales and service functions. All operational process information is available on a real-time basis and it is supported by emerging technologies such as augmented reality (AR), virtual reality (VR), Artificial Intelligence and Machine Learning (AI/ML) etc. The horizontal integration spans across partners, suppliers and customers in the digital ecosystem. Since the operating models are changing significantly, the companies need to develop new or modify/reconfigure existing seizing and reconfiguration capabilities for DT. The capabilities identified as core dynamic capabilities by Eisenhardt and Martin (2000), namely, cross-functional R&D teams, new product development, quality control, technology/knowledge transfer and some performance measurements systems need to change due to vertical and horizontal integration. These modified and enhanced dynamic capabilities are DTC and impact DT.

Business model and operating model transformation are two key transformative capabilities for Digital Transformation. However, another key element is the culture and workforce transformation for successful Digital Transformation.

6.2.3 DTC for Cultural Transformation

Most industrial companies are facing digital talent and skill challenges and they need to develop digital workforces by improving their company culture and offering suitable incentives and growth opportunities for its digital workforce. The key challenges (WEF, 2018) in this are:

- **Attracting and retaining talent:** The companies should develop proper recruitment and retention strategies for their employees. Also, companies need to have transparent hiring policies because digitally savvy applicants receive information from different online channels, such as Glassdoor, Linkedin.com etc. and any negative comments might impact in selecting and retaining talent. Also, employee satisfaction is associated with long-term returns, profitability and valuation of the companies in countries with high labour market flexibility (Edmans, Lucius and Zhang, 2015). Creating and sensing opportunities are not uniformly distributed within the employees or the organization and the employees need to have the capability and knowledge to recognize and execute it (Teece, 2007; Noaka and Toyama, 2007). Thus, a digitally savvy and knowledgeable workforce possesses necessary capabilities for sensing and seizing opportunities and works with internal and external partners to execute those opportunities.

- **Creating a digital workforce:** Due to the shortages of the digital workforce, the companies should develop strategies and capabilities to get digitally trained employees from within and from outside companies. Digital success is not all about technology, however, organizations with digital maturity are four times more likely to provide the necessary digital skills to their employees for DT (Kane, Palmer, Phillips, Kiron and Buckley, 2015). Industrial businesses should assess their digital needs and develop proper training and development programmes for their employees including digital boot camps, in-house training and should encourage employees to participate in the educational courses outside the company. Companies should also take existing employee skill inventory and encourage hidden talent within the company (WEF, 2018).

- **Bringing in a digital leadership team:** Companies need to hire digital managers from within or outside the organization, such that they can bring changes in the organization and these individuals should be placed in different functions in the organization to bring changes on a broader scale, not restricted to one business function. The top managers in a company work as catalysts for Digital Transformation. The significant feature of DC (in this case DTC) resides in the tactic knowledge and processes in an organization and in the leadership skills of its top managers (Helfat et al., 2007; Teece, 2009). Top management's entrepreneurial and leadership skills around sensing, seizing and transforming skills are required to sustain dynamic capabilities (Teece, 2010).

- **Moving away from a risk-averse culture to more entrepreneurial approaches:** Due to digital disruption, companies should experiment with newer and bolder ideas to bring changes. For example, GE engaged with 500 coaches to train its executive in risk-taking initiatives and to learn from failures (Alsever, 2015). According to Teece (2009), risk averse managers tend to discount outcomes which are probable and go after outcomes which are certain. For Digital Transformation, entrepreneurial capability, such as risk taking, is becoming a norm, as more digital companies are taking risks to venture into new areas of business (Kane, Palmer, Phillips, Kiron and Buckley, 2015). The role of middle managers is also important for driving innovation in an organization. Middle managers must perceive resources for innovative works in the organization and they should encourage risk taking and experimentation (Hornsby, Kuratko and Zahara, 2002).

- **Implementing digital traction matrices** to measure success in Digital Transformation: Companies should implement digital traction matrices, such as number of unique visitors, number of active users on a daily/weekly/monthly basis, churn/exit rate etc. such that they can measure the success of the initiatives (WEF, 2018).

'DTC – Culture Transformation' represents the cultural aspect of DTC and a cultural shift is needed for Digital Transformation. Business model and Operating model transformation alone cannot foster Digital Transformation (Qualitative Study).

6.2.4 Factors influencing DTC

Industrial internet is accelerating Digital Transformation for industrial businesses. As discussed in the industry survey (chapter 3), companies such as General Electric (GE), Snyder, Cisco, Intel, Boeing, AT&T and others are developing their Digital Transformation strategies based on Industrial Internet-based solutions for their customers. In essence, they must do so, and are locked in fierce competition to achieve successful Digital Transformation. Yet, while the Industrial Internet is pushing firms to digitally transform, this stimulus is not enough to explain the rate or extend or its success.

Digital assets across the entire economy doubled over the first fifteen years as most firms invested not only in IT but also in digitizing their physical assets (Gandhi, Khanna and Ramaswamy, 2016). However, the digitization efforts are mostly in silos and a comprehensive analysis of firm performance cannot be performed unless all these digitization processes are integrated. To understand digitization across the enterprise, one should understand two important concepts: Digitization and Digitalization which have profound effects on DTC. Digitization is the process of converting analog signals into digital form and ultimately into binary digits, whereas, Digitalization is the socio-technical process of applying digitizing techniques to social and institutional contexts (Tilson, Lyytinen and Sorensen, 2010). Social scientists Brennen and Kreiss (2014) define digitalization as the way social life interacts with digital communications. However, the strategic consulting firm Gartner[19] refers to digitalization as a process of moving to digital business by using digital technologies which change business models and customer values. In this current study, the definition of digitalization is closer to Gartner. The digitization

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[19] https://www.gartner.com/en/information-technology/insights/digitalization

processes refer to siloed value chains within the organization, whereas, digitalization is a holistic way of connecting these siloed value chains (processes, routines and capabilities) together, which in turn will transform the business (this view is consistent with the results of the Qualitative Study reported in chapters 4 and 5). Industrial businesses are digitizing individual value chains (e.g. inventory management, order management) for a longer period of time. However, Digital Transformation is more related to vertical and horizontal integration of these value chains (e.g. integration of manufacturing and logistics value chains within the organization and with partners and customers). An industrial company has new product development (NPD) capability. However, that capability can be enhanced (namely, DTC for NPD) through digitalization, where all design, manufacturing, testing and servicing information is integrated together for the product engineer. Similarly, integration and coordination capabilities (namely, DTC for Integration and Coordination capability) could be made more effective by supply chain digitalization.

For industrial businesses, three core factors affect the digitalization effort (drawn from the results of the Qualitative Study reported in Chapters 4 and 5). These factors are Digital Twin (process feature), Digital Thread (process feature), and digital mind-set (firm feature) and together it is expected that these factors will increase the digitalization of industrial businesses. This study has taken the position that digitalization affects DTCs which in turn influences Digital Transformation. In the subsequent sections, these factors are described in detail.

6.2.4.1 Digital twin

The concept of Digital Twin was introduced by Michael Grieves in 2003[20], in which he represented the notion of physical products in digital form. According to Grieves, Digital Twin has three main components: the physical product in real space, the virtual product in virtual space and the connection of data and information which connect real space to virtual space. Though initially Digital Twins were used for complex product life cycle management situations, now, due to the richness both on the physical and virtual sides, the Digital Twin concept is being applied to many industries and situations (Grieves et al., 2017). Digital twin represents a digital version of the physical product for greater scrutiny, analysis and innovation.

Digital twin is the digital representation of the physical world (including assets, processes, systems etc.) and it helps not only to optimize the business processes but also to develop new products and services which were not possible earlier. For example, an aircraft engine can be modelled by its Digital Twin, which will include its 3D design models, aerodynamic models, engineering changes and its impact on engine performance etc. In the digital model, we can experiment or simulate different conditions which are not possible in the physical model (or it is prohibitively expensive to do so). Then we can optimize the performance of the aircraft engine digitally and bring it back to the physical model design, fabrication and manufacturing. Similarly, the waze[21] app is a Digital Twin of the physical representation of roads for a destination. Based on the real-time road condition and inputs from its fellow drivers/users, waze collects and analyses the road conditions and gives driving directions to its users. Not only does it optimize the physical roads, it also helps the drivers to use a new road, perhaps not used by the

[20] http://innovate.fit.edu/plm/documents/doc_mgr/912/1411.0_Digital_Twin_White_Paper_Dr_Grieves.pdf

[21] www.waze.com

driver previously. In this situation, waze, as a Digital Twin helps the driver to reach the destination in the shortest time and sometimes through new paths not travelled earlier.

Digital twin is foreseen as a key input for DTC and companies can develop new business models by utilizing Digital Twins as it can help in developing new products and managing the existing business processes pro-actively. In a connected digital ecosystem, Digital Twin enhances the NPD dynamic capability of a firm. While researching the performance of the NPD units of 180 firms, Pavlou and Sawy (2011) observe that dynamic NPD capabilities are more likely to quickly introduce new products that better match customer needs, help the firm to develop technologically sophisticated new products by new knowledge of technological breakthroughs and improve the orchestration of resources, tasks and activities. Using Digital Twin models, product engineers can simulate the existing and new product related attributes in the digital models and can experiment with different scenarios, develop product prototypes and finally develop products for their customers. This Digital Twin can reduce the NPD cycle time and make a firm more competitive. Digital twin can also improve the dynamic innovative capability of a firm. It can influence the mainstream innovation and new-stream innovation for a firm. Mainstream innovation capabilities are for improving the quality, efficiency, speed and flexibility of a firm and new-stream capabilities are for identifying and developing new values for customers (Lawson and Samson, 2001). Digital twin can improve the quality and efficiency of existing products as well as help in developing new products and services for an organization. It also improves the entrepreneurial capability of a firm as it accelerates new product development and innovation, which is a key dynamic capability (Teece, 2009). For example, scientists from the US Airforce Research Laboratory have developed Digital Twins to predict the structural life of aircraft such that they can detect problems in advance in a digital environment (Tuegel, Ingraffea, Eason and Spottswood, 2011). GE has developed a Digital Twin model for a digital power plant to predict the behaviour of the power plant assets. The twin is based on a physics-based system and application of analytics on these systems. This Digital Twin can develop mitigation strategies for any failures. [22] Thus, Digital Twin influences DTC by helping a firm in developing dynamic NPD, innovation and entrepreneurial capabilities.

Siemens[23] suggests that Digital Twin eliminates the need of physical prototypes, reduces product development time and improves product quality and service. Haag and Anderl (2018) developed a proof of concept for Digital Twin and they concluded that Digital Twin could be used for new product development. So, based on these industry and academic sources, it can be suggested that Digital Twin influences the NPD dynamic capability of a firm. There is no academic evidence that Digital Twin influences DTC – Digital Model Transformation but it could be looked at through a NPD lens. Shepherd and Ahmed (2000) argue that the traditional NPD framework is changing from product innovation to solution innovation by leveraging advanced technologies and its leads to a new solution-focused business model. Gronlund, Sjodin and Frishammar (2010) noted that NPD can be a source of business model innovation but not all NPD projects fit with established business models. So, it can be inferred that Digital Twin should influence DTC – Business Model Transformation. By improving product and process qualities through Digital Twin, firms can drive business process innovation which could lead to business model innovation (Amit and Zott, 2012). Chesborough (2007) suggested that business model innovation is not a technology anymore and process innovation should be integrated with business model

[22] https://www.ge.com/digital/sites/default/files/Digital-Twin-for-the-digital-power-plant-.pdf
[23] https://www.plm.automation.siemens.com/global/en/our-story/glossary/digital-twin/24465

innovation. So, looking through process innovation lens, Digital Twin should influence DTC – Business Model Transformation.

Based on the discussion above, the following can be surmised:

Digital Twin positively influences Digital Transformative Capability (DTC).

Hypotheses:

- *H1A: Digital Twin positively influences DTC – Business Model Transformation.*
- *H1B: Digital Twin positively influences DTC – Operating Model Transformation.*
- *H1C: Digital Twin positively influences DTC* – Cultural Transformation.

6.2.4.2 Digital thread

The Digital Thread concept originated from the defense industry and now it is being popularized in the industrial world. "Digital thread is the creation and use of a digital surrogate of the material systems to allow dynamic real-time assessment of the system's current and future capabilities to inform decisions" (United States Air Force Global Science and Technology Vision, AF/ST TR-1301, 2013). Digital thread is a framework to collect data from the initial stages of an asset, including design, fabrication, manufacturing to actual usage of the asset in the real world. Digital thread is the manufacturing health records of the assets and may accelerate Digital Transformation. Currently, enterprise business systems are siloed and it is difficult to collect, collate and analyze the vast amount of data across different systems, for meaningful decision making. However, due to IIoT and cloud technologies, it is possible to create digital threads of physical assets and analyze their behaviour in the real world and then adjust the threads to optimize the performance of the assets. The data related to information technology (IT) and operational technology (OT) must be meshed together for real time business analysis and decision making. Definitions of IT and OT are needed before proceeding.

Information Technology (IT): The spectrum of technologies for information processing which includes hardware, software, communication technologies and related services. For example, Enterprise Resource Planning (ERP) and Supply Chain are IT systems in an enterprise.

Operational Technology (OT): The hardware and software which monitor and manage the factory operational systems. For example, Programmable Logic Controller (PLCs), Supervisory Control and Data Acquisition (SCADA) are OT systems in an enterprise.

For a successful implementation of digital thread, integration capabilities within the organization and outside partners are very important. Two types of dynamic integration capabilities, external integrative capabilities and internal integrative capabilities (Tripas, 1997) help a firm to develop digital threads. According to Tripas, external integrative capability consists of internal R&D investments (indicative of an absorptive capability, Cohen and Levinthal, 1990) and external communication infrastructure to facilitate transmission of external knowledge. Another area of interest is dynamic knowledge integration capability for digital thread. Founded on knowledge-based theory (Grant, 1996), inter-organizational knowledge networks are formed by integrating knowledge bases within organizations. Integrating capabilities within and outside the organization are important when systems and networks are present (Teece, 2009) and Digital Thread is integration of business processes within and outside the organization. Though vertical integration was considered a major step for operational efficiency, Heskett (1977) was the first scholar who emphasized the role of logistics integration as a way to improve firm performance. Proper digital threads could be constructed by integrating design, sourcing, manufacturing, distribution and customer service business processes within a firm. Supply chain integration has been considered as a major foundation for corporate competitiveness and it includes cross-functional integration of business processes within and outside the organization (Stonebraker and Liao, 2004).

The Digital Thread concept is gaining importance in additive manufacturing (AM) which is being explored by automotive, healthcare and medical industries. Digital thread contains all essential components from design to testing of AM parts and it would be extensible and traceable for future components (Nassar and Reutzel, 2013). The National Institute of Science and Technology (NIST) in USA is developing a Digital Thread for a smart manufacturing system project which will contain design, manufacturing and product support processes which will help in integrating smart manufacturing systems[24]. Dynamic integration, coordination and innovation capabilities are important DTC. Based on these discussions, Digital Thread is expected to influence DTC which in turn is expected to influence Digital Transformation.

Like Digital Twin, Digital Thread is expected to have a profound impact on DTC and hence it is proposed that:

Digital Thread positively influences Digital Transformative Capability (DTC).

Hypotheses:

- *H2A: Digital Thread positively influences DTC – Business Model Transformation.*
- *H2B: Digital Thread positively influences DTC – Operating Model Transformation.*
- *H2C: Digital Thread positively influences DTC* – Cultural Transformation.

6.2.4.3 Digital mindset

Managers need to have a digital mindset such that they can foster Digital Transformation. This is a cognitive behavioral capability of IIoT managers. Dynamic managerial capabilities of this kind are capabilities by which managers build, integrate and reconfigure resources and competencies (Adner and Helfat, 2003). Coordinating and adapting effectively to changing business environments (Cyert and March 1963) is an important managerial function and this is an element of dynamic capability (Teece, 2009). Dynamic managerial capability is the capacity of managers to perform not only physical but mental activities (Healfat and Peteraf, 2014). The mindsets of the executives and top managers influence strategic change. Adner and Helfat (2003) found total

[24] https://www.nist.gov/programs-projects/digital-thread-smart-manufacturing

variance of firm performances (around 2%) based on single strategic change initiated by managers. Bertrand and Schoar (2003) also found a significant impact of managers on firm policies and performance. As industrial businesses are expanding their digitalization efforts, companies are redrawing their industry boundaries and developing new and innovative ways to deliver services to their customers (Kaganer, Sieber and Zamora, 2014). According to these authors, digital leadership is not a job title or a role, but a mindset of managers responsible for Digital Transformation. The cognition capability (via digital mindset) is an important attribute of top managers (Finkelstein, Hambrik and Canella, 2009). Smith and Tushman (2005) suggest that top managers need to build "paradoxical cognition" that enables them to pursue exploration and exploitation simultaneously. Digital managers need to make sure their existing business is growing and new digital capabilities are helping them to come up with new revenue models from their current business; they need to explore to develop new products and services to expand the firm boundaries. Digital managers are also responsible for asset orchestration and resource management, two important dynamic managerial capabilities (Sirmon and Hitt, 2009) as matching resource investment and deployment decisions affect firm performance. Entrepreneurial mindset is another important characteristic of digital managers. In the book, "The Entrepreneurial Mindset" by McGrath and MacMillan (2000), entrepreneurial leaders are distinguished from other managers by three personal practices, which are: (i) setting the work climate for entrepreneurship, (ii) orchestrating opportunities clearly and removing uncertainties from the teams, and (iii) moving the ventures personally based on their hands-on management knowledge and experience. Since IIoT and cloud technologies have created uncertainties in business, digital managers should possess entrepreneurial capabilities for transforming their businesses. Kaganer, Sieber and Zamora (2014) suggested key managerial capabilities for digital managers which are discussed below.

- **Provide visions yet empower others:** The digital manager needs to have a vision of the organization and how to achieve that vision through actionable plans/initiatives, however, the manager should empower employees to translate the vision to on-site actions.

- **Give up control yet be choice architect:** Digitally-oriented managers should encourage employees to make decisions, but the manager should be the architect of choices for the company. The managers need to nudge the employee to think outside of the box. As suggested in the book ‘Nudge’ (Sunstein and Thaler, 2008), nudging means anything which influences our choices. Managers should nudge the employee to participate in social media discussions (like company forums, chats etc.) about their ideas, thoughts and other items which could influence their work. The managers are ‘choice architects’ and they influence employees by nudging them for the benefit of the company.

- **Sustain yet disrupt:** The digital manager should keep track of both sustaining and disrupting activities of their employees and should mitigate any conflict and act as a mediator between the old and new ways of doing business.

- **Rely on data yet trust your intuition:** Digital managers should be more objective and develop new capabilities or modify existing ones through a logical lens with data-driven approaches. Digital managers should make decisions based on information. However, experience and intuition remain very important for making managerial decisions.
- **Be skeptical yet open minded:** Digital transformation poses different challenges for the digital managers as there are multiple and conflicting technological choices, process

options and capabilities, however, they should be skeptical yet open minded and they should try out different options before choosing one option. They should encourage experimentation but keep a close eye on the outcomes of these processes.

Nudge theory (Sunstein et al., 2008), as discussed earlier, has gained lot of interest from academic scholars and government policymakers and administrators. Both in the USA and Europe, government policymakers are evaluating different ways to nudge citizens such that they behave in certain ways. This allows policymakers to better understand and influence people's behaviour and help them to formulate public policies.[25] In nudging, the focus shifts from employing behavioural insights as a prognosticator to being key in the practice of shaping the behaviour (Kosters and Heijden (2015). Sunstein et al. (2008) refer nudging as choice architects and digital managers could influence their employees by proper interventions for shaping employee behaviors. Thus, dynamic managerial capabilities, cognitive capabilities and nudging capabilities are important DTC for digital managers who are accelerating Digital Transformation.

Based on these discussions, the following hypotheses are proposed:

Digital Mindset positively influences Digital Transformative Capability (DTC).

Hypotheses:

- *H3A: Digital Mindset positively influences DTC – Business Model Transformation.*
- *H3B: Digital Mindset positively influences DTC – Operating Model Transformation.*
- *H3C: Digital Mindset positively influences DTC* – Cultural Transformation.

Digitalization profile is expected to influence DTC and some internal and external factors

[25] Obama Administration Document for Behavioral Insight Team, http://www.foxnews.com/politics/interactive/2013/07/30/behavioral-insights-teamdocument/

moderate the relationship between digitalization profile (Digital Twin, Digital Thread and Digital Mindset) and DTC (Qualitative study). The impacts of these factors are described in the subsequent sections.

6.2.4.4 Technology turbulence

Technology turbulence is expected to influence Digital Twin, Digital Thread and Digital Mindset and their relationship to DTC. Pavlou and El Sawy (2011) suggest that environmental turbulence (Technology Turbulence and Market Turbulence) affects NPD capabilities because environmental turbulence creates new opportunities and firms must reconfigure its operational capabilities and deploy dynamic capabilities to explore those opportunities. Digital Twin is a digitalization process for NPD and hence it is expected to be influenced by Technology Turbulence. The study proposes that Technology Turbulence influences the relationship of Digital Twin and digital business model transformation because, due to Technology Turbulence, firms tend to focus more on Digital Twin capability, which leads to more digital business models for firms. Environmental turbulence enhances the value potential of new products (Griffin, 1997) and dynamic NPD capability such as Digital Twin is more valuable during environmental turbulence, which influences DTC: business models for new products, operating models for manufacturing and delivering those products and services to their customers and mindsets of the employees who are involved in the transformation. Though some scholars (Wilden and Gudergan, 2014) suggest that technological capabilities enhance performance in stable competitive environments and marketing capabilities enhance performance in highly competitive environments, this study proposes that environmental turbulence affects NPD capability for Digital Twin and DTC for Digital Transformation. Another area of interest is the influence of

Digital Twin on innovative and entrepreneurial capabilities and how it affects DTC, which in turn affects firm performance. Huang, Ouyang, Pan and Chou (2013) find that Technology Turbulence positively affects the relationship between external technology acquisition and firm performance and not external technology exploitation and firm performance. Though Digital Twin is an internal digitalization process, in the connected ecosystem joint product development with partners is necessary. As mentioned in the previous section discussing Digital Thread, supply chain integration influences the development and management of digital thread. Greater environmental turbulence encourages greater supply chain integration to captures the benefits of coordinated activities within the firm (Williamson, 1975); these coordinated activities will help to develop more DTCs. Under turbulent conditions, costs associated with production, inventory scheduling and R&D coordination across multiple parties are substantially increased (Stonebraker and Liao, 2004). Thus, Technology Turbulence influences Digital Thread development and management and DTC, as firms expand their digitalization efforts across its supply chain. Environmental turbulence also influences digital mindset (dynamic managerial capabilities of the digital managers) and DTC. A top management team can be considered as the information processing centre of an organization (Thompson, 1967). Haleblian and Finkelstein (1993) suggest that the degree of environmental turbulence or stability greatly influences the information processing requirements of a top team (managers). So, environmental turbulence influences the use of dynamic managerial capabilities of top managers in a turbulent industrial environment and their capability for Digital Transformation through DTC. Another important characteristic of a digital manager is the manager's perception of the need for change as in a stable environment a manager perceives the environment as predictable and that there is less need for change, whereas in a turbulent environment, manager perceives it as fast paced, unpredictable and that the need for change is very high (Ambrosini, Bowman and Collier, 2009). Environmental turbulence influences digital managers to develop DTC for Digital Transformation.

In his book, "The Innovator's dilemma", Christensen (1997) argues that the organization needs to align differently when faced with technology disruption and changing market conditions. Christensen further suggests that the firm needs to have exploration and exploitation strategies in these disruptive situations. However, the firm needs to consider its existing capabilities and systematically develop new strategies and capabilities for exploration and exploitation. As suggested by Teece (1997), a high-velocity environment with changing technology landscapes is a pre-requisite for developing dynamic capability. The technology revolution (which causes a high-velocity environment) accelerates DTC by interacting with digitalization profile. However, Eisenhardt et al. (2000) suggest that a high-velocity environment is not a pre-requisite for developing dynamic capability. Industrial businesses are going through technology disruption and the companies must develop new DTC or reconfigure their existing capabilities for successful DT. Though digitalization profile (Digital Twin, Digital Thread and Digital Mindset) influences DTC, the study proposes that Technology Turbulence accelerates this relationship.

Based on the discussions, the study proposes the following hypotheses:

The relationship between Digital Twin and DTC is positively moderated by technology turbulence.

Hypotheses:

- *H4A: The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by technology turbulence.*

- *H4B: The relationship between Digital Twin and DTC – Operating Model Transformation is positively moderated by technology turbulence.*
- *H4C: The relationship between Digital Twin and DTC –* Cultural Transformation *is positively moderated by technology turbulence.*

The relationship between Digital Thread and DTC is positively moderated by technology turbulence.

Hypotheses:

- *H5A: The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by Technology Turbulence .*
- *H5B: The relationship between Digital Thread and DTC – Operating Model Transformation is positively moderated by Technology Turbulence .*
- *H5C: The relationship between Digital Thread and DTC –* Cultural Transformation *is positively moderated by Technology Turbulence .*

The relationship between Digital Mindset and DTC is positively moderated by Technology Turbulence.

Hypotheses:

- *H6A: The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by Technology Turbulence .*
- *H6B: The relationship between Digital Mindset and DTC – Operating Model Transformation is positively moderated by Technology Turbulence .*
- *H6C: The relationship between Digital Mindset and DTC –* Cultural Transformation *is positively moderated by Technology Turbulence .*

6.2.4.5 Market turbulence

The effect of environmental dynamism in the form of market turbulence affects dynamic transformation capability, however, whether it moderates the relationship between digitalization profile and DTC is not very clear. A study conducted by Jiao at al. (2011) in China suggests that environmental dynamism may not influence dynamic capability. In another study, Wang (2016) finds that environmental dynamism is an antecedent of dynamic capability. While studying e-business transformation, Daniel and Wilson (2003) observe that when a market is changing rapidly, firms are required to develop dynamic capabilities (in this case DTC) faster than they could have done before. Thus, the study proposes that digitization profile which influences DTC development would be positively impacted by market turbulence. In other words, the higher the market turbulence, the higher the impact of digitalization profile on DTC. Wang, Dou, Zhu and Zhou (2015) looked into the relationship of internal dynamic capabilities (innovation, information and relational) and market turbulence. According to them, innovation (for example, NPD) and information (for example, internal and external collaboration) dynamic capabilities are positively moderated by market turbulence, whereas, relational (for example, alliance capability) capability consistently influences collaboration capability irrespective of market turbulence. High market-linking capabilities (the capability which helps a firm to create and retain lasting relationships with customers and suppliers and establish strong bonds with channel members) (Moorman and Slotegraaf, 1999; Song et al., 2007) and high market turbulence strengthens new product development performance (Chen, Wang, Huang and Shen, 2016) in service-based firms. So, by extending NPD capabilities' influence on Digital Twin and collaboration capabilities' influence on digital thread, it can be proposed that market turbulence moderates the relationship between digitalization profile and DTC for DT.

The relationship between Digital Twin and DTC is positively moderated by market turbulence.

Hypotheses:

- *H7A: The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by market turbulence.*
- *H7B: The relationship between Digital Twin and DTC – Operating Model Transformation is positively moderated by market turbulence.*
- *H7C: The relationship between Digital Twin and DTC –* Cultural Transformation *is positively moderated by market turbulence.*

The relationship between Digital Thread and DTC is positively moderated by market turbulence.

Hypotheses:

- *H8A: The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by market turbulence.*
- *H8B: The relationship between Digital Thread and DTC – Operating Model Transformation is positively moderated by market turbulence.*
- *H8C: The relationship between Digital Thread and DTC –* Cultural Transformation *is positively moderated by market turbulence.*

The relationship between Digital Mindset and DTC is positively moderated by market turbulence.

Hypotheses:

- *H9A: The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by market turbulence.*

- *H9B: The relationship between Digital Mindset and DTC – Operating Model Transformation is positively moderated by market turbulence.*
- *H9C: The relationship between Digital Mindset and DTC –* Cultural Transformation *is positively moderated by market turbulence.*

6.2.4.6 Competitive turbulence

Competitive turbulence refers to the degree of competition in an industry (Porter, 1985). When the market is highly competitive, the companies must watch out for their competitors and its relative positioning in the market (Han et al., 1998). The Industrial Internet business is highly competitive, and companies are coming from different industries to get a share in industrial businesses. The leading consulting firm Bain predicts that the business-to-business IoT segment will grow to $300B by 2020[26]. Competitive turbulence effects the performance of the dynamic capabilities in a firm (Wilden, Gudergan, Nielsen and Lings, 2013). They further suggest that frequent sensing and reconfiguring resources for marketing capabilities have a positive influence on firm performance when Competitive Turbulence is high. Competitive turbulence influences Digital Twin, Digital Thread and digital mindset. Cui, Griffith and Cavusgil (2005) find that Competitive Turbulence and market dynamism both influence the knowledge management capabilities of a firm (which in turn influence NPD and innovation capabilities) and market dynamism influences more than competitive turbulence. So, it can be inferred that Competitive Turbulence influences the relationship between digitalization profile and DTC. As Industrial Internet is gaining more momentum across industrial businesses, information technology (IT) capabilities are becoming more important. Digital Twin is a process by which firms can develop product innovation capabilities and Competitive Turbulence moderates the relationship between

[26] http://www.bain.com/publications/articles/choosing-the-right-platform-for-the-industrial-iot.aspx

product innovation performance (through Digital Twin) and IT capabilities (Chen, Wang, Nevo, Benitez-Amado and Kou, 2015) responsible for Digital Transformation. Competitive turbulence also influences the relationship between Digital Thread and DTC. Dynamic collaboration and integration capabilities within and outside the organization help a firm to develop digital thread. However, Competitive Turbulence has a significant impact on cross-functional collaboration on new product development and performance (Tsai and Hsu, 2014). Thus, it can be inferred that Competitive Turbulence negatively influences the relationship between Digital Thread and DTC. Andrevski et al. (2014) find that Competitive Turbulence mediates the racial diversity effect on market share gain. Based on this observation, one can infer that racially diverse digital managers influence firm performance through DTC when Competitive Turbulence is high.

The study proposes that competitive intensity/turbulence negatively moderates the relationship between digitalization profile and DTC.

The relationship between Digital Twin and DTC is negatively moderated by competitor turbulence.

Hypotheses:

- *H10A: The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by competitor turbulence.*
- *H10B: The relationship between Digital Twin and DTC – Operating Model Transformation is negatively moderated by competitor turbulence.*
- *H10C: The relationship between Digital Twin and DTC* – Cultural Transformation *is negatively moderated by competitor turbulence.*

The relationship between Digital Thread and DTC is negatively moderated by competitor turbulence.

Hypotheses:

- *H11A: The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by competitor turbulence.*
- *H11B: The relationship between Digital Thread and DTC – Operating Model Transformation is negatively moderated by competitor turbulence.*
- *H11C: The relationship between Digital Thread and DTC –* Cultural Transformation *is negatively moderated by competitor turbulence.*

The relationship between Digital Mindset and DTC is negatively moderated by competitor turbulence.

Hypotheses:

- *H12A: The relationship between Digital Mindset and DTC – Business Model Transformation is negatively moderated by competitor turbulence.*
- *H12B: The relationship between Digital Mindset and DTC – Operating Model Transformation is negatively moderated by competitor turbulence.*
- *H12C: The relationship between Digital Mindset and DTC –* Cultural Transformation *is negatively moderated by competitor turbulence.*

6.2.4.7 Path dependency

Path dependency is a property of a system where the outcomes over a period are determined by initial set of conditions (Goldstone, 1998). While defining dynamic capability, Teece (2007) has defined Path Dependency as a firm's previous investment and set of routines which restricts the firm's future behaviour. Path dependencies are not inexorable and are strong in some domains (system software, computer operating systems) and weak in others (construction, manufacturing) (Teece, 2009). Path dependency affects capability formation and the effects of Path Dependency can speed up, slow down or halt construction of capabilities which could better position the firm (Sydow, Schreyogg and Koch, 2009). Path dependency is developed when contingent events trigger self-reinforcing paths (i.e. the set of positive and negative mechanisms which increases the attractiveness of a path related to other paths) (Vergne and Durand, 2011). These scholars also suggest that Path Dependency creates a lock-in within a firm. I propose to take it one step further and suggest that the degree of lock-in is negatively related to DTC. For example, some software companies are not able to move from their traditional businesses of selling software to a service-based business model and, when facing a technological disruption like the Industrial Internet, these software companies consider it as an extension of their current software business (as evidenced in my qualitative study). So, they are not able to transform their capabilities and may face challenges to meet their customer demands in future. During technology disruption, a firm tends to develop more DTC to compete in the market. Technology disruption creates unique opportunities and challenges for a firm. But Path Dependency creates a barrier to develop DTC. A firm may not be able to sense the opportunity and may remain on its historic path during this disruption. For example, though Blackberry realized that the mobile application market was changing drastically from a mobile phone for conversation to a multi-purpose mobile device for conversation, audio and video, due to Path Dependency it did not change its original path/business and lost business. So, Path Dependency for Blackberry created a negative effect on its DTC during a technology disruption phase. The above discussion suggests that Path Dependency negatively influences DTC. However, the study proposes that the influence of digitalization profile on DTC is accelerated by Path Dependency as it creates a serious barrier for

Digital Transformation. According to Acur, Kandemir, Weerd-Nederhof and Song (2010), Path Dependency is associated with technology alignment and with better technology alignment a firm's NPD processes can be more effective. However, the authors find that better technology alignment (Path Dependency) lowers the speed of NPD process. So, it can be inferred that Path Dependency will have a negative influence on Digital Twin (as industrial businesses are using Digital Twins for NPD processes) and DTC. Danneels (2002) suggests that product innovation generates Path Dependency by developing certain technological competencies, which in turn help in developing new products. However, this Path Dependency can be mitigated by proper marketing competencies (capabilities). Thus, Path Dependency affects the Digital Twin process and DTC, as NPD capability and innovation capability are two important capabilities for Digital Twin which helps in developing DTC. Path dependency also influences managerial capability for digital managers. Though Path Dependency is considered as a constraining force, managers can cope with and benefit from path dependencies if they select self-reinforcing capability paths that emerge from the firm–environment interaction (Durand and Vergne, 2011). However, as explained above, managers may not be able to change their paths (for example, Blackberry) and develop new DTC or reconfigure existing capabilities to DTC, when faced with external factors and that could have serious effects on firm performance. Thus, Path Dependency negatively influences the relationship between digital mindset (managerial capability) and DTC.

Based on the above discussion, it can be inferred that Path Dependency negatively influences digitalization profile (Digital Twin, Digital Thread and digital mindset) and DTC.

Based on these discussions, the following hypotheses are proposed:

The relationship between Digital Twin and DTC is negatively moderated by path dependency.

Hypotheses:

- *H13A: The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by path dependency.*
- *H13B: The relationship between Digital Twin and DTC – Operating Model Transformation is negatively moderated by path dependency.*
- *H13C: The relationship between Digital Twin and DTC –* Cultural Transformation *is negatively moderated by path dependency.*

The relationship between Digital Thread and DTC is negatively moderated by path dependency.

Hypotheses:

- *H14A: The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by path dependency.*
- *H14B: The relationship between Digital Thread and DTC – Operating Model Transformation is negatively moderated by path dependency.*
- *H14C: The relationship between Digital Thread and DTC – Cultural Transformation is negatively moderated by path dependency.*

The relationship between Digital Mindset and DTC is positively moderated by path dependency.

Hypotheses:

- *H15A: The relationship between Digital Mindset and DTC – Business Model Transformation is negatively moderated by path dependency.*

- *H15B: The relationship between Digital Mindset and DTC – Operating Model Transformation is negatively moderated by path dependency.*
- *H15C: The relationship between Digital Mindset and DTC – Cultural Transformation is negatively moderated by path dependency.*

6.2.4.8 Summary of Front-End Model

Table 10 : Summary of Front-End Model

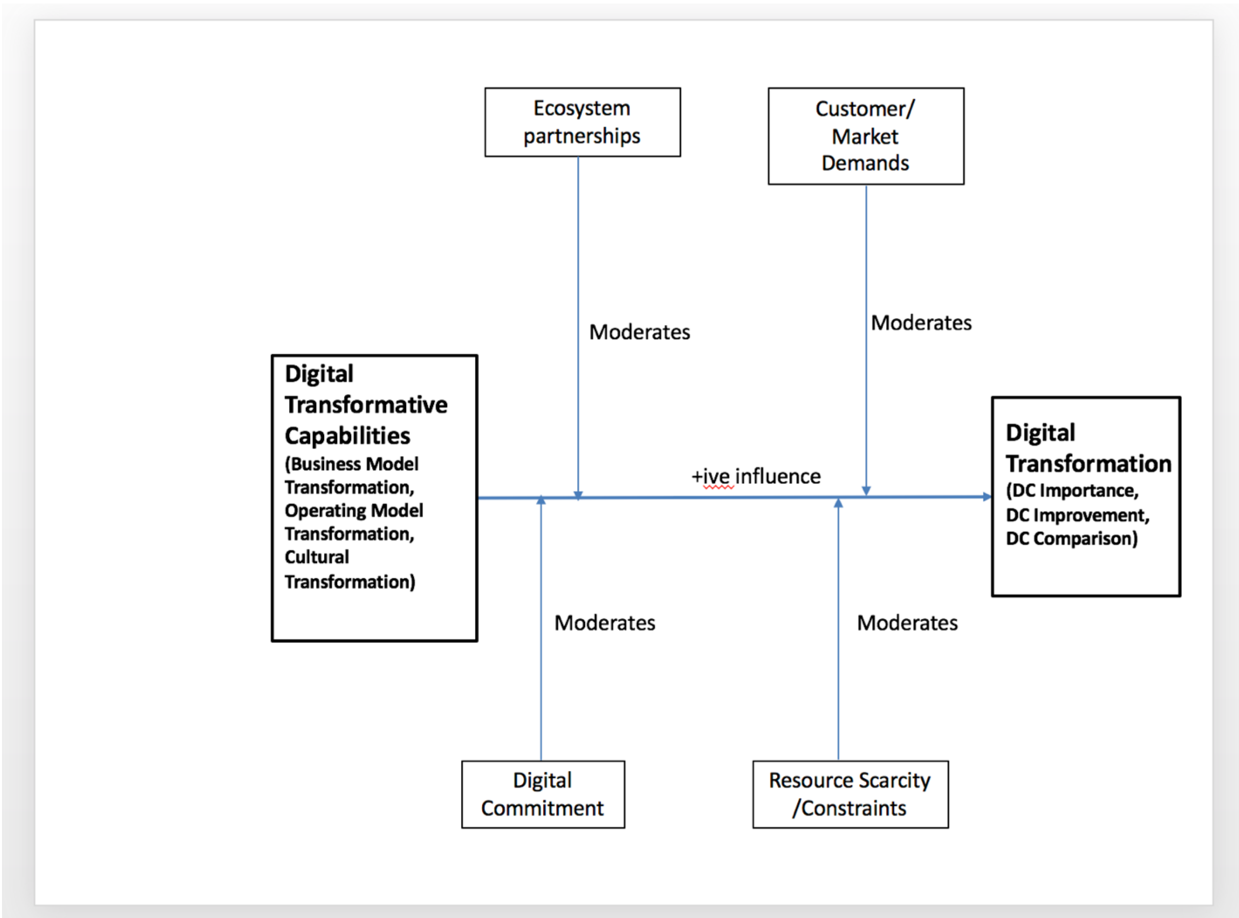
Hypothesis	Description
	Digitalization Profile -> DTC
H1A	Digital Twin positively influences DTC – Business Model Transformation
H1B	Digital Twin positively influences DTC – Operating Model Transformation
H1C	Digital Twin positively influences DTC – Cultural Transformation
H2A	Digital Thread positively influences DTC – Business Model Transformation
H2B	Digital Thread positively influences DTC – Operating Model Transformation
H2C	Digital Thread positively influences DTC – Cultural Transformation
H3A	Digital Mindset positively influences DTC – Business Model Transformation
H3B	Digital Mindset positively influences DTC – Operating Model Transformation
H3C	Digital Mindset positively influences DTC – Cultural Transformation
	Moderation effects of technology turbulence
H4A	The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H4B	The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H4C	The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H5A	The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H5B	The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H5C	The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H6A	The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H6B	The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by Technology Turbulence
H6C	The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by Technology Turbulence
	Moderation effects of market turbulence
H7A	The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by market turbulence

H7B	The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by market turbulence
H7C	The relationship between Digital Twin and DTC – Business Model Transformation is positively moderated by market turbulence
H8A	The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by market turbulence
H8B	The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by market turbulence
H8C	The relationship between Digital Thread and DTC – Business Model Transformation is positively moderated by market turbulence
H9A	The relationship between Digital Mindset – Business Model Transformation is positively moderated by market turbulence
H9B	The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by market turbulence
H9C	The relationship between Digital Mindset and DTC – Business Model Transformation is positively moderated by market turbulence
	Moderation effects of Competitive Turbulence
H10A	The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by Competitive Turbulence
H10B	The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by Competitive Turbulence
H10C	The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by market turbulence
H11A	The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by competitive turbulence
H11B	The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by competitive turbulence
H11C	The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by competitive turbulence
H12A	The relationship between Digital Mindset – Business Model Transformation is negatively moderated by competitive turbulence
H12B	The relationship between Digital Mindset and DTC – Business Model Transformation is negatively moderated by competitive turbulence
H12C	The relationship between Digital Mindset and DTC – Business Model Transformation is negatively moderated by competitive turbulence
	Moderation effects of Path Dependency
H13A	The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by Path Dependency
H13B	The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by Path Dependency
H13C	The relationship between Digital Twin and DTC – Business Model Transformation is negatively moderated by Path Dependency
H14A	The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by Path Dependency
H14B	The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by Path Dependency
H14C	The relationship between Digital Thread and DTC – Business Model Transformation is negatively moderated by Path Dependency

H15A	The relationship between Digital Mindset – Business Model Transformation is p negatively moderated by Path Dependency
H15B	The relationship between Digital Mindset and DTC – Business Model Transformation is negatively moderated by path dependency
H15C	The relationship between Digital Mindset and DTC – Business Model Transformation is negatively moderated by path dependency

6.3 Back-end Model: Digital Transformation (DT)

Figure 13: Conceptual Framework for Digital Transformation (Back-end model)



Digital Transformation strategy is related to coordination, prioritization and implementation of Digital Transformation initiatives within a firm (Matt, Hess and Benlian, 2015). Some researchers (Bharadwaj et al., 2013) have focused on the digital adoption and implementation of digital technologies in businesses. However, based on our qualitative study, Digital Transformation of industrial businesses is more than technology adoption within a firm; it refers to a new way of doing business which affects all aspects of dynamic capabilities. Since Digital Transformation for industrial businesses is a relatively new initiative, the historical performance measures like revenue growth, market share growth, increase in profitability and efficiency/productivity may not be appropriate to understand the impact of DTC on Digital Transformation.

Digital Transformation is defined by the degree of improvements, comparisons and superiority of DCs for a firm with respect to its competitors. So, for this study, new evaluation criteria have been developed where key dynamic capabilities related to sensing, seizing and reconfiguration are selected and analyzed using three different criteria:

- importance of DCs (DCImp)
- improvement in DCs (DCIpr)
- comparison of DCs with competitors (DCCom)

DCImp:

The degree of importance of dynamic capabilities for Digital Transformation is considered as a representation of transformation in a firm. Since Digital Transformation for industrial businesses is a recent event, the financial measures may not reflect the degree of Digital Transformation within a firm. Strategic management literature references are thin for Digital Transformation, so based on qualitative analysis, the study proposes that the importance of core DCs responsible for Digital Transformation are good indicators to understand the degree of Digital Transformation within a firm.

DCIpr:

Like DCImp, the study proposes that the improvements of core DCs responsible for Digital Transformation in the last three years are a good representation of the degree of Digital Transformation within a firm. If a firm improves its core sensing, seizing and reconfiguration capabilities for Digital Transformation, this will help the firm in its transformation.

DCCom:

Like DCIpr, the study proposes that the comparisons of DCs with respect to competitors are good indicators of Digital Transformation within a firm. It is proposed that if a firm has better sensing, seizing and reconfiguration capabilities responsible for Digital Transformation with respect to its competitors, then that firm will have greater Digital Transformation.

6.3.1 Importance of Key Sensing Capabilities

One of the criteria for evaluating Digital Transformation within a firm is to consider the importance and improvement of key sensing capabilities against its competitors. If a firm gives more importance to improving its core sensing capabilities for Digital Transformation against its competitors, it is hypothesized that the firm will be more successful in Digital Transformation. These core sensing capabilities for Digital Transformation include: research & development (R&D) capabilities for selecting new technologies for business, developing new and innovative products and services using digitalization processes (based on the digitalization profile) and constantly sensing new opportunities in the market and evaluating competitors. If a firm can sense better Digital Transformation opportunities, analyze its competitors' moves and spend on R&D capabilities for developing new products and services for Digital Transformation, that firm will be more successful in Digital Transformation. It is also proposed that once a firm develops more DTCs, it will positively influence core sensing capabilities and the firm will improve these capabilities in comparison to its competitors. The subsequent sections conceptualize the sensing DCs for Digital Transformation.

6.3.1.1 R&D capability

Dynamic R&D capability enables firms to develop new products and processes in changing market conditions (Helfat, 1997). Though R&D capability has been treated as a key dynamic capability for an organization, if R&D does not pay off in the presence of a strong competitors who invest in imitative R&D, then that capability may not be important for the organization (Winter, 2003). So, the R&D capability needs to be a differentiating capability for a firm to bring new products and services into the market. For Digital Transformation, companies are spending significant R&D budgets to develop Digital Twins for their physical assets; it helps bring innovative products into the market faster. Though some researchers have suggested that the amount of R&D capability based on R&D expenditure (Rothaermel and Hess, 2007) could be a measure of dynamic capability, other researchers (Laaksonen and Peltoniemi, 2016) suggest that since dynamic capability is not similar across companies, these types of measures may not be appropriate. It is hypothesized that DTC also affects the importance, improvement and comparison of R&D capability as proper implementation of R&D capabilities is influenced by business model transformation, operating model transformation and cultural transformation capabilities. For this study, instead of direct measures like R&D expenditure, the manager's evaluation of the importance, improvement and comparison of R&D capability for Digital Transformation has been considered for understanding of the degree of Digital Transformation within the firm. It is proposed that DTC will positively influence the importance of R&D capability, and that as the firm develops more DTCs, it will improve its R&D capability in comparison to its competitors.

6.3.1.2 New product development (NPD) capability

New product development has been considered as a typical first-order dynamic capability that supports creation of new products and services (Winter, 2003). The rapid development of new products is necessary for cash flow, external visibility and increased likelihood of success in a high-technology industry (Deeds, Decarolis and Coombs, 2000). For industrial businesses, NPD capability becomes a key capability for Digital Transformation. Since industry lines are becoming blurred and companies are redefining their customers, NPD using in-house R&D capabilities and with ecosystem partnership becomes a key factor for successful Digital Transformation. So, the importance of NPD capability is considered for effective Digital Transformation within a firm. It is hypothesized that as a firm gives more importance to NPD capabilities and improves it against its competitors, the firm will be more successful in Digital Transformation. It is also proposed that DTC will have positive influence on NPD capabilities and as the firm develops more DTC, it will positively impact NPD capability and improve this capability in comparison to its competitors.

6.3.1.3 Product and service innovation capability (NPI/NSI)

There is a difference between new product or service development and new product or service innovation. NPD includes existing products with new incremental improvements; it does not always produce a new product or service. Also, even if firms innovate with new products and services, sometimes there may not be commercial feasibilities and those innovative products and services may not lead to new products or services in the market. Product and service innovation also includes process innovation which can be influenced by ecosystem partners (from Qualitative Study interviews) and this does not lead to new products or services. However, product and service innovation are important capabilities for Digital Transformation and it is proposed that its importance, improvement and comparison against competitors will give good understanding of the Digital Transformation within a firm.

A firm builds its technological capabilities by investing significantly in R&D, which involves discovery of new products, accumulation of new knowledge and training of technology personnel (Afuah, 2002) and by this process the firm increases its ability to evaluate and use new technologies and skills in product innovation (Zahra and George, 2002). However, organizational innovation can be seriously affected by organizational inertia (Gilbert, 2005). According to Gilbert, one type of inertia is caused by the problems in allocating resources, which can arise due to resource constraints and other causes by the inertia in organizational processes for resource investments. In a highly volatile environment, companies face difficulty in allocating resources (Christensen, 1997). Even if a firm seeks to allocate resources, the inflexibility in the firm's routines and processes may not allow this process to work effectively (Teece et al., 1997, 2007). Service innovation is gaining importance due to the servitization in industrial businesses. The term servitization was coined by Vandermerwe and Rada (1988) and is now widely used for creating value by adding services to products. Servitization is an innovative initiative of an organization where the organization transforms itself from selling products to selling products and differentiated services to its customers (Baines, Lightfoot, Benedettini and Kay, 2009). In the manufacturing industry, service has been included as a key value driver and differentiator (Vandermerwe and Rada, 1988; Quinn, 1992; Gebauer et al., 2006) and some companies have found this to be the most effective way to obtain sales prospects for their businesses (Wise and Baumgartner, 1999). The connected ecosystem has taken this concept one step further and now companies are thinking of providing pay-per-use services to their customers; instead of selling a product, they plan to sell services with a specific service-level agreement (Equipment-as-a-Service, EaaS). Some manufacturers like Caterpillar, ThysenKrupp and Tennant are experimenting with the EaaS service model (Lux Research, 2016[27]). The design of services is more difficult than the design of products (Slack, 2005) and firms should develop capabilities to be service-oriented and value services in their current installed bases (Olivia and Kallenberg, 2003). Organizations should have the capabilities to develop client-specific solutions using the combination of product and service (Miller et al., 2002). According to Agarwal and Selen (2009), higher-order dynamic capabilities in services are evolved by collaborating with stakeholders and they identified four dynamic capabilities for service innovation, namely: customer engagement (CuE), collaborative agility (CA), entrepreneur alertness (EA) and collaborative innovative capacity (CIC). CuE capability is the ability of a firm to encourage customers to participate in the service definition and delivery processes (Agarwal and Selen, 2009). CA refers to the firm's capability to interact with customers, orchestration of internal

[27] https://members.luxresearchinc.com/research/report/18970

operations and utilization of ecosystem partnership for service innovation (Sambamurthy et al., 2003). EA is the ability of an organization to explore its marketplace and detect current and future threats and opportunities for service (Sambamurthy et al., 2003. CIC is the ability of an organization to come up with innovative ideas, which allows partnering organizations to develop new services or extend existing services based on customer requirements by integrating service capabilities and resources which foster service innovation (Agarwal and Selen, 2003). Thus, product and service innovations are key dynamic capabilities for Digital Transformation and if a firm gives more importance to and improves these capabilities, it is hypothesized that it will lead to more Digital Transformation. Also, it is proposed that DTC will positively influence product and process innovation capabilities as a firm develops more DTC; these innovation capabilities will improve more in comparison to its competitors.

6.3.1.4 Organizational sensing

As mentioned in the literature survey (chapter 2), sensing is a key dynamic capability for an organization and sensing processes should be embedded in the organization. For sensing Digital Transformation opportunities and developing business processes to implement these opportunities, industrial businesses have started separate businesses (like GE has started GE Digital and Hitachi has started Hitachi Vantara). Lack of proper sensing of environment cues may create business issues. For instance, Intel missed the initial mobile phone chips business and Qualcomm and ARM became dominant players to the detriment of Intel. Following the theorization of Teece (2007), scanning technology, the industry and customers, experimenting product ideas through R&D and collaborating with strategic partners and suppliers for market opportunities are key sensing capabilities for a firm's Digital Transformation. It is also proposed that DTC positively influences the importance and improvement of organization sensing capabilities, i.e. the more a firm develops DTCs, the more it will pay attention to sensing capability and improve this capabilities in comparison to its competitors.

The study proposes that DTC influences the importance of DCs (DCImp), the improvement in DCs (DCIpr) and the comparison of DCs with respect to its competitors (DCCom) related to key sensing capabilities such as NPI/NPD, R&D and organization sensing. It is proposed that as a firm develops more DTCs, it helps that firm give more importance to sensing capabilities for DT, hence it improves its core sensing DCs for Digital Transformation and, compared to competitors, it does a better job in developing new sensing or maintaining existing sensing DCs for Digital Transformation.

6.3.2 Key Seizing Capabilities

Like sensing, seizing capabilities are another group of dynamic capabilities which are important for Digital Transformation and influenced by DTC. It is hypothesized that if a firm gives more importance and improves its core seizing capabilities for Digital Transformation in comparison to its competitors, the firm will more be successful in Digital Transformation. For this study, learning & knowledge management (KM), exploration and exploitation, strategic flexibility and developing new business models based on market responsiveness are considered. It is also proposed that DTC positively influences the importance and improvement of seizing capabilities, i.e. the more a firm develops DTCs, the more it will pay attention to seizing capabilities and improve these capabilities in comparison to its competitors.

6.3.2.1 Learning and knowledge management (KM)

Learning and knowledge management are key dynamic capabilities for a firm and the researchers agree with that. The role of learning and its impact on dynamic capability has been discussed by researchers in different ways. According to Bowman et al. (2003) and Teece et al. (1997), learning is a dynamic capability which is based on identification, experimentation and repetition of opportunities in a continuous manner. However, Zott (2003) identifies learning as a performance relevance attribute of dynamic capability. On the other hand, Esienhardt and Martin (2000) and Winter (2003) suggest that learning mechanisms guide the evolution of dynamic capability. However, all these researchers agree that learning is a key dynamic capability for an organization and it can be a key differentiator for organizational success. KM has become important due to the increased awareness of the importance of KM for organizational prosperity and survival (Easterby-Smith and Prieto, 2007). The knowledge-based view of the firm proposes knowledge as a key resource for the resource-based view of competitive advantage (Grant, 1996). KM capability enhances the dynamic capability of organizations, which in turn increases organizational performance and provides competitive advantages (Tseng and Lee. 2014). In view of Digital Transformation, learning and KM become key capabilities and companies should utilize these capabilities for Digital Transformation. It is proposed that DTC positively influences the importance and improvement of KM capabilities, i.e. as a firm develops DTCs, it will pay more attention to KM capabilities and improve these capabilities in comparison to its competitors.

6.3.2.2 Exploration and exploitation

Exploration and exploitation refer to the ability of a firm to simultaneously explore and develop new products and services and continue to exploit the existing products and services such that it can adapt to changing environments (O'Reilly and Tushman, 2007). Exploitation is about efficiency, increasing productivity, control and certainty with the firm and exploration is about search, discovery and innovation within the firm. Recent research suggests that exploration and exploitation need different competencies (Andriopoulos and Lewis, 2010, Raisch and Zimmermann, 2017) as they require different structures, processes and capabilities. Although exploration and exploitation are complimentary forces, they also generate organizational tensions (Koryak, Lockett, Hayton, Nicolaou and Mole, 2017). To reduce these tensions, sometimes firms create a separate organization entity. Google created a separate company – Alphabet – to concentrate more on exploration while Google became the business for exploitation of search-based businesses. Similarly, GE started a new business – GE Digital – to concentrate on its software-focused Digital Transformation business. The importance of exploration and exploitation capabilities create a big differentiator for DT. Since DT of an industrial business is a long-term, resource-intensive initiative (Qualitative Study Interviews) for a firm, it needs to continue to exploit its current businesses and generate enough resources, including financial resources, such that it can utilize those resources for exploitation. Thus, the importance of these capabilities is a good indicator of successful Digital Transformation for a firm. It is also proposed that exploration and exploitation capabilities are influenced by DTC; as a firm develops more DTCs, it will pay more attention to exploration and exploitation capabilities and improve these capabilities in comparison to its competitors.

6.3.2.3 Strategic flexibility

Strategic flexibility is the ability of a firm to reassign and reconfigure resources and capabilities for environmental changes (Sanchez, 1995). Since Digital Transformation is disrupting industrial businesses, strategic flexibility is a key capability to deal with the uncertainty and challenges. The firm should have the capability for allocating resources based on business needs (resource flexibility) and it should also have the flexibility to reorganize existing routines or create new routines to deal with environmental changes (coordination flexibility) (Zhou and Wu, 2010). The researcher in the ambidexterity study found that there is a link between ambidextrous capability and strategic flexibility which in turn influences operational efficiency (Kortmann, Gelhard, Zimmermann and Piller, 2014). They found that strategic flexibility mediates the relationship between operational efficiency and ambidextrous capability. Strategic flexibility is a key capability in businesses, for example, Apple defines and implements strategies to exploit emerging opportunities such that they can stay ahead of the competition (Chaston and Scott, 2012). The most cited outcome of strategic flexibility is the financial performance of companies. The higher the level of strategic flexibility, the higher the firm's financial performance (Combe et al., 2012; Cadogan, 2012). However, this relationship is moderated by competitive intensity, environmental dynamism, resource combinations and managerial ties (Wei et al., 2014). Thus, it is hypothesized that strategic flexibility is a key capability for a firm for Digital Transformation and its importance and improvement in comparison to its competitors are very important for Digital Transformation. It is also proposed that strategic flexibility capability is influenced by DTC and as a firm develops more DTCs, it will pay more attention to strategic flexibility and improve this capability in comparison to its competitors.

6.3.2.4 Market responsiveness

Market responsiveness is defined as the ability of the firm to respond in a timely manner and effectively to customer needs, competitive threats and market demands (Garrett et al., 2009). Companies need to have capabilities to collect, analyze and respond to the needs and threats of the environment. Currently, industrial businesses are going through disruptive technological changes and the market responsiveness capability is crucial for high-velocity markets. A market responsiveness culture should be developed within the firm and the organizational structure should support that (Masiello, 1988). According to Masiello, the firm should develop a market responsive system such that it can identify key strategic marketing and business issues, get functional departments to work together more closely to deliver customer requirements, drive the business with more customer focus, increase collaboration with internal and external partners and find competitive advantages to differentiate themselves from competitors. The risk-taking capability of top managers and the market responsiveness capability positively influence market pioneering strategy by which a firm enters a new market or new segments of a market (Garrett, et.al. 2009). Since Digital Transformation blurs industry boundaries, the market responsiveness capability is an important capability for a firm for entering new markets. Lee (2010) studied 140 foreign firms in China and suggests that market turbulence and Technology Turbulence positively influence market responsiveness. This has more relevance for Digital Transformation as technologies and markets are going through disruptions and market responsiveness capability will play a critical role for a firm for successful Digital Transformation. Thus, the importance and improvement of this capability in comparison to its competitors gives a good indication of Digital Transformation within a firm. A market responsive firm could proactively address customer needs, and this is a key dynamic capability for Digital Transformation. It is also proposed that market responsiveness is influenced by DTC and as a firm develops more DTCs, it will pay more attention to market responsiveness and improve this capability in comparison to its competitors.

The study proposes that DTC influences the importance of DCs (DCImp), improvement in DCs (DCIpr) and comparison of DCs with respect to its competitors (DCCom) related to key seizing capabilities such as KM, exploitation and exploration, strategic flexibility and market responsiveness. It is proposed that as a firm develops more DTCs, it helps that firm to pay more importance to seizing capabilities for Digital Transformation, hence it improves its core seizing DCs for Digital Transformation and, compared to competitors, it does a better job in developing new seizing or maintaining existing seizing DCs for Digital Transformation.

6.3.3 Key Reconfiguration Capabilities

Like sensing and seizing capabilities, reconfiguration is another group of dynamic capabilities which are important for Digital Transformation and influenced by DTC. A firm which gives more importance to and improves its core reconfiguration capabilities for Digital Transformation in comparison to its competitors will be more successful in Digital Transformation. For this study, it is proposed that the importance of Integration, Coordination and Alliance management capabilities are key reconfiguration DCs for Digital Transformation. It is also proposed that DTC positively influences the importance and improvement of reconfiguration capabilities, i.e. the more a firm develops DTCs, the more attention it will pay to reconfiguration capabilities and improve these capabilities in comparison to its competitors.

6.3.3.1 Integration capability

The integration capability of a firm is the ability of the firm to combine internal and external integration practices to achieve better firm performance (Johnson and Filippini, 2013). The authors discovered that integration practices are not enough and that companies should develop integration capabilities for positive performance effects. The seminal studies of internal collaboration within design, manufacturing and marketing personnel demonstrated that each functional area worked as a silo and this might lead to conflict and confusion (Dougherty, 1992; Maltz and Kohli, 2000; Song et al., 1997). So, internal collaborations should be managed effectively for positive performance and companies should develop intra-firm integration capabilities to manage internal collaborations. External collaboration with suppliers and partners are touted to reduce development costs and gain competitive advantages (Fliess and Becker, 2006). For Digital Transformation, external collaborations with ecosystem partners are very important to provide end-to-end solutions for customers. The suppliers' cooperation benefits product success and timelines (Johnson and Luo, 2008) and collaboration of suppliers and customers may improve product quality (Kayank and Hartley, 2008). Like internal collaboration, external collaboration does not guarantee product performance, however, working with them on a regular basis will develop effective processes which will lead to the creation of firm-level integration capabilities. Integration capability is a core reconfiguration capability of a firm and the importance of integration capability for Digital Transformation gives a good indication of success for Digital Transformation within a firm. It is also proposed that integration capabilities are influenced by DTC and as a firm develops more DTCs, it will pay more attention to integration capabilities and improve these capabilities in comparison to its competitors.

6.3.3.2 Coordination capability

Coordination capability is a key dynamic capability for a firm. Teece et al. (1997) suggest that in the global market, companies could be successful if they demonstrate timely market responsiveness, rapid product innovation, coupled with management capability to coordinate and deploy internal and external competencies. Strategy scholars (Gulati et al., 2002) suggested that coordination and organization learning are important dynamic capabilities which help in the reconfiguration of resources and capabilities. For industrial businesses, coordination with internal and external ecosystem partners is important for firm performance. For example, Gao & Tian (2014) studied supply chain coordination in the manufacturing industry and propose that the former is a dynamic capability and influences firm performance. Tai and Ku (2016) studied how companies were developing competitive advantage for new product development (NPD) and suggested that companies should concentrate on demand and supply side coordination for a successful NPD initiative. Like integration capability, business coordination capability is a core reconfiguration capability of a firm and the importance of coordination capability for Digital Transformation gives a good indication of the success for Digital Transformation within a firm. Like integration capability, it is proposed that coordination capabilities are influenced by DTC and as a firm develops more DTCs, it will pay more attention to coordination capabilities and improves these capabilities in comparison to its competitors.

6.3.3.3 Alliance management capability

As industrial businesses are going through technology disruption, strategic alliance management becomes a critical capability for success. Alliance management capability (AMC) is the ability of the firm to share, store and apply partnership knowledge from its alliances and it is an antecedent of firm performance (Niesten and Jolink, 2015). The strategic alliances provides resources and learning and thereby companies can develop competitive advantages using those relationships. Though alliances are critical, they should be managed effectively to obtain actual outcomes (Ireland, Hitt and Vaidyanath, 2002). The theoretical view of AMC is that it improves alliance success because it enables the partners to adjust alliance attributes based on environmental changes (Heimeriks and Schreiner, 2010; Schilke and Goerzen, 2010). AMCs have been considered as key resources for inter-organizational (IO) relationships for firm performance (Heimerik et al., 2009; Schilke and Goerzen, 2010). Kauppila (2015) studied AMC in manufacturing companies and showed that AMC had an inverted U-shaped relationship with co-exploration but an increasingly positive effect on co-exploitation. AMC enables companies to master the difficult task of alliance management (Ireland et. al., 2002) and thus is considered a main determinant of alliance performance (Kale and Singh, 1999; Sanchez, 2001; Anand and Khanna, 2000; Eisenhardt and Martin, 2000). Hence, AMC is a core DC for Digital Transformation and its importance and improvement have great impact on successful Digital Transformation for a firm. It is proposed that AMC is influenced by DTC and as a firm develops more DTCs, it will pay more attention to AMC and improve this capability in comparison to its competitors.

The study proposes that DTC influences the importance of DCs (DCImp), improvement in DCs (DCIpr) and comparison of DCs with respect to its competitors (DCCom) related to key reconfiguration capabilities, such as coordination, integration and alliance management. It is proposed that as a firm develops more DTCs, it helps to pay more importance to seizing capabilities for Digital Transformation, hence it improves the firm’s core seizing DCs for Digital

Transformation and, compared to competitors, it does a better job in developing new reconfiguration or maintaining existing reconfiguration DCs for Digital Transformation.

Based on the above discussions, the following hypotheses are proposed:

Hypotheses for DTC – Business Model Transformation:

- *H16A: DTC – Business Model Transformation positively influences DC-Importance (DCImp).*
- *H16B: DTC – Business Model Transformation positively influences DC-Improvement (DCIpr).*
- *H16C: DTC – Business Model Transformation positively influences DC-Comparison (DCCom).*

Hypotheses for DTC – Operating Model Transformation:

- *H17A: DTC – Operating Model Transformation positively influences DC-Importance (DCImp).*
- *H17B: DTC – Operating Model Transformation positively influences DC-Improvement (DCIpr).*
- *H17C; DTC – Operating Model Transformation positively influences DC-Comparison (DCCom).*

Hypotheses for DTC – Cultural Transformation:

- *H18A: DTC – Cultural Transformation positively influences DC-Importance (DCImp).*
- *H18B: DTC – Cultural Transformation positively influences DC-Improvement (DCIpr).*

- *H18C: DTC – Cultural Transformation positively influences DC-Comparison (DCCom).*

6.3.4 Moderators of the Relationship Between DTC and Digital Transformation

The relationship between DTC and Digital Transformation are moderated by external and internal factors and these factors are described in the subsequent sections.

6.3.4.1 Ecosystem partnership

Ecosystem partnership poses a serious challenge for any organization as it should manage projects across multiple organizations under complex and uncertain conditions (Rothaermel and Deeds, 2006). The performance of the partnership varies between companies (Anand and Khanna, 2000) and certain companies possess certain characteristics to manage the partnership effectively (Kale et al., 2002). Ecosystem partnership in a firm is developed through strategic alliances and it has five underlying organizational routines: alliance portfolio coordination, inter-organizational coordination, inter-organizational learning, alliance pro-activeness and alliance transformation (Schilke and Goerzen, 2010). A firm tends to enter into an ecosystem partnership when faced with technological changes in uncertain times. Several empirical studies have demonstrated the positive relationship between ecosystem partnership and innovation in the area of new product development (Rothaermel and Deeds, 2004, Shan et al., 1994). Some scholars suggest that a firm which has a technical advantage in an emerging technology may like to develop new products internally, whereas a firm without technical advantage tends to form an ecosystem partnership to bridge the gap (Anand, Oriani, Vassalo, 2010). These scholars distinguish between traditional technology and emerging technology and suggest that ecosystem partnership is important for emerging technology. Ecosystem partnership influences the relationship between DCImps, DCIpr & DCCom and DTC. As firms develop more ecosystem partnerships, it is proposed that they tend to develop more DTC, which in turn affects DCs responsible for Digital Transformation. As industrial businesses are going through uncertain times and ecosystem partnership plays a critical role to bridge capability gaps for companies, hence it is proposed that ecosystem partnership moderates the relationship between DTC and Digital Transformation.

The relationship between DTC-Business Model Transformation and Digital Transformation *is positively moderated by Ecosystem Partnership.*

Hypotheses:

- *H19A: The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is positively moderated by ecosystem partnership.*
- *H19B: The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is positively moderated by ecosystem partnership.*
- *H19C: The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is positively moderated by ecosystem partnership.*

The relationship between DTC-Operating Model Transformation and Digital Transformation *is positively moderated by ecosystem partnership.*

Hypotheses:

- *H20A: The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is positively moderated by ecosystem partnership.*
- *H20B: The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is positively moderated by ecosystem partnership.*

- *H20C: The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is positively moderated by ecosystem partnership.*

The relationship between DTC- Cultural Transformation and Digital Transformation *is positively moderated by ecosystem partnership.*

Hypotheses:

- *H21A: The relationship between DTC- Cultural Transformation and DC-Importance (DCImp) is positively moderated by ecosystem partnership.*
- *H21B: The relationship between DTC- Cultural Transformation and DC-Improvement (DCIpr) is positively moderated by ecosystem partnership.*
- *H21C: The relationship between DTC- Cultural Transformation and DC-Comparison (DCCom) is positively moderated by ecosystem partnership.*

6.3.4.2 Digital commitment

As mentioned in Chapter 2 (literature survey), the origin and intent of dynamic capability is influenced by exogenous factors, such as technology disruption, high-velocity environment (Teece et al., 1997) and medium-velocity environment (Eisenhardt et al., 2000). However, other than intent, strategic focus is equally important for Digital Transformation. Strategic focus and intent creates digital commitment for a firm and it accelerates the development of Digital Transformation. For example, the Board of Directors of GE, including previous chairman Jeff Immelt[28], was committed to Digital Transformation of GE businesses and establishing GE Digital as among the top ten software companies in the world. Without top-down digital commitment, DTC will have siloed influence on Digital Transformation and firms will be

[28] http://www.cnbc.com/2017/02/15/ge-ceo-jeff-immelt-tells-cramer-hes-betting-on-the-industrial-internet.html

engaged in departmental- or factory-centric Digital Transformation with slow pace of transformation. During qualitative discussions, all managers emphasized the importance of top-down digital commitment for accelerating enterprise-wide Digital Transformation. Adner and Helfat (2003) propose that within a single industry, where managers face the same external environment, time-varying corporate effects for managerial decisions are statistically significant. By extending this concept to digital commitment, it can be said that faced with digital disruptions, the commitment of managers and allocating resources for Digital Transformation will have significant impact on overall transformation. According to Aiken and Keller (2007), CEOs should be involved in leading transformation throughout the organization. Digital commitment from the top, especially the CEO, should enable commitment to transformation initiatives and allocate the necessary resources to achieve that, otherwise transformation will be sporadic (Bendor-Samuel, 2017). Thus, digital commitment is a moderator and it is proposed that it moderates the relationship between DTC and DT positively. Digital commitment moderates the relationship between DTC and DCs responsible for DT, because as a firm is more digitally committed, it develops more DTC which leads to development of core DCs responsible for Digital Transformation.

Based on this discussion, the following hypotheses are proposed:

The relationship between DTC-Business Model Transformation and Digital Transformation is positively moderated by digital commitment.

- *H22A: The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is positively moderated by digital commitment.*

- *H22B: The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is positively moderated by digital commitment.*
- *H22C: The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is positively moderated by digital commitment.*

The relationship between DTC-Operating Model Transformation and Digital Transformation is positively moderated by digital commitment.

- *H23A: The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is positively moderated by digital commitment.*
- *H23B: The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is positively moderated by digital commitment.*
- *H23C: The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is positively moderated by digital commitment.*

The relationship between DTC- Cultural Transformation and Digital Transformation is positively moderated by digital commitment.

Hypotheses:

- *H24A: The relationship between DTC- Cultural Transformation and DC- Importance (DCImp) is positively moderated by digital commitment.*
- *H24B: The relationship between DTC- Cultural Transformation and DC- Improvement (DCIpr) is positively moderated by digital commitment.*
- *H24C: The relationship between DTC- Cultural Transformation and DC- Comparison (DCCom) is positively moderated by digital commitment.*

6.3.4.3 Resource scarcity/constraints

DT for industrial businesses are resource intensive and lack of critical resources may impact the speed and/or outcome of DCs responsible for Digital Transformation. Developing DTC is not enough for Digital Transformation. Environmental munificence refers to either scarcity or abundance of important resources needed by a firm in a particular environment (Castrogiovanni, 1991). Environmental munificence is an important factor for managing resources (Sirmon, Hitt and Ireland, 2007). According to Rajagopalan, Rasheed and Datta (1993), dynamic environment with low environmental munificence is significantly different to dynamic environment with high environmental munificence and each of these environments should be managed differently. Managers need to have different skills in managing resources with changing environmental conditions. The companies need new or improved resources for facing customer demands when they are faced with environmental shocks (like technology disruption) otherwise they will be less capable to respond in a changing environment (Sirmon, Hitt and Ireland, 2007). Thus, resource scarcity and constraint are moderators and it is proposed that they moderate the relationship between DTC and Digital Transformation.

The relationship between DTC-Business Model Transformation and Digital Transformation is negatively moderated by resource scarcity/constraints.

Hypotheses:

- *H25A: The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is negatively moderated by resource scarcity/constraints.*
- *H25B: The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is negatively moderated by resource scarcity/constraints.*

- *H25C: The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is negatively moderated by resource scarcity/constraints.*

The relationship between DTC-Operating Model Transformation and Digital Transformation is negatively moderated by resource scarcity/constraints.

Hypotheses:

- *H26A: The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is negatively moderated by resource scarcity/constraints.*
- *H26B: The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is negatively moderated by resource scarcity/constraints.*
- *H26C: The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is negatively moderated by resource scarcity/constraints.*

The relationship between DTC- Cultural Transformation and Digital Transformation is negatively moderated by resource scarcity/constraints.

Hypotheses:

- *H27A: The relationship between DTC- Cultural Transformation and DC- Importance (DCImp) is negatively moderated by resource scarcity/constraints.*
- *H27B: The relationship between DTC- Cultural Transformation and DC- Improvement (DCIpr) is negatively moderated by resource scarcity/constraints.*
- *H27C: The relationship between DTC- Cultural Transformation and DC- Comparison (DCCom) is negatively moderated by resource scarcity/constraints.*

6.3.4.4 Customer and market demands

Customer and market demands for IIoT solutions/business models have a significant impact on developing DTC and developing and improving DCs responsible for Digital Transformation. Among various factors of market dynamics, demand uncertainty and competitor intensity are two important factors because they are related to customers and competitors (Voss and Voss, 2000). Competitor turbulence has been discussed earlier as it influences the relationship between digitalization profile and DTC. Demand uncertainty refers to heterogeneity and instability in customer preferences (Gatignon and Xuereb, 1997). When market demand is highly uncertain, as industrial businesses are currently going through, monitoring customer needs may not enable the firm to identify what the customers are looking for as they are not aware of their requirements and, in this case, customer orientation declines and technology orientation becomes more prominent (Zhou and Li, 2010). We can notice that emerging technologies, such as AR, VR, AI/ML, Blockchain and other related technologies, are promising better firm performance and hence impact Digital Transformation. As customer and market demands for Industrial Internet-based solutions increase, they will influence DTC and firms concentrate on key DCs responsible for Digital Transformation, hence those capabilities are improved with respect to competitors. Thus, it is proposed that customer and market demands moderate the relationship between DTC and Digital Transformation.

The relationship between DTC-Business Model Transformation and Digital Transformation is positively moderated by customer and market demands.

Hypotheses:

- *H28A: The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is positively moderated by customer and market demands.*
- *H28B: The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is positively moderated by customer and market demands.*
- *H28C: The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is positively moderated by customer and market demands.*

The relationship between DTC-Operating Model Transformation and Digital Transformation is positively moderated by customer and market demands.

Hypotheses:

- *H29A: The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is positively moderated by customer and market demands.*
- *H29B: The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is positively moderated by customer and market demands.*
- *H29C: The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is positively moderated by customer and market demands.*

The relationship between DTC- Cultural Transformation and Digital Transformation is positively moderated by customer and market demands.

Hypotheses:

- *H30A: The relationship between DTC- Cultural Transformation and DC- Importance (DCImp) is positively moderated by customer and market demands.*

- *H30B: The relationship between DTC- Cultural Transformation and DC- Improvement (DCIpr) is positively moderated by customer and market demands.*
- *H30C: The relationship between DTC- Cultural Transformation and DC- Comparison (DCCom) is positively moderated by customer and market demands.*

6.3.4.5 Summary of the Back-End Model

Table 11 : Summary of Back-End Model

Hypothesis	**Description**
	DTC -> Digital Transformation
H16A	DTC – Business Model Transformation positively influences DC-Importance (DCImp)
H16B	DTC – Business Model Transformation positively influences DC-Improvement (DCIpr)
H16C	DTC – Business Model Transformation positively influences DC-Comparison (DCCom)
H17A	DTC – Operating Model Transformation positively influences DC-Importance (DCImp)
H17B	DTC – Operating Model Transformation positively influences DC-Improvement (DCIpr)
H17C	DTC – Operating Model Transformation positively influences DC-Comparison (DCCom)
H18A	DTC – Cultural Transformation positively influences DC-Importance (DCImp)
H18B	DTC – Cultural Transformation positively influences DC-Improvement (DCIpr)
H18C	DTC – Cultural Transformation positively influences DC-Comparison (DCCom)
	Moderation effects of ecosystem partnership
H19A	The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is positively moderated by ecosystem partnership
H19B	The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is positively moderated by ecosystem partnership
H19C	The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is positively moderated by ecosystem partnership
H20A	The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is positively moderated by ecosystem partnership
H20B	The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is positively moderated by ecosystem partnership
H20C	The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is positively moderated by ecosystem partnership
H21A	The relationship between DTC- Cultural Transformation and DC-Importance (DCImp) is positively moderated by ecosystem partnership
H21B	The relationship between DTC- Cultural Transformation and DC-Improvement (DCIpr) is positively moderated by ecosystem partnership
H21C	The relationship between DTC- Cultural Transformation and DC-Comparison (DCCom) is positively moderated by ecosystem partnership

	Moderation effects of digital commitment
H22A	The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is positively moderated by digital commitment
H22B	The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is positively moderated by digital commitment
H22C	The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is positively moderated by digital commitment
H23A	The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is positively moderated by digital commitment
H23B	The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is positively moderated by digital commitment
H23C	The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is positively moderated by digital commitment
H24A	The relationship between DTC- Cultural Transformation and DC-Importance (DCImp) is positively moderated by digital commitment
H24B	The relationship between DTC- Cultural Transformation and DC-Improvement (DCIpr) is positively moderated by digital commitment
H24C	The relationship between DTC- Cultural Transformation and DC-Comparison (DCCom) is positively moderated by digital commitment
	Moderation effects of resource scarcity and constraints
H25A	The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is negatively moderated by resource scarcity and constraints
H25B	The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is negatively moderated by resource scarcity and constraints
H25C	The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is negatively moderated by resource scarcity and constraints
H26A	The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is negatively moderated by resource scarcity and constraints
H26B	The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is negatively moderated by resource scarcity and constraints
H26C	The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is negatively moderated by resource scarcity and constraints
H27A	The relationship between DTC- Cultural Transformation and DC-Importance (DCImp) is negatively moderated by resource scarcity and constraints
H27B	The relationship between DTC- Cultural Transformation and DC-Improvement (DCIpr) is negatively moderated by resource scarcity and constraints
H27C	The relationship between DTC- Cultural Transformation and DC-Comparison (DCCom) is negatively moderated by resource scarcity and constraints
	Moderation effects of customer and market demands
H28A	The relationship between DTC-Business Model Transformation and DC-Importance (DCImp) is positively moderated by customer and market demands
H28B	The relationship between DTC-Business Model Transformation and DC-Improvement (DCIpr) is positively moderated by customer and market demands
H28C	The relationship between DTC-Business Model Transformation and DC-Comparison (DCCom) is positively moderated by customer and market demands
H29A	The relationship between DTC-Operating Model Transformation and DC-Importance (DCImp) is positively moderated by customer and market demands

H29B	The relationship between DTC-Operating Model Transformation and DC-Improvement (DCIpr) is positively moderated by customer and market demands
H29C	The relationship between DTC-Operating Model Transformation and DC-Comparison (DCCom) is positively moderated by customer and market demands
H30A	The relationship between DTC- Cultural Transformation and DC-Importance (DCImp) is positively moderated by customer and market demands
H30B	The relationship between DTC- Cultural Transformation and DC-Improvement (DCIpr) is positively moderated by customer and market demands
H30C	The relationship between DTC- Cultural Transformation and DC-Comparison (DCCom) is positively moderated by customer and market demands

6.4 Conclusion

The conceptual model, based on literature survey and preliminary qualitative study has been presented in this chapter. This model, comprising of front-end DTC model and back-end DTC model, is illustrated in details and hypotheses related to front-end and back-end model are proposed. In the next chapter (chapter 7), research methodology and hypothesis testing are discussed.

Chapter 7: Research Methodology and Hypotheses Testing

7.1 Introduction

The conceptual framework (chapter 6) has been developed by leveraging literature survey (chapter 2), industry survey (chapter 3), preliminary exploratory study (chapter 4) and detailed exploratory study (chapter 5). In this chapter, the research methodology is discussed. The purpose of this is to test the hypotheses, which are described in the conceptual framework. To begin with, the chapter highlights different types of research designs, then the data collection methods, with a special focus on quantitative analysis followed by the sampling discussion. The following section describes the questionnaire design and the final section describes the quantitative analysis used for the study.

7.2 Philosophical Position

This section of the chapter deals with the philosophical positioning of the research. Before deciding on a particular research methodology and subsequent research methods for investigating the research questions, it is necessary to discuss the philosophy of different methodologies and methods and what type of method could be suitable for the research questions.

The selection of the research methodology is informed by the paradigm that guides the research activity. Also, it is guided by the nature of reality (ontology), the theory of knowledge, which informs the research (epistemology) and how to acquire that knowledge (methodology) (Tuli, 1997).

7.2.1 Epistemology

The social science view is similar to natural science and social researchers concentrate on human behaviors (Schulze, 2003; Krauss, 2005). The researchers in this area constantly debate whether social research follows the same principles as natural science (Bryman, 2001). Epistemology has two positions: positivism and interpretivism–constructivism. According to Neuman (2003), positivism sees social science as an organized way to mix deductive logic and empirical observations. On the other hand, interpretivist–constructivist researchers believe in a theoretical framework for qualitative research in which the world can be constructed, interpreted and experienced by people in their own interactions with social systems (Guba and Lincoln, 1985; Merriam, 1998 and Maxwell, 2005). Both positivist and interpretivist researchers believe that human behaviour is patterned, whereas positivists see cause and effect relationships and interpretivists see that the patterns are created through social interactions. I take the interpretivist approach for my research work. The IIOT industry is evolving and the cloud computing business model is around ten years old, so most of the research work is based on my discussions with the industry leaders, direct observations in the industry and conducting a survey to test my observations.

7.2.2 Ontology

In social science, ontology refers to the nature of reality. There are two schools of thought about ontology: one school believes there is an independent reality (objectivism) and the other believes that reality consists of social processes (Neuman, 2003). Positivists believe that reality exists and that it should be discovered using scientific methodologies (Bassey, 1995). They do not consider themselves as variables in their research works and research findings are represented quantitatively (Bassey, 1995; Mutch, 2005). On the other hand, interpretivists cannot believe that reality is there without people and they see reality as human driven (Mutch, 2005). Interpretivist researchers use qualitative methodology to investigate and interpret social realities (Bassey, 1995; Cohen, Manion and Morrison, 2000). The qualitative research methodology treats people as participants in the research and empowers them to influence the outcome of the research. I follow the ontological philosophy of the qualitative research methodology.

7.2.3 Methodology

Methodology is a research strategy that guides how the research should be conducted based on epistemological and ontological principles (Sarantakos, 2005) and it prescribes the principles, procedures and practices for the research (Kazdin, 1992, 2003, Marczyk, DeMatteo and Festinger, 2005).

The positivist research paradigm favours **quantitative** methodology, which is objective and detached. It emphasizes measuring variables and testing hypotheses that are linked to causal explanations (Sarantakos, 2005; Marczyk, DeMatteo and Festinger, 2005). The data collection techniques focus on gathering numerical data such that the analysis can be done using the quantitative method (Neuman, 2003; Sarantakos, 2005).

However, interpretivist epistemology and constructionalist ontology favour the **qualitative** methodology. They believe that the meaning of any research can be found based on the participant's experience and mediated through the researcher's own perceptions (Merriman, 1997). Researchers involved in qualitative methodology observe people's interactions, participate in activities, interview key people, construct case studies and analyse existing documents or other artifacts.

Other than quantitative and qualitative methodology, there is another methodology, which mixes the best of both worlds. This is called **critical theory**. This theory challenges the status quo and uncovers reality shaped by social structures and mechanisms. Critical theorists believe that reality is constructed by what people see and experience within social and historical contexts (Ponterroto, 2005). Critical theory is based on constructionist ontology and entomological empowerment of the research. In critical theory, observations and participant interviews are combined together such that situations can be understood clearly. Using dialogue, the researchers and participants can understand the situation and engage in meaningful conversations. This is a way to reclaim conflict and tension (Guba and Lincoln, 1994).

For my research work, I have taken a **mixed methods approach**, where I have conducted a preliminary qualitative study to understand the IIoT landscape for Digital Transformation related to my research work, then a detailed qualitative study to conceptualize my research questions and come up with hypotheses. Subsequently, I have conducted a survey from enterprise companies involved in Digital Transformation by leveraging IIoT to test my hypotheses. Thus, I have conducted a systematic and structured mixed methods approach for my research study.

7.2.4 Method

There are different methods for qualitative and quantitative research methodology. The major difference between qualitative and quantitative methods is that one is more flexible than the other. In general, most quantitative methods are less flexible. With quantitative methods, such as surveys and questionnaire, the researcher asks the same questions, the order of the questions is fixed and the answers are not open-ended. In qualitative study, the researcher has the liberty to ask open-ended questions and the researcher and participants can discuss the research topic informally. Case study method is one common method in qualitative research. The qualitative method has some advantages in exploratory research. Since the questions are open ended, the researcher can ask one question to one respondent and then change the question for other respondents based on his/her knowledge and understanding of the research problem. This allows the respondents to give their views openly and helps the researcher to understand the research problem clearly. Another advantage to the researcher in qualitative methodology is to probe the respondents based on their answers to "why" or "how' questions.

In the quantitative method, the researcher collects numerical data to explain particular phenomena using quantitative methods. According to Aliaga and Gunderson (2000), the quantitative method explains a phenomenon by collecting numerical data and analysing the data using mathematical methods, in particular, statistics. Since the data needs to be analysed with mathematical methods, the data should be in numerical form. The following types of research questions are suitable for quantitative research (Balnaves and Capiti, 2001). When the researcher is looking for a quantitative answer, quantitative research is appropriate. For example: how many firms are actively engaged in Digital Transformation by leveraging IIOT for a particular year? The answer to this question is a quantitative answer.

- If we wish to know the impact of numerical changes for a particular research question, a quantitative measure will be right for that purpose. For example, the question by what percentage can we reduce the machine down time by applying IIOT technology can be answered using a quantitative method.

- If we want to predict some phenomenon in the future from the past trends, then quantitative methods are appropriate for that kind of analysis. For example, we can find the probability of machine failure by its past break down maintenance records and by simulating the pattern.
- Quantitative research is the only answer for testing hypotheses. For example, we can have a hypothesis that the asset utilization is positively correlated to the application of IOT technology. We can test the hypothesis from the numerical data and we can conclude whether the hypothesis is valid or invalid.

The following table compares two methodologies:

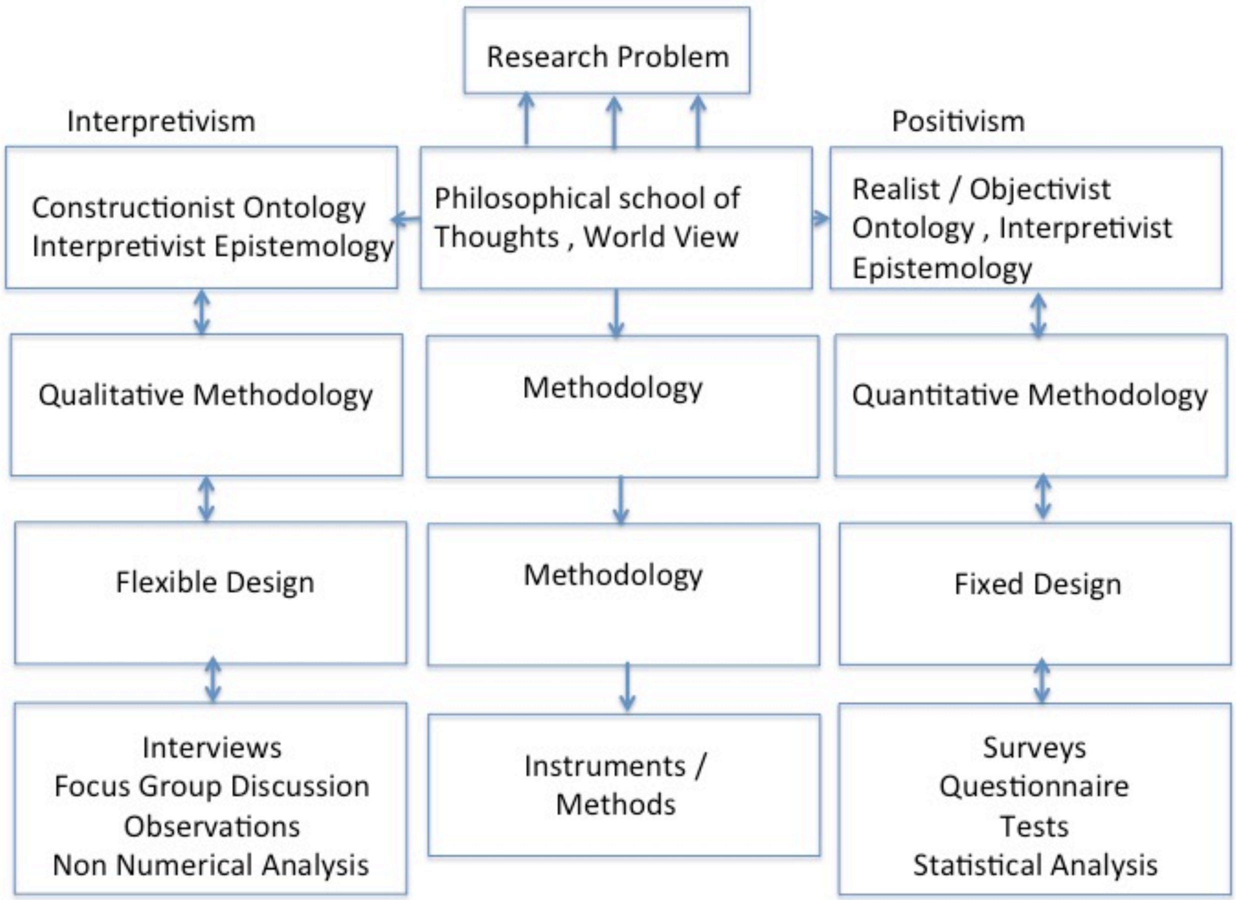
Table 12 : Comparison of Quantitative and Qualitative Methods

Category	Quantitative	Qualitative
Framework	• Suitable for testing of hypothesis • Instruments are more rigid style for answering questions • Use highly structured methods, like surveys, questionnaires etc.	• Suitable for exploring phenomenon • Instruments are more flexible and iterative style • Use semi structured methods, in-depth interviews, focus groups and participant observation
Objectives	• To quantify variations • To predict relationships • To describe a population behaviour	• To describe variations • To describe and explain relationships • To describe an individual's observation
Question format	Close ended	Open ended
Data format	Numerical, by assigning numerical values of answers	Textual (for interview transcripts, field notes)
Research design	• Study design is fixed from the beginning • The number and order of questions are the same for all participants • Study design is subjected to mathematical assumptions	• Study design is semi flexible and can be more discussion oriented • The number and order of questions may vary based on the participants • Study design is iterative and adjusted based on the answers

Source: Miles, Hubarman and Saldana (1994), Osborne (2008)

The following figure, summarizes the philosophy of the research.

Figure 14: Philosophy of research



Source: Tuli F, (1997), Foundation of Research

7.3 Research Design

A research design is a framework to conduct a research in a structured manner. The type of research guides the information collection, sources of information and the methodologies to be adopted for data collection (Malhotra & Briks, 2003). Three types of research methodologies – qualitative, quantitative and mixed methods – are described in chapter 7.2.3. In this chapter, two research design methods – exploratory and conclusive research designs – are explained.

7.3.1 Exploratory Research Design

The exploratory research design has been discussed in section 5.1.

7.3.2 Conclusive Research Design

The conclusive research design provides information for alternative courses of action. The purpose of conclusive research is to describe the specific phenomenon, to test hypotheses and to examine the relationship between constructs (Parasuraman, Grewaland and Krishnan, 2007). There are two sub-classes of conclusive research (Singer, Willett and Willett, 2003): descriptive research and causal research. The descriptive research design has two types:

- **Cross-Sectional Design:** in this design, a sample of the population is taken at one point in time and this presents a snap shot of the situation (Malhotra & Briks, 2003). This method is associated with sample surveys. Since there is no time scale, it is difficult to develop causal relationships between studied phenomena. A cross-sectional study is well suited for complex research models which are common in social science research (Bryman, 2004).
- **Longitudinal Design:** In this design, the data is collected from the same sample at multiple points in time. It is akin to a filmstrip where multiple pictures are taken in a time

frame and its continuity can be observed (Malhotra & Briks, 2003). Though longitudinal research illustrates better causal inferences than cross-sectional research, it is difficult to execute due to the cost and time involved for the study (Lee and Lings, 2008). Moreover, since Digital Transformation and IIoT concepts are evolving, it is difficult to perform a longitudinal study at this time because of such fluidity.

The descriptive research is appropriate, when the research objectives include the following (Elahi and Dehdashti, 2011):

- Portraying the characteristics of a social or physical phenomenon
- Determine the degree of association of the variables
- Making predictions regarding the occurrence of the social or physical phenomenon

Causal research depends on conducting experiments and it is appropriate when the research objective is to understand the variables that cause the phenomenon. This type of research is cost and time intensive and not suited for the study principally because it relies on being able to control as many as possible, if not all, of the variables in a study in a controlled environment, preferably in a lab test, akin to what we associate with the natural sciences.

To summarize, the current study includes exploratory research and conclusive research. Initial exploratory research was conducted (chapters 4 and 5) to assist in developing hypotheses and then a cross-sectional research design was applied to test these hypotheses.

The qualitative study has been discussed in detail in earlier chapters (chapters 4 and 5) and the quantitative study is discussed in the subsequent sections.

7.4 Data Collection

7.4.1 Data Types

There are two types of data which can be collected for a study: primary data and secondary data (Kinnear, 1991). Primary data is collected by the researcher and it is directly related to the study. The secondary data can be internal or external. Internal secondary data is available from the organizations participating in the study and external secondary data is collected from databases and other external sources (Gordon et al., 1988). It is advised to use the secondary data from a known source, e.g. from the organizations (Aaker, Kumar and Day, 2007). In most cases, financial data from the secondary sources are used for this study.

In the current study, firm revenue and firm size were collected from the annual reports and Security and Exchange Commission (www.sec.gov) form 10-K filings for public companies in the United States for the respective companies. Mostly, primary sources were used for data collection.

7.4.2 Quantitative Data Collection

The survey method is the most common method of data collection for business and management research (Griffis, Goldsby and Cooper, 2003). The questionnaire is used for the survey and the same questions are asked to each respondent with a given set of options to answer those questions. This allows statistical relationships between constructs and comparison between respondents (Churchill and Iacobucci, 2002).

There are different methods for administering the survey: face-to-face, telephonic, postal and online surveys.

The face-to-face survey was rejected because it is very difficult to ask questions for a survey in 30 to 35 minutes and the respondents might be sensitive to answering Digital Transformation-related questions for their companies in the presence of another person. Also, the senior managers in the companies are often too busy to spare 30 to 35 minutes of their schedule for face-to-face interviews.

The postal mail survey was rejected as most managers did not receive postal mail in their offices and it was difficult to get home addresses. Also, senior managers are mostly traveling and may not be available to answer postal surveys. All these factors will decrease the response rate and increase the probability of data collection biases (Dillman, 2007).

The telephonic survey was not considered as the survey was long and it was difficult to ask questions in 30 to 35 minutes, similar to face-to-face interviews. Also, the usual response rate of telephonic surveys is in single digits (Keeter, Christian, Dimock, & Gewurz, 2012. The decline of telephonic surveys has paved the way for online surveys which are gaining importance in scientific research.

For this study, the online survey was chosen as all the respondents were in the technology industry and their companies were going through Digital Transformation. Research has shown that mixed mode survey, sending mail survey requests and augmenting them by online survey, improves the response rate (Church, 1993). Instead of sending postal mail, email and internet messages through **Linkedin.com** were sent to potential respondents at regular intervals.

7.4.3 Online Survey – Advantages and Disadvantages

The cost of hardware, software and communication charges are decreasing rapidly, and the Internet is used for communication and information. Communication researchers have found that the Internet is a rich domain to conduct survey research (Wright, 2005).

The main advantages of online survey are as follows:

One primary advantage of online survey is that it takes advantage of the Internet to connect with groups and individuals who are difficult, if not impossible, to access through other means (Garton, Haythornthwaite, & Wellman, 1999). Some of the groups are virtual groups and only available through the Internet. In this study, online survey played an important role as it was easy and convenient to access senior managers through emails and Linkedin.com messages with the link of the survey to respond. It would have been very difficult to reach them otherwise.

Another advantage of online survey is to reach a large number of people with common characteristics, who are geographically dispersed, within a short period of time, (Bachmann, Elfrink and Vazzana, 1996; Garton et al., 1999). Online survey helps the researcher to reach the target audience quickly and at less cost. Online surveys allow researchers to continue working while the data collection is in progress. The data is collected and stored immediately, and the researchers can start the initial analysis during this process (Llieva et al., 2002).
Another distinct advantage of online survey is related to cost. In comparison to paper-based survey, the online survey is relatively cheap and easy to implement (Bachmann, Elfrink, and Vazzana, 1996; Llieva et al., 2002; Yun & Trumbo, 2000).

There are some disadvantages to online survey. Researchers may face sampling problems for online research. For example, researchers may not know about the online communities and the respondents may not be a representative sample for the population. However, for the current study, respondents were selected from companies which were members of an industrial consortium and the job responsibilities of the participants were known in advance. There are some other sampling issues with online surveys. It is difficult to track non-response rates of the respondents, although online surveys are equal or better than postal surveys (Mehta & Sivadas, 1995).

There are **some limitations** of self-selection for online survey (Stanton, 1998; Thompson et al., 2003; Witmer et al., 1999). In any online communities, some members are more interested to reply than others and they are most active in the community. So, the surveys may limit participation to only one group of individuals. However, in the current study, three to four executives were contacted from each company to avoid self-selection biases.

Reaching respondents through emails or internet messages may not be liked by some recipients, as they may find it rude or offensive (Hudson & Bruckman, 2004) or these types of communication may be considered as spam and they may delete them (Andrews et al., 2003). However, in this study, all the respondents were contacted by email and internet messages first and, once they agreed to answer, the link to the survey was sent to them. Also, all the contact details of the researchers were included in the emails such that the respondents knew in advance about the study and they were encouraged to contact the researchers for any concerns about privacy or other related matters.

7.5 Sampling

Sampling is an important component for quantitative data analysis. Churchill and Iacobucci (2002) suggested six important steps for sampling:

- Definition of the target population
- Identification of the sample frame
- Selection of the sample procedure
- Determination of the sample size
- Selection of the sample elements
- Data collection from the sample elements

7.5.1 Target Population

The target population for the sample describes the elements which are considered for data collection. These elements can be individuals, households, businesses etc. The current study is related to industrial companies who are leveraging IIOT for Digital Transformation, so the target population for this study consists of all the companies who are engaged in Digital Transformation leveraging Industrial Internet of Things. There is no specific SIC code for this kind of company. Based on the discussions with executives during the qualitative study and subsequent discussions with industrial business executives, it was decided to use the Industrial Internet Consortium (IIC)[29] membership list (238 companies), the Allseen Alliances membership

[29] http://www.iiconsortium.org/members.htm

list (14 companies), CB Insight IoT startups for IIoT (125 startup companies) and the top 100 IIoT Companies (52 companies were not included in other lists), Index from IoTone[30], as the target population of industrial businesses who are engaged in IIOT. Altogether, 430 companies were included in the target population.

7.5.2 Sample Frame

A sample frame is the list of the elements from which the sample is drawn (Malhotra and Birks, 2003). A target population is general, but a sample frame is specific to a research work. For this study, from the target population of 430 companies, all publicly listed companies with a revenue of $1B or more were selected as a sample frame. The publicly listed companies are selected because the revenue data are publicly available. Since Digital Transformation is resource intensive, companies with $1B or more can allocate proper resources for such transformation. Based on these two criteria, 87 companies were selected as the sample frame (Appendix A7).

7.5.3 Sample Procedure

There are two sampling procedures to select elements from the sample frame: probability samples and non-probability samples (Kinnear, 1991). The probability samples are such that each element has a known and non-zero chance of being included in the sample. (Churchill and Iacobucci 2002). The probabilities of the selection are not equal but known and hence it represents the population. The non-probability samples are based on the personal judgement of the researcher and hence the probability of selecting an element is not known and as a result it cannot be generalized to the target population (Yeager et al., 2011).

[30] http://guide.iotone.com/top-100-iiot-companies

For this study, to reduce any judgmental bias, all elements from the sample frame were selected for analysis, so altogether, 87 companies were selected for analysis.

7.5.4 Sample Size

All the companies in the sample frame were selected for the study. Also, 3 or more respondents were targeted from each company, because Digital Transformation responsibilities are not concentrated on any particular individual within a company and views from different departments and functional areas are important for making any generalization for that company. All respondents were chosen who are senior managers and above in the company and they have direct responsibilities for implementing or supporting Digital Transformation. So, a total of 300 respondents were selected from 87 companies. So, on an average, 3 or more respondents were selected from each company.

7.6 Survey Design

7.6.1 Questionnaire Design

Questionnaire provides a way to capture structured and unstructured data from a respondent in a standardized way either as a part of a structured interview or self-completion (Somekh and Lewin, 2005). The data collected from the respondents are either numerical in nature or they can be represented numerically (ranked in order of preference) such that they can be analyzed statistically. Self-completion questionnaire is most cost effective for the internet and social media age; thus, this is a preferred method of administering a survey. The questionnaire development is iterative and goes through multiple revisions and a lot of time should be devoted to forming proper questions (Sudman and Bradburn, 1982). The researcher has to decide the wording of each question and forms of response (Oppenheim, 2000).

A researcher should put considerable attention into developing clear and non-ambiguous questions and, as suggested by De Vaus (2013), the following guidelines are recommended:

- Jargon or technical terms should be avoided.
- The questions should be short and precise.
- Each single question should not contain more than one questions. So, the word 'and' should be avoided.
- Leading questions are not recommended as it might influence the response.
- There are no right or wrong answers and the respondents should be aware of that.

Questions can be open-ended or closed-ended, however, open-ended questions should be avoided as they take more time to answer and the response rate is lower for mail surveys (Hox and De Leeuw, 1994). The closed-ended questions take less time to answer (Baker et al., 2003). There are multiple answer scales available to answer closed-ended questions. Kinnear (1991) suggests four types of scales: nominal, ordinal, interval and ratio scale.
In the nominal scale, the cases are classified by numbers, though numbers do not have any significance and are used for counting the cases, not indicating one is greater than others (Churchill et al., 2001).

An ordinal scale assigns orders to the objects or events. For example, in an ordinal scale, the scale could be '1 = Always', '2 = Sometimes' and '3 = Never' which is a kind of order, but for a researcher it is difficult to figure out whether difference between 1 & 2 and 2 & 3 are the same or different. There is no meaning to the gaps between the numbers (Lee and Lings, 2008).

The interval scale ranks the objects or events. Unlike ordinal scale, there is equality of difference between the alternatives. In this scale, the quantitative variable has fixed distance but not fixed origin. For examples, temperature can be interval scale, but it can be in Celsius and Fahrenheit scale. So, in a Fahrenheit scale, the difference between 10 degrees and 15 degrees, is the same as between 15 degrees and 20 degrees, but the origin can change.

The ratio scale is a special case of interval scale where distances are measured from rational zero rather than with respect to mean or other measures (Nunnaly, 1967). The measurement of distance is a ratio scale.

Likert scale is the most commonly used scale for survey questionnaire. This scale captures the intensity of the respondents' feelings for different items. The respondents specify their level of agreement and disagreement on a symmetric agree-disagree scale for a set of questions from the survey. Likert scale is a type of interval scale (Kinnear, 1991).

Most of the items in the questionnaire were measured using a 7-point Likert scale. The respondents were asked to select their agreements and disagreements with statements on a 7-point scale, with '1= Strongly Disagree' to '7 = Strongly Agree'. Though 7-point scale is more popular with researchers, some authors have used 5-point scale (Malhotra, 2006) and others suggest a 9-point Likert scale for detailed analysis (Roy Morgan Research, 1993).

For this study, 7-point Likert scale was selected for majority of the questions (Appendix – A8). Out of 25 questions, 18 questions use Likert scale. 7 questions about the company are open-ended questions. After the questions were finalized, the sequences of the questions were decided.

The logical flow of the questions is important such that the respondents can understand the questions clearly (Sudman and Bradburn, 1982).

7.6.2 Constructs Measurements and Measures

The digital transformative capabilities and Digital Transformation for industrial businesses are new concepts and relevant academic studies are not readily available. So, some of the measurements of the constructs were developed using Digital Transformation-related articles, discussions available in industrial businesses, and industry forums (IIC, World Economic Forum etc.). The measurements related to environmental constructs are available in the academic literature and they were included. Some of the constructs were developed from the discussions during the qualitative study. The details of the measurements are discussed in the following sections.

7.6.2.1 Digital Twin

Digital Twin is the digital representation of the business systems (including assets/machines, processes, systems etc.) which help not only to optimize the business processes but also to develop new products and services which were not possible earlier.

Most of the measures (6 out of 8) for Digital Twin were derived from business journals and 2 measures were derived from the interviews for the qualitative study. Digital Thread concepts came from the United States Air Force, as they were planning to build the next generation US Weapon system in a more modular approach based on their learning from manufacturing and installation of earlier weapon systems. The concepts developed in the US military are being utilized in commercial businesses. Conard Leiva, a product strategist, explained the concepts in the article "Demystifying the Digital Thread and Digital Twin concepts"[31]. He explained the terminologies and how these could influence Digital Transformation. Gartner[32] has developed a strategy document, 'Exploiting Digital Twins to drive ecosystem strategies', which describes the business use cases for Digital Twin and how they can affect the business.

Table 13 : Digital Twin Measures

Measures	**Sources**
Using Digital Twin, we build a bridge between the physical and digital world	West and Blackburn, 2017.
Using Digital Twin, we simulate the actual production environment Using Digital Twin, we detect production shortcomings in advance Using Digital Twin, we design new products with complex requirements	Conard, Leiva, Industry Week, Aug. 2016; Gartner, March 2018
Using Digital Twin, we build better quality products Using Digital Twin, we run/operate new products with greater efficiency Using Digital Twin, we receive early warning of system failures	Conard, Leiva, Industry Week, Aug. 2016; Gartner, March 2018

[31] https://www.industryweek.com/systems-integration/demystifying-digital-thread-and-digital-twin-concepts

[32] https://www.gartner.com/doc/3865372/exploiting-digital-twins-drive-ecosystem

Using Digital Twin, we build new products	Qualitative study
Using Digital Twin, we foresee the business outcomes of our decisions	

7.6.2.2 Digital Thread

Digital Thread is a framework to collect data from the initial stages of assets, including design, fabrication, and manufacturing to actual usage of the assets in the real world. It is the manufacturing health record of the assets which accelerate digital manufacturing.

Out of 8 measures, 6 were derived from business journals, US military articles and industry experts. 2 measures were derived from qualitative study interviews. Other than the discussions mentioned in Digital Twin, the McKinsey article "Digital Manufacturing: The revolution will be virtualized" (Hartman et al., 2015) discusses some of the key elements of Digital Thread and some measures were derived from that discussion. One measure was derived from the GE CIO's discussion about advanced manufacturing[33].

Table 14 : Digital Thread Measures

Measures	**Sources**
By mining data, our engineers are gaining new insights into our assets By mining data, our engineers are improving the reliability of our assets	Hartman, King, Narayanan, (McKinsey, August, 2015)

[33] http://presentations.canontradeshows.com/events/orlando/2015/industry-4-0-sessions/download/3203

By using digital technologies, we are improving distribution of our products to our customers By using digital technologies, we are integrating our supply chain networks with our customers and partners	West, and Blackburn, 2017. Conard, Leiva, Industry Week, Aug. 2016; Gartner, March 2018
We are using more digital technologies in our manufacturing processes	Qualitative Study
We integrate our Information Technology (IT) data with Operational Technology (OT) data to accelerate Digital Transformation	Qualitative Study
We maintain manufacturing health records (from design, sourcing, and production to distribution, point of sale and use) to optimize digital manufacturing	GE Digital Transformation, Jim Beilstein – CIO Advanced Manufacturing

7.6.2.3 Digital Mindset

The managers need to have digital mindset such that they can foster Digital Transformation. This is a cognitive behavioural capability of IIoT managers. 6 out of 7 measures for Digital Mindset were derived from the article, “The 5 Keys to A Digital Mindset” (Kaganer et al., 2014) and 1 measure was adopted from the interviews conducted for the qualitative study.

Table 15 : Digital Mindset Measures

Measures	Sources
The managers in our firm have a clear vision for Digital Transformation The managers in our firm empower employees to implement digital strategies The managers in our firm encourage employees to make decisions for Digital Transformation The managers in our firm make decisions based on information for Digital Transformation	Kaganer, Sieber, Zamora, 2014
The managers in our firm make decisions based on experience for Digital Transformation	
The managers in our firm encourage experimentation by our employees for Digital Transformation	
The managers in our firm try out different technological and process options before deciding on particular options for Digital Transformation	Qualitative Study

7.6.2.4 Digital Transformative Capability (DTC)

DTC is the ability of a firm to systematically identify and coordinate digital changes/digitization of the core business routines. As per World Economic Forum Report (WEF 2018), a firm needs capabilities in three key areas for Digital Transformation: Digital Business Models (what companies need to do), Digital Operating Models (how to do it) and Digital Talent and Skills (what skills they have for success).

All the measures for business model transformation were adopted from Neely (2008). The measures for operating model transformation were adopted from the World Economic Forum Report (WEF 2018). DTC – Cultural Transformation measures were adopted from 3 different sources: 1 out of the 5 measures was adopted from Colbert et al. (2016), 2 measures were adopted from Bhattacharya et al. (2005) and the remaining 2 measures were derived from Deloitte's article on the digital workplace[34].

Table 16 : Business Model Transformation Measures

Measures	**Sources**
We are changing our marketing activities from transactional to relational marketing We are changing our sales activities from selling multi-million-dollar products to selling services capabilities We are educating our customers from owning products to seeking	Neely, 2008

[34] https://www2.deloitte.com/content/dam/Deloitte/mx/Documents/human-capital/The_digital_workplace.pdf

service We are extending the timescale of our customer engagements by managing and delivering multi-year partnerships We are extending the timescale of our customer engagements by managing and delivering multi-year partnerships. We are extending the timescale of our customer engagement by modeling and understanding of cost and profit implications of long-term partnerships. We are changing our customer offerings by understanding what value means to them We are changing our customer offerings by delivering services rather than products We are promoting an organizational culture such that our employees have high concern for servicing customers	

Table 17 : Operating Model Transformation Measures

Measures	**Sources**
We are looking for business opportunities beyond our industry that are possible by Digital Transformation	World Economic Forum Report (WEF 2018)

We are experimenting with our ideas and launching them faster for transforming our business We are developing strategic relationships with our partners to augment our capabilities for Digital Transformation We are gaining full support from our top executives for Digital Transformation We are implementing digital traction metrics (such as number of unique users/active users, customer retention rate, abandon rate) to measure the performance of our digital business	

Table 18 : Cultural Transformation Measures

Measures	**Sources**
Our employees bring a high level of digital fluency to the workforce	Colbert et al. (2016).
Our employees can be utilized in many kinds of jobs since they have multiple skills	Bhattacharya et al. (2005)
Our employees are flexible and willing to change their working habits in response to external influences	
We are creating an open collaborative environment powered by digital collaboration tools such that employees can participate in decision making processes	Deloitte, Digital Workplace: Think, Share, Do. Transform Your Employee
We have created a digital workplace such that our employees can	

collaborate, communicate and connect with each other	Experience

7.6.2.5 Market Turbulence

Environmental dynamism is caused by turbulence in firms' external environment and it includes market and Technology Turbulence which influence DTC. The measures for market turbulence were adopted from different academic articles as mentioned in the table below.

Table 19 : Market Turbulence Measures

Measures	**Sources**
The market activities of our competitors are not predictable	Miller et al. (1980)
The rate of innovations of new operating processes in our industry has increased drastically	Drnevich et al. (2011)
The rate of innovations of new products and services in our industry has increased drastically	
The market activities of our key competitors now affect us in more ways than before	
We are witnessing demand from a totally new group of customers who did not previously buy our products/services	Destan et al. (2006)
New customers have producto-related needs that are very different from our existing customers	Jaworski et al. (1993)

Environmental demands on us are constantly changing	Schilke (2014)
Environmental changes in our industry are unpredictable	

7.6.2.6 Technology Turbulence

The measures were adopted from academic articles and these are listed in table below. The word "Digital Business" was added for each measure.

Table 20 : Technology Turbulence Measures

Measures	**Sources**
Technology in our digital business is changing rapidly	Pavlou, El Sawy, 2011
Technology breakthroughs provide substantial opportunities in our digital business	Jaworski, Kohli, 1993
A large number of new product ideas have been made possible through technological breakthroughs in our digital business	
The rate of product/service obsolescence in the digital business is very high	Destan, Yaprak, Cavusgil, 2006.
In digital business, our production and service technologies change often and in major ways	

7.6.2.7 Competitor Turbulence

The competitors in the market are changing rapidly and new competitors are entering the market. Competitor turbulence influences DTC. 3 out of 5 measures for competitor turbulence were adopted from academic articles and 2 were adopted based on the interviews conducted for the qualitative study.

Table 21 : Competitor Turbulence Measures

Measures	**Sources**
We encounter new competitors all the time	Danneels, and Sethi, 2011
Competitors change their strategy constantly	
Our competitors are not the same as in previous years	Jaworski, Kohli, 1993
Our customers have competing assets and capabilities	Qualitative Study
Our partners have competing assets and capabilities	

7.6.2.8 Ecosystem Partnership

Strategic partnership is very important to deliver end-to-end solutions for the customers who are going through Digital Transformation by leveraging IIoT. It also helps a firm to fill the gaps either in technology or in commercial areas and has strong influence on DTC. 7 out of 9 measures were adopted from Schilke (2014). The phrase “R&D” was dropped from the measures and another 2 measures were adopted from the interviews conducted for the qualitative study.

Table 22 : Ecosystem Partnership Measures

Measures	**Sources**
Our activities with alliance partners are well coordinated	Schilke (2014) Note: R&D words are dropped
There is a great deal of interaction with our alliance partners in most decisions	
We ensure an appropriate coordination among the activities of our different alliances	
We determine the area of synergy in our alliance portfolio	
We ensure that interdependencies between our alliances are identified	
We have the managerial competence to absorb knowledge from our alliance partners	
We can successfully integrate our existing knowledge with new information acquired from our alliance partners	
Collaboration among ecosystem partners is a key success factor for IIoT	Qualitative Study
Interfirm collaboration is helping us to create specific intellectual property	

7.6.2.9 Customer and Market Demands

There should be demand in the market for products/services for IIoT and the customers are either using those products and/or services or plan to use them in the next couple of years. These demands will accelerate Digital Transformation. All of the measures for this construct were adopted from the interviews for the qualitative study.

Table 23 : Customer and Market Demands Measures

Measures	**Sources**
We have significant demands from our customers for IIoT solutions	Qualitative Study
We are delivering a significant number of IIoT-based products and services in the next year	
Our competitors are delivering a significant number of IIoT-based products and services this year	
Some of our customers have implemented IIoT solutions	
Some of our customers have plans to use IIoT solution in the next year	

7.6.2.10 Organizational Process (Path Dependency)

A firm would like to maintain its current path as its past investment and routine constrain the firm in its future behaviour (Teece, Pisano, Shuen, 1997). The organizational process affects the

Digital Transformation process. All of the measures for this construct were adopted from the interviews for the qualitative study.

Table 24 : Path Dependency Measures

Measures	Sources
We hold on to our current businesses which were profitable in the past	Qualitative Study
We seldom give discounts to our customers to move from our old products and services to new products and services	
Our biggest challenge is to move from our existing systems to the new and improved systems	
We seldom help our customers to move them from the old business models (e.g. licensing) to the new business models (e.g. cloud)	
We like to maintain strong relationships with our current partners and occasionally look for new partners	

7.6.2.11 Digital Commitment

The firm should have strategic focus and intent for Digital Transformation. This should be a priority of the firm. We need to differentiate between digitization and digitalization. Digitization is the process of digitizing the original documents in digital form. It is simply converting non-digital entities (e.g. health records, location data, identity cards) into digital format. Digitization also means automating sales, manufacturing, customer support processes. However, digitalization or Digital Transformation includes digitization and new ways of doing business. It is improving and transforming critical business operations and/or business routines and/or business models of the firm.[35] All of the measures for this construct were adopted from the interviews for the qualitative study.

Table 25 : Digital Commitment Measures

Measures	**Sources**
Most of our business processes (generating leads, sales information, manufacturing information etc.) are digitized	Qualitative Study
Most of our business routines (new product development, after sales support, manufacturing execution system etc.) are digitized	
Our senior executives are committed to Digital Transformation	
We have developed digital strategies for the next 3 years	
We are implementing digital strategies for our groups/businesses	
We have formed strategic partnerships for Digital Transformation	

[35] https://www.i-scoop.eu/digitization-digitalization-digital-transformation-disruption/

7.6.2.12 Resource Scarcity and Constraints

Digital Transformation for industrial business is incumbent on high availability of resources (human and financial resources) for a longer duration of time. Any scarcity of resources will have significant impact on the transformation process. Out of 5 measures, 2 are adapted from Mahoney and Pandian (1992) and the other 3 measures are adapted from the interviews for the qualitative study.

Table 26 : Resource Scarcity and Constraints Measures

Measures	**Sources**
We face a shortage of skilled personnel (proper software and domain knowledge) for implementing digital strategies in our organization	Mahoney et al. (1992)
We face a shortage of financial resources for implementing digital strategies in our organization	
We face a shortage of managerial capacity for implementing digital strategies in our organization	Qualitative Study
The shortage of resources is delaying our digital projects	
We understand that Digital Transformation projects are resource intensive and multi-year projects	

7.6.2.13 Digital Transformation

There is no direct measure for Digital Transformation and regular financial and market measures, like growth in revenue or market share, may not be applicable as the Digital Transformation is relatively new and these measures may not reflect the transformation. Instead of that, critical dynamic capabilities which accelerate Digital Transformation are considered as the measures.

Three different measures are considered: **importance of dynamic capabilities within the organization**, **improvements of capabilities in the last three years**, and **comparison of capabilities with respect to competitors.**

Table 27 : Digital Transformation Measures

Measures	Sources
New Product Development	McKelvie & Davidsson, 2009 Pavlou and El Sawy, 2006 Schilke, 2014
Product Innovation	Cheng and Chen, 2013, Garcia-Morales et al., 2012, Cai & Tylecote, 2008.
Service Innovation	
Sensing about opportunities/market/competitors	Chen and Lien 2013, Chen et al., 2009, Lee et al., 2010
Learning & knowledge management	Lee et al., 2010, Kale et al., 2000, Chang et al., 2015, Garcia-Morales et al., 2012
Integration	Wu, 2006, 2007, 2010, Pavlou, El Sawy, 2011, Huang et al., 2012
Coordination	

Exploration (for new products/services)	Chen and Lien, 2013, Lee et al., 2010, Li and Liu, 2014
Exploitation (of existing products and services)	Bhattacharya et al., 2005, Cai & Tylecote, 2008, Garcia-Morales et al., 2012
Strategic flexibility	Gnizy et al., 2014, Li and Liu, 2014
Market responsiveness	Griffith et al., 2006
Alliance management	Schilke, 2014 Schilke & Goerzen, 2010, Kale & Singh, 2007
Research and Development	Cai & Tylecote, 2008, Ettlie and Pavlou 2006, Danneels 2011

7.6.2.14 Information about the company

Three open-ended questions were included in the questionnaire regarding the information about the company. Based on the information and the respondent's email, the firm size and firm revenue were determined. The scales for these measures are included in Appendix A-8.

7.6.2.15 Information about the respondents

Three open-ended measures and one closed-ended measure were included in the questionnaire regarding the information about the respondents. For the statement, "I have adequate knowledge answering the questions in this survey", if the answer was "strongly disagree or disagree", then that respondent was not included in the study. For the statement"The questions in this survey are relevant to my organization", if the answer was "strongly disagree or disagree", then that respondent was not included in the study. Altogether, 4 out of 107 respondents were eliminated by this process.

7.6.3 Measurement Errors

Measurement errors occur when observed values are not representative of the true values for the research study (Hair et al., 2008). There are four types of errors for a survey research: construct errors, survey instrument errors, data analysis errors and method errors (Dunn, 2009).

Construct development errors occur from the ambiguity of the variables/measures for a particular construct (Podsakoff et al., 2003). To mitigate this error, measures were selected from relevant business journals, industry journals, academic journals or from the interviews of the qualitative study. It should be noted that some of the constructs are relatively new and therefore relevant academic research articles are not available; also, to minimize the construct development errors, the measures are adopted from business journals or from industry forum articles.

Survey instrument errors occur when the items in the survey are misinterpreted (Collins, 2003). During pre-testing and pilot testing, these items were identified and either they were dropped, or proper explanations were added to the questionnaire. For example, Digital Twin and Digital Thread constructs were more suitable for the manufacturing industry and some of the respondents from the software companies were confused. So, to mitigate this issue, proper explanations were added to the questions with ‘More Info’ tabs. Also, in the question headers in each page, the sentence “please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses” were added for clarity.

Data analysis errors occur if inappropriate analytical procedures are selected for analysis (Hair et al., 2008). For the current study, Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis (PCA) with Varimax rotation method to analyse the inter-relationships between the variables such that these variables form a common dimension (Ringim et al., 2012). After determining the constructs from the measures, multiple regression analysis using SPSS was conducted to test the hypothesis. The details of PCA and Regression Analysis are described in the subsequent paragraphs.

Common Method Variance (CMV) error is one of the serious errors in survey methods. CMV error refers to the amount of false covariance shared among variables due to the common method used for data collection (William, Cote and Buckley, 1989). And, in this case, the actual phenomenon under investigation cannot be differentiated from measurements (Hufnagel and Conca, 1994).

Self-report surveys are most common in management research, where the same respondents answer the items in a single questionnaire at the same point in time, which may lead to CMV error (Kemery and Dunlap, 1986, Lindell and Whitney, 2001). In order to minimize the effect of CMV, it is suggested to obtain multiple measures from different respondents at different points in time (Podsakoff and Organ, 1986). In the current study, the data were collected from multiple respondents from a company at multiple points in time.

Harman's single-factor test is the most widely known approach for assessing CMV in a single-factor test (Podsakoff et al., 2003). In this test, all items in a study are subject to EFA then CMV is assumed if: (i) single factor emerged from un-rotated factor solutions, or (ii) a first factor explains the majority of variance in the variables (Podasakoff and Organ, 1986).

7.7 Pre-Testing

Before conducting the main survey, a pre-testing of the survey was performed to take care of problems with wording, clarity, and any measurement issues which might affect the survey (Churchill and Iacobucci, 2002). The pre-testing consists of two steps: protocols/debriefing and pilot testing (Aaker and Day, 1990). Both steps were followed for the current study.

7.7.1 Protocols and Debriefing

The protocol analysis is a process by which the researcher interviews respondents with the questionnaire and asks the respondents to think out loud and provide feedback about the wording of the questions, ordering of the questions, clarity of the measurements and any other feedback necessary to enhance the questionnaire (Diamantopoulos, Reynolds and Schlegelmilch, 1994).
The debriefing is similar to protocol testing, but it is conducted after the respondents answer the questions. The purpose of this phase is to understand any difficulties the respondents face in answering the questions. This helps the researcher to develop more clarity for any question(s) and ambiguity can be reduced (Diamantopoulos, Reynolds and Schlegelmilch, 1994).

For the study, four respondents were selected for protocols and debriefing. Two respondents were technical writers at GE Digital, one respondent was a Product Manager at GE Digital and the fourth respondent was an academic. Technical writers at GE Digital deal with complex technology terminologies and documentation for Digital Transformation and they were familiar with Digital Transformation and Industrial Internet. The product manager at GE Digital was responsible for the analytics platform and was an Industrial Internet evangelist for GE. The protocol pre-testing and debriefing was conducted for an hour for each respondent and these were conducted in person at the GE Digital office.

7.7.2 First Questionnaire Revision

All respondents expressed concerns about the length of the questionnaire, which had 26 questions. So, all of them were worried whether any respondent could answer these questions in 30 minutes or so. To answer all questions in 30 minutes, the number of questions was reduced to 20. Some of the definitions of the constructs were not clear and those were changed after discussion with the respondents. These questions are explained in the next paragraphs.

Digital Twin (Old Definition): This is the digital representation of business systems (including assets/machines, processes, systems etc.) that helps not only to optimize businesses processes but also to develop new products and services that were not possible earlier.

Digital Twin (New Definition): This is the digital representation of business systems (including assets/machines, processes, systems etc.) that helps to optimize businesses processes and develop new products and services that were not possible earlier.

Digital Thread (Old Definition): This is a framework to collect data from the initial stages of assets, including design, fabrication, and manufacturing to actual usage of the assets in the real world. It is the manufacturing health record of the assets which accelerates digital manufacturing. “Initial stages” was not clear to a respondent.

Digital Thread (New Definition): This is a framework to collect data from the different stages of assets, including design, fabrication, and manufacturing to actual usage of the assets in the real world. It is the manufacturing health record of the assets which accelerates digital manufacturing.

Digital Mindset (Old Definition): This is a cognitive behavioural capability of IIoT managers and they could achieve this through learning and experience. The managers need to have a digital mindset such that they can foster Digital Transformation.

Digital Mindset (New Definition): This is a cognitive behavioural capability of IIoT managers and is achieved through learning and experience. The managers need to have a digital mindset such that they can foster Digital Transformation.

Digital Transformative Capability (DTC): The structure of the question for DTC – Business Model Transformation was not clear, and it was changed as follows:

Old Question:

We are changing our business model from a traditional to a digital business model.

By changing the mindset –

- of Marketing: from transactional to relational marketing
- of Sales: from selling multi-million-dollar products to selling capabilities
- of Customers: from wanting to own the products to being happy with the service

Note: The format and the layout were confusing.

New Question:

We are changing our business model from a traditional to a digital business model.

- We are changing the mindset of marketing: from transactional to relational marketing.
- We are changing the mindset of sales: from selling multi-million-dollar products to selling capabilities.
- We are changing the mindset of customers: from wanting to own the products to being happy with the service.

Two other questions related to DTC – Business Model Transformation: customer engagements and customer offerings were changed in a similar fashion. The formats of the questions for DTC – Operating Model Transformation and DTC – Cultural Transfoemation were changed similarly. After the questionnaire was revised, the pilot study was conducted.

7.7.3 Pilot Study

The pilot study was conducted with the first revision such that any other concerns and ambiguities could be reduced. The pilot study was conducted with a group of respondents who were actively involved in Digital Transformation at their respective organizations and some of them also participated in the qualitative study. Altogether, 15 participants were contacted.

1) All participants were contacted by email (Appendix A-5) and the link of the study was included in the emails. They were requested to answer the questions at their convenience. The confidentiality of the information provided by them was noted in the emails.
2) All of them were contacted again by email after 1 week.
3) One week after that, i.e. two weeks after the initial contact, all participants were contacted by phone to answer the survey.

From the 15 participants, 10 responded to the survey, so the response rate was 67%. This was a high response rate and it could be achieved because 12 out of 15 participants participated in the qualitative study and they were interested to help in the survey. All 10 respondents were contacted for debriefing and all of them participated in a 45 minute debrief session.

7.7.4 Second Questionnaire Revision

Based on the pilot study and subsequent debriefing, the questionnaire was revised again.

1) Initially it was estimated that the respondent could answer all questions in 30 minutes, however respondents reported that if the description of the questions was shortened, they could complete the questions in less time (20 minutes to 30 minutes). So, a "More Info" tab was introduced, and the description of the questions was shortened. Since most of the respondents were familiar with terminologies, they might not look into "More Info" tabs for each question.

2) Some of the respondents in the pilot study mentioned that the first two constructs, "Digital Twin" and "Digital Thread" are related to the manufacturing industry, and since they worked for software companies, they were not sure how to reply to these questions. Based on discussions with the respondents, the following items were added to all the pages of the questionnaire:

   "Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses."

   The following comments were added on the first page:

   "The first two questions, Digital Twin and Digital Thread, are not only related to the manufacturing industry, but applicable for all other industries. There are two digitalization processes for Digital Transformation".

3) All the questions were made mandatory, such that respondents could not skip any particular questions. This was conveyed by email during the pilot study, but it was revised and the mandatory function of the survey tool was used.
4) A preliminary Principal Component Analysis (PCA) was performed using the SPSS data analysis package. This was performed just to get a first look at the constructs and not for drawing any inferences.
5) Based on PCA and debriefs with the pilot survey respondents, the following measures were modified or deleted.
    - The measure for Digital Twin, “using Digital Twin we can detect shortages in the early design stages” was deleted due to low factor loading (less than 0.4).
    - The measure for Digital Twin “using Digital Twin we can build new products with better quality” was broken into two measures for clarity and these measures are: (i) “using Digital Twin we build new products” and (ii) using Digital Twin we build better quality products”.
    - The measure for DTC – Operating Model Transformation, “we are collecting a vast amount of data to look for ways to monetize it” was deleted due to low factor loading (less than 0.4).
    - The measure for DTC – Operating Model Transformation, “we are organizing digital boot camps to re-skill our employees” was deleted due to low factor loading (less than 0.4).
    - The measure for Environmental Dynamism, “the market activities of our key competitors are more competitive” was deleted for low factor loading ((less than 0.4).

- The measure for Ecosystem Partnership, “we have the capability to learn from our alliance partners” was deleted as other measures have covered this factor.
- The measure for Digital Commitment, “we coordinate with other groups/businesses for Digital Transformation”, was deleted as this was not a clear measure and confused the respondents.
- The measures “product and services innovation” were broken into two measures: (i) product innovation and (ii) services innovation for all three dynamic capability constructs.

7.7.5 Main Survey

After revising the questionnaire for the second time, it was finalized for the main survey (Appendix – A8). It contained 20 questions. The respondents were expected to complete the survey in 20 to 30 minutes. To reduce survey fatigue, the respondents were advised to finish the survey in multiple sittings by saving the responses and coming back to the questionnaire where they left off.

The link of the survey was sent by email to 300 participants from 87 companies (Appendix A-7). The final survey was hosted at Loughborough University supported by a survey administrator site (https://admin.onlinesurveys.ac.uk/account/lboro/home/). A copy of the email is included in the Appendix A-5. The participants were also reminded by messages from Linkedin.com on a regular basis (Appendix A-6). The reminder emails were sent at two-week intervals. The survey was started in September 2017 and 97 responses were received by January 2018. Altogether there were 97 + 10 (from the pilot survey) = 107 respondents for the survey.

7.7.6 Response Rate

The response rate for the survey was 107/300 = 36%. This is an acceptable response rate based on the survey length and seniorities of the respondents (Dilman, 2007). The response rate for a survey with top managers as respondents is typically around 15% to 20% (Menon, Bharadwaj, Adidam and Edison, 1999). According to Cavana, Delahaye and Sekaran (2006), 30% response rate is acceptable for surveys. Hair et al. (2008) suggested that for regression analysis, the sample size should be between 5 to 10 times per independent variable, so for the current study with 9 independent variables, the respondents should be 90 or more. Hence, the figure of 107 respondents was adequate for the regression analysis.

7.8 Analytical Procedure

Two-stage analytical procedures were conducted to test the hypotheses for this study. Exploratory Factor Analysis was conducted, and the number of measures was reduced. In the second stage, multiple linear regressions were performed. In both of these cases, the SPSS statistical package was used.

7.8.1 Exploratory Factor Analysis

To understand the underlying structures within the items, Exploratory Factor Analysis (EFA) was conducted before analysing the model further (Hair et al., 2008). EFA uses inter-item correlations to determine the underlying latent variables (factors) which are responsible for the pattern of correlations observed in the data (Sharma and Sharma, 1996). In factor analysis, the variables are grouped together based on their variances. The total variance has three components: common variance (variance shared with other variables), specific variance (variance observed in specific variables) and error variance (variance which cannot be explained by correlations with other variables). Exploratory Factor Analysis deals with common variance. The higher the correlations of one item with other items, the higher the common variance or communality of that item (Hair et al., 2008). As per the guidelines from researchers (Coakes & Steed, 2003., Hair et al., 2010), a minimum of five subjects per variable are needed for factor analysis. In the current study, five or more subjects per variable were considered for factor analysis.

There are two types of EFA: (i) common factor analysis (the least number of factors that account for the common variance), and (ii) principal component analysis (PCA is to identify the number of factors explaining the total variance) (Gorsuch, 1997). The researcher conducts common factor analysis when he/she wants to eliminate specific and error variance due to little knowledge about it and PCA is conducted when the primary reason for such analysis is data reduction and the researcher has prior knowledge that the amount of specific and error variance is low (Diamantopoulos and Schlegelmilch, 2000). PCA is widely used and it is the default factor analysis in SPSS and other statistical packages. The steps in PCA are as follows.

7.8.1.1 Factor determination

The first step is to determine the principal components (factors). If the items do not correlate with one another, it will not fall into clusters and the eigenvalues will be equal to 1, which indicates the variance in the original items. When eigenvalues are more than 1, then the items will cluster into factors that contain more variance of the items (Widaman, 1993).

The factors with eigenvalues more than 1 are selected. In case the eigenvalue is less than 1, then that factor does not explain the variance in the items and is not significant. If items are perfectly correlated, only 1 factor is formed (Spector, 1992). Another way to determine the number of factors is to draw a Cattell Scree plot (Cattell, 1966), where eigenvalues are plotted in a decreasing order on the Y axis and items are plotted on the X axis. The drop ceases of the curve and it makes an elbow. The selection of the elbow is subjective.

7.8.1.2 Rotation

The factors in EFA are rotated for better interpretability (Field, 2009). There are two types of rotation: orthogonal (e.g. Varimax) and oblique (Oblimin). Orthogonal rotation is used when it is assumed that the factors do not correlate to one another and are kept at 90-degree angles. The SPSS allows different types of rotations (SPPS user manual)[36]:

- Varimax: An orthogonal rotation method that minimizes the number of variables that have high loading on each factor. This method simplifies the interpretations of factors.
- Quartimax: Minimizes the number of factors needed to explain each variable. This method simplifies the interpretations of observed variables.
- Equamax: A combination of Varimax and Quartimax.
- Direct Oblimin method: This is a non-orthogonal rotation method and determines the obliqueness of the factors.
- Promax: Also a non-orthogonal rotation method, which allows factors to be correlated. This is a useful method for a large dataset.

The Varimax rotation is the most common form of orthogonal rotation in PCA or factor analysis (Jackson, 2005) and was used for the current study (chapter 7).

[36] http://www-01.ibm.com/support/docview.wss?uid=swg27047033

7.8.1.3 Factor loading

Another important element of EFA is factor loading. The loading indicates the correlation of an item with the factor and the squared loading is the amount of total variance of the variable, which is explained by the factor. For example, 0.60 loading means 60% of the variance is accounted by the factor. A loading of 0.40 is the minimum acceptable loading for an item and a loading of 0.70 or more is considered as being a well-defined factor (Hair et al., 2008).

7.8.1.4 Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO)

Two other statistical tests are important for determining the appropriateness of the results. These are Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO). Bartlett's test of sphericity is a statistical test, which indicates whether the correlation matrix is an identity matrix. If it is an identity matrix then the structure is not suitable for factor analysis. A small significance level (less than 0.05) indicates that the factor analysis will be useful. The KMO is a statistic which indicates the proportion of the variance in the variable that might be caused by underlying factors. A high value, closer to 1.0, indicates that the factor analysis is useful for the data. A value of 0.6 or higher is acceptable for factor analysis (Hair et al., 2008).

7.8.1.5 Reliability analysis

After EFA is performed, the reliability of the factors should be checked, as there might be some degree of error in the measurements. The reliability is assessed using Cronbach's α coefficient (Cortina, 1993). The α is a ratio of the sum of covariance of the components of the items, to the sum of all elements in the variance-covariance matrix of measures (observed variance). It should be 0.7 or more (Nunnally, 1978). Other than α value, the item-to-total, inter-item correlations and the value of α, when the item is deleted should be checked. As a general rule, the item-to-total correlation should be 0.5 or more and the inter-item correlation should be 0.3 or more (Hair et al., 2008). The value of α, when the item is deleted shows the increase or decrease of reliability scale based on the items.

7.8.2 Multiple linear regression

The multiple linear regression estimates the coefficient of linear equation involving two or more independent variables, which predicts the value of the dependent variable. It helps in determining the overall fit (variance explained) of the model and the relative contribution of each of the predictors to the total variance explained. The multiple regression was carried out using SPSS statistical tool (IBM SPSS Statistics Base 24).

7.8.2.1 Linear regression statistics

The following statistics were selected for the regression model:

- **Regression Coefficient:**
  - Estimates: This displays the regression coefficient *B,* standard error of *B*, standardized coefficient beta, t value for *B* and two-tailed significance level of t.
  - Confidence Intervals: This displays the confidence intervals with the specified level of confidence for each coefficient or a covariance matrix.
- **Model Fit:**

  The goodness of fit of a linear regression model indicates how it will fit with the given set of data or how it will predict the future set of observations. The variables entered and removed from the model are displayed and following statistics are displayed:

  - Multiple variance R
  - A global measure of “variance explained”, R^2

  - A global measure of "variance explained" that is adjusted for the number of parameters in the model, adjusted R^2
  - Standard error of the estimate
  - Analysis of variance table (ANOVA)

- **Collinearity diagnostics**

Collinearity or Multi-Collinearity is an undesirable situation when one independent variable is the linear function of other independent variables. There are two ways to check multicollinearity in SPSS: through tolerance and Variance inflation factor (VIF). The VIF value should be less than 3 and any value above that shows multicollinearity within independent variables.

7.8.2.2 Linear regression options

In SPSS, the following options are available for linear regression:

- **Stepping Method Criteria:** This method is applied when forward, backward or step-wise variable selection method has been specified in linear regression analysis. Variables can be entered or removed from the model based on the significance (probability) of F or the value of F itself.
- **Use probability of F:** A variable is entered into the model if the significance level of the F value is less than the entry value and removed if the significance level of the F value is greater than the entry value. By default, the significance level of F value is set to 0.05 for entry level and 0.10 for removal level. **This is the default choice, and this was used in the study.**

- **Use of F value:** A variable is entered into the model if the F value is less than the entry value and removed if the F value is greater than the entry value.

Include constant in equation: By default, the regression analysis uses a constant term. Deselecting this option will force the regression through the origin and it is rarely done. If the regression is forced through the origin, then R^2 cannot be interpreted in the current form.

Missing values: Three choices are available:

- **Exclude cases listwise:** Only cases with valid values for all variables are included in the analysis. **This choice was selected in the study.**
- **Exclude case pairwise:** Cases with complete data of the pair of variables being correlated are used to compute the correlation coefficients.
- **Replace with mean:** All cases are used for computations and missing values are substituted by the mean of the variable.

7.8.2.3 Linear Regression Output[37]

The relevant outputs of the linear regression model are described in this section. The detailed discussion of the study is included in chapter 7.

Variables in the model

Model: SPSS allows specifying multiple models in a single regression command and it lists the number of models being reported.

[37] SPSS annotated output regression analysis - https://stats.idre.ucla.edu/spss/output/regression-analysis/

Variables Entered: SPSS allows the researcher to enter variables in the regression models in blocks and allows stepwise regression. Hence it indicates which variables are entered in the regression model.

Variables Removed: This column lists all the variables removed from the regression analysis. If stepwise regression is not performed, this column will be empty.

Method: This column indicates the method used for the regression. “Enter” means that each independent variable was entered in its usual way.

Overall Model Fit: Model Summary

Model: SPSS allows specifying multiple models in a single regression command and it lists the number of models being reported.

R: R statistics is square root of R^2 and it is the correlation between observed and predicted values of the dependent variable.

R^2: The proportion of variance in the dependent variable, which can be explained by the independent variables. This is the overall measure of the strength of the association and does not reflect the association of any particular independent variable(s) with the dependent variable.

Adjusted R^2: R^2 value is adjusted for the number of predictors in the model.

Standard error of estimates: This is also referred as root mean squared error. It is the standard deviation of the error term and square root of the mean squared of the residuals term in the equation.

ANOVA Table:

Model: SPSS allows specification of multiple models in a single regression command and it lists the number of models being reported.

Regression/Residual/Total: The breakdown of the variance in the outcome variable is depicted by these categories. The Total variance is partitioned by the variance which can be explained by independent variables (Regression) and some variance cannot be explained by the independent variables (Residual).

Sum of squares: These are the sum of square associated with 3 sources of variance, including Total, Regression and Residual.

df: The degree of freedom associated with the sources of variance.

Mean Square: This is the sum of squares divided by the respective df.

F and Sig: The F statistics is the mean square Regression divided by the mean square Residual and p value is the significance level.

Parameter Estimates:

Model: SPSS allows specifying multiple models in a single regression command and it lists the number of models being reported.

The model column also shows the predictor variables. The first variable in the list is referred as constant or the Y intercept in the regression line.

B: This is the value of regression equation to predict the value of the dependent variable from the independent variables.

Std. error: This is the standard error associated with the coefficients.

Beta: These are the standardized coefficients, which can be obtained if all the variables in the regression are standardized including dependent and independent variables. Standardization means putting all the variables in the same scale and then running the regression and comparing the effects of different variables. If the Beta value is large, t value will be large as well and p-value will be low.

t & sig: The t statistics and two-tailed p values used in testing whether a given coefficient is significant or not. Since in the current study direction of the hypotheses is known, the single-tail tests were used. The critical t-values and notations for the current study are: ***$p \leq 0.01$, $t = 2.32$; **$p \leq 0.05$, $t = 1.645$; *$p \leq 0.1$, $t = 1.282$.

7.9 Conclusion

In this chapter, the methodology of the quantitative analysis was presented. To test the conceptual model, sample frames of 300 senior executives from industrial businesses were selected. An online data collection method was selected due to ease of use and cost factor and the survey web site sponsored by Loughborough University was used. Prior to the main survey, the questionnaire was pre-tested through protocols, debriefing and one pilot survey. The questionnaire was modified based on the feedback received during pre-testing. All 300 respondents were contacted and the response rate for the survey was 36%. The chapter concluded with the explanation of factor analysis and linear regression analysis used in the study. In the next chapter, the analysis and results are discussed.

Chapter 8: Analysis and Results

8.1 Introduction

This chapter describes the data analysis process and the results of the data analysis. The current study has two conceptual models: a front-end model and a back-end model. The front-end model explains how firms develop digital transformative capabilities (DTC) and the back-end model describes how DTC affects Digital Transformation (DT).

First, the Exploratory Factor Analysis (EFA) is presented, which helps in examining the underlying structures of the items and how the expected constructs are formed. Following the EFA, reliability analysis and collinearity analysis are discussed. Finally, the conceptual models are tested using linear regression in SPSS.

8.2 Exploratory Factor Analysis (EFA) – Front-End Model

The EFA analyses for the front-end model are included in the subsequent sections.

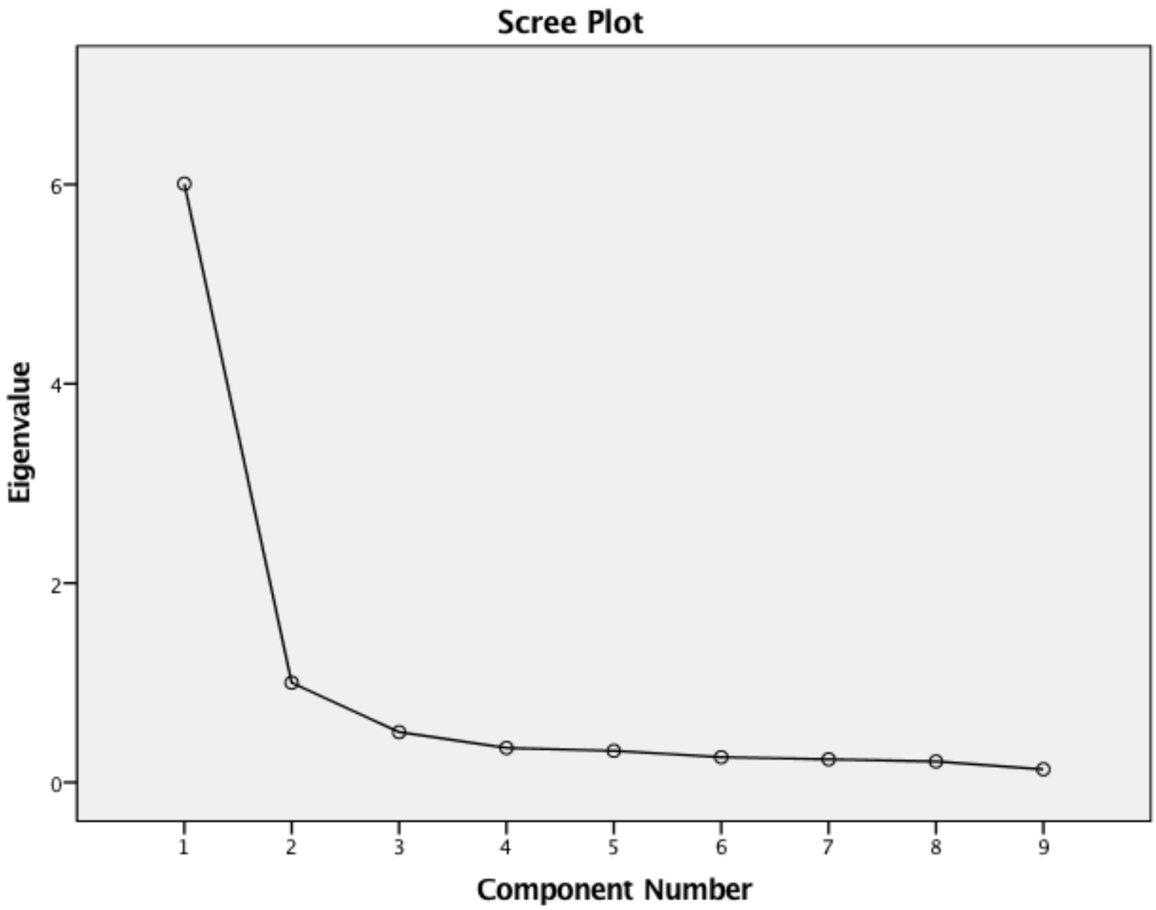
8.2.1 Digital Twin

Table 28 : EFA Digital Twin

Kaiser-Meyer-Olkin Measure		0.917
Bartlett's Test of Sphericity	Approx. Chi-Square	739.277
	df	36
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	Using Digital Twin, we build a bridge between the physical and digital world.	.764
2	Using Digital Twin, we simulate the actual production environment.	.697
3	Using Digital Twin, we detect product shortcomings in advance.	.831
4	Using Digital Twin, we design new products with complex requirements.	.886
5	Using Digital Twin, we build new products.	.801
6	Using Digital Twin, we build better quality products.	.746
7	Using Digital Twin, we run/operate new products with greater efficiency.	.794
8	Using Digital Twin, we receive early warning of system failures.	.822
9	Using Digital Twin, we foresee the business outcomes of our decisions.	.666

Extraction Method: Principal Component Analysis



Var. No	Variable description	Component 1	Component 2
1	Using Digital Twin, we build a bridge between the physical and digital world.	.413	.771
2	Using Digital Twin, we simulate the actual production environment.	.746	
3	Using Digital Twin, we detect product shortcomings in advance.	.848	
4	Using Digital Twin, we design new products with complex requirements.	.898	
5	Using Digital Twin, we build new products.	.840	
6	Using Digital Twin, we build better quality products.	.607	.614
7	Using Digital Twin, we run/operate new products with greater efficiency.		.843
8	Using Digital Twin, we receive early warning of system failures.		.879
9	Using Digital Twin, we foresee the business	.426	.696

	outcomes of our decisions.		

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

The factor analysis was performed after removing variable 6 for component 1.

Factor Loading (Rotated Component Matrix) – Component 1		
Var. No	**Variable description**	**Only one component was extracted.**
2	Using Digital Twin, we simulate the actual production environment.	
3	Using Digital Twin, we detect product shortcomings in advance.	
4	Using Digital Twin, we design new products with complex requirements.	
5	Using Digital Twin, we build new products.	

The factor analysis was performed after removing variables 1 and 6 for Component 2.

Factor Loading (Rotated Component Matrix) – Component 2		
Var. No	**Variable description**	**Only one component was extracted.**
7	Using Digital Twin, we run/operate new products with greater efficiency.	
8	Using Digital Twin, we receive early warning of system failures.	
9	Using Digital Twin, we foresee the business outcomes of our decisions.	

Reliability Statistics

Digital Twin (Product Development)	**Cronbach's Alpha – 0.918 (number of items 4)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	2	.919
	3	.884
	4	.874
	5	.899

Digital Twin (Product Quality)	**Cronbach's Alpha – 0.853 (number of items 3)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	7	.785
	8	.746
	9	.848

The factor analysis was performed for all 9 variables of Digital Twin (see Table 28). The KMO measure was 0.917 and the significance value of Bartlett's Test of Sphericity was 0.00, which indicated that the data was factorable.

Based on factor loading (rotated component matrix), the variable 1 had a better loading for component 2 than on component 1 and the loading on component 1 was less than 0.5, so item 1 was considered for component 2. However, the factor was not related to product quality and variable 1 did not fit the description of product quality, so it was dropped.

Variables 2, 3, 4 and 5 had loading for component 1 only. Variable 6 had cross-loading and the cross-loaded values were more than 0.5, so variable 6 was taken out from both components. The factor analysis was performed again with variables 2, 3, 4 and 5 and it resulted in one factor, which was labelled Digital Twin – Product Development.

Variables 7 and 8 were only loaded on component 2. Variable 9 also had cross-loading but the loading on component 1 was less than 0.5, so variable 9 was considered for component 2. Also, after removing variable 1, factor analysis was performed again, and it resulted in one factor. So, variables 7, 8 and 9 formed another factor labelled, Digital Twin – Product Quality.

Based on the reliability statistics, Cronbach's Alpha for Digital Twin – Product Development was 0.918 and there were no significant improvement in Cronbach's Alpha value by deleting items, so variables 2, 3, 4 and 5 were kept for Digital Twin – Product Development.

The Cronbach's Alpha for Digital Twin – Product Quality was 0.853 and there were no significant improvement in Cronbach's Alpha value by deleting items, so variables 7, 8 and 9 were kept for Digital Twin – Product Quality.

8.2.2 Digital Thread

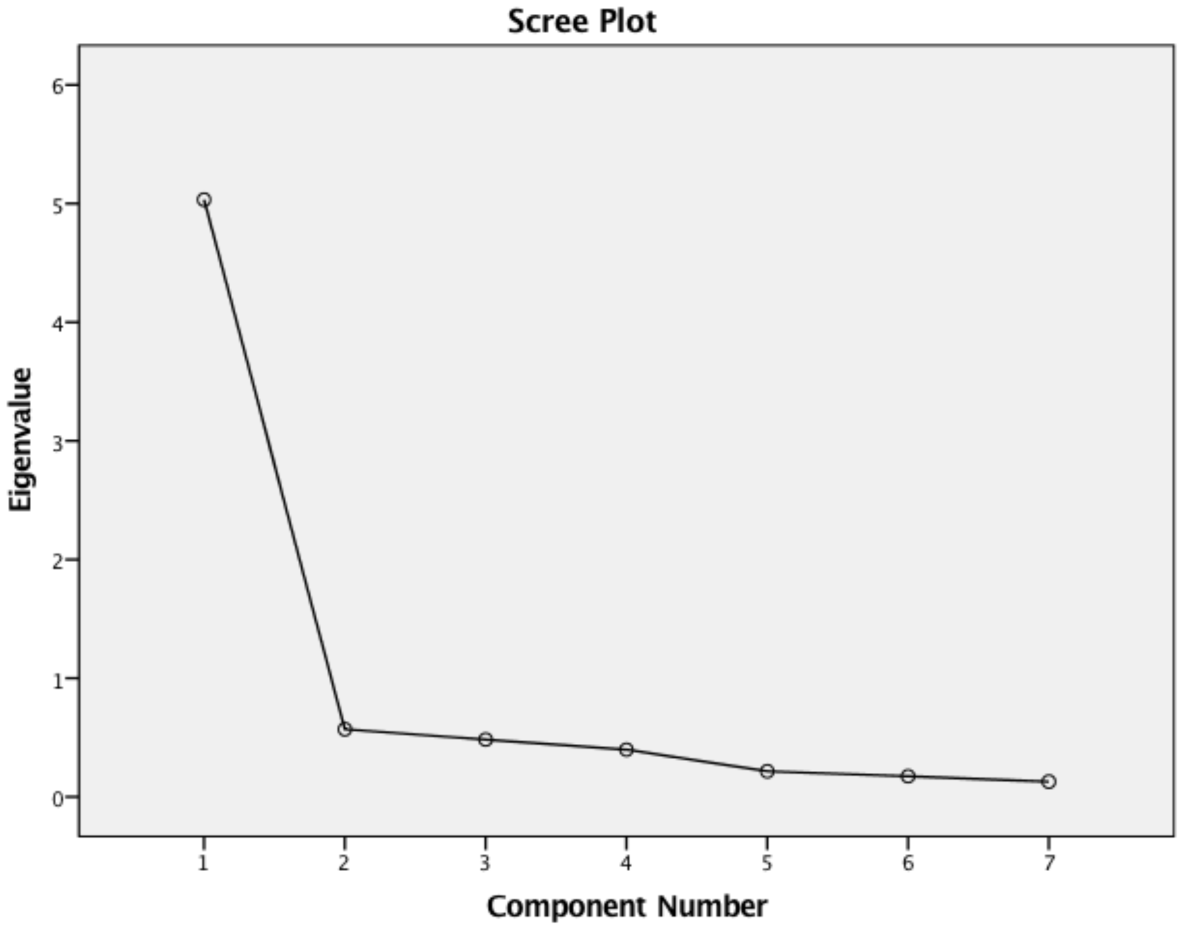
Table 29 : EFA Digital Thread

Kaiser-Meyer-Olkin Measure		0.879
Bartlett's Test of Sphericity	Approx. Chi-Square	587.002
	df	21
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted Value**
1	We are using more digital technologies in our manufacturing processes.	.764
2	We integrate our Information Technology (IT) data with Operational Technology (OT) data to accelerate Digital Transformation.	.697
3	We maintain manufacturing health records (from design, sourcing, and production to distribution, point of sale and use) to optimize Digital Transformation.	.831
4	By mining data, our engineers are gaining new insights into our assets.	.886
5	By mining data, our engineers are improving the reliability of our assets.	.801
6	By using digital technologies, we are improving distribution of our products to our customers.	.746
7	By using digital technologies, we are integrating our supply chain networks with our customers and partners.	.794

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Digital Thread	Cronbach's Alpha – 0.934 (number of items 7)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.926
	2	.917
	3	.929
	4	.921
	5	.919
	6	.927
	7	.924

The factor analysis was performed for all 7 variables of Digital Thread (see Table 29). The KMO measure was 0.879 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the

KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables.

The Cronbach's Alpha for Digital Thread was 0.934 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 7 were kept for Digital Thread.

8.2.3 Digital Mindset

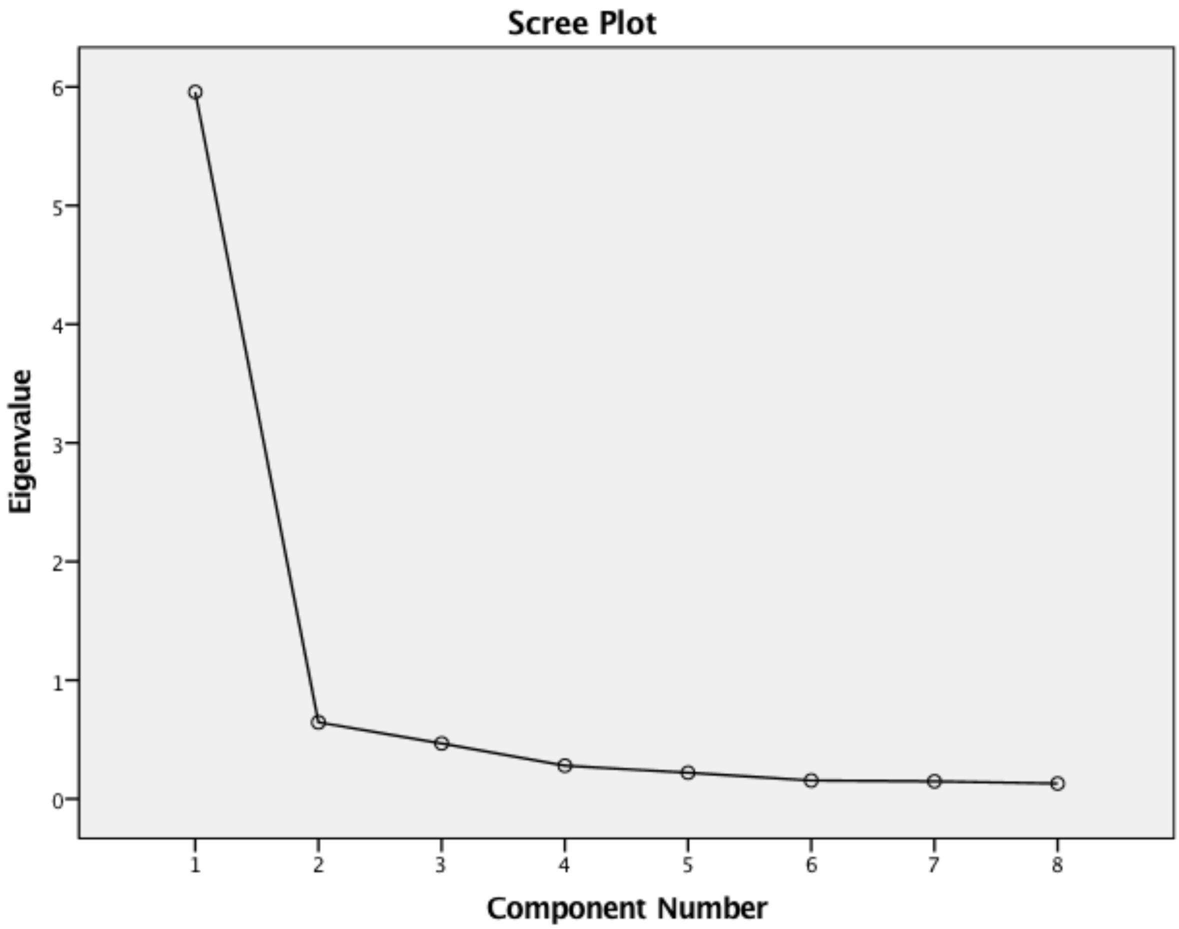
Table 30 : EFA Digital Mindset

Kaiser-Meyer-Olkin Measure		0.928
Bartlett's Test of Sphericity	Approx. Chi-Square	791.240
	df	28
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	The managers in our firm do not have/have a clear vision for Digital Transformation.	.684
2	The managers in our firm do not empower/empower employees to implement digital strategies	.848
3	The managers in our firm do not encourage/encourage employees to make decisions for Digital Transformation.	.816
4	The managers in our firm do not make/make decisions based on information for Digital Transformation.	.854
5	The managers in our firm do not make/make decisions based on intuition for Digital Transformation.	.467
6	The managers in our firm do not make/make decisions based on experience for Digital Transformation.	.767
7	The managers in our firm do not try out/try out different technological and process options before deciding on particular options for Digital Transformation.	.750
8	The managers in our firm do not encourage/encourage experimentation by our employees for Digital Transformation.	.770

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Digital Mindset	Cronbach's Alpha – 0.950 (number of items 8)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.946
	2	.938
	3	.939
	4	.938
	5	.955
	6	.942
	7	.942
	8	.941

The factor analysis was performed for all 8 variables of digital mindset (see Table 30). The KMO measure was 0.928 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the data was factorable.

The Cronbach's Alpha for Digital Mindset was 0.950 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 8 were kept for Digital Mindset.

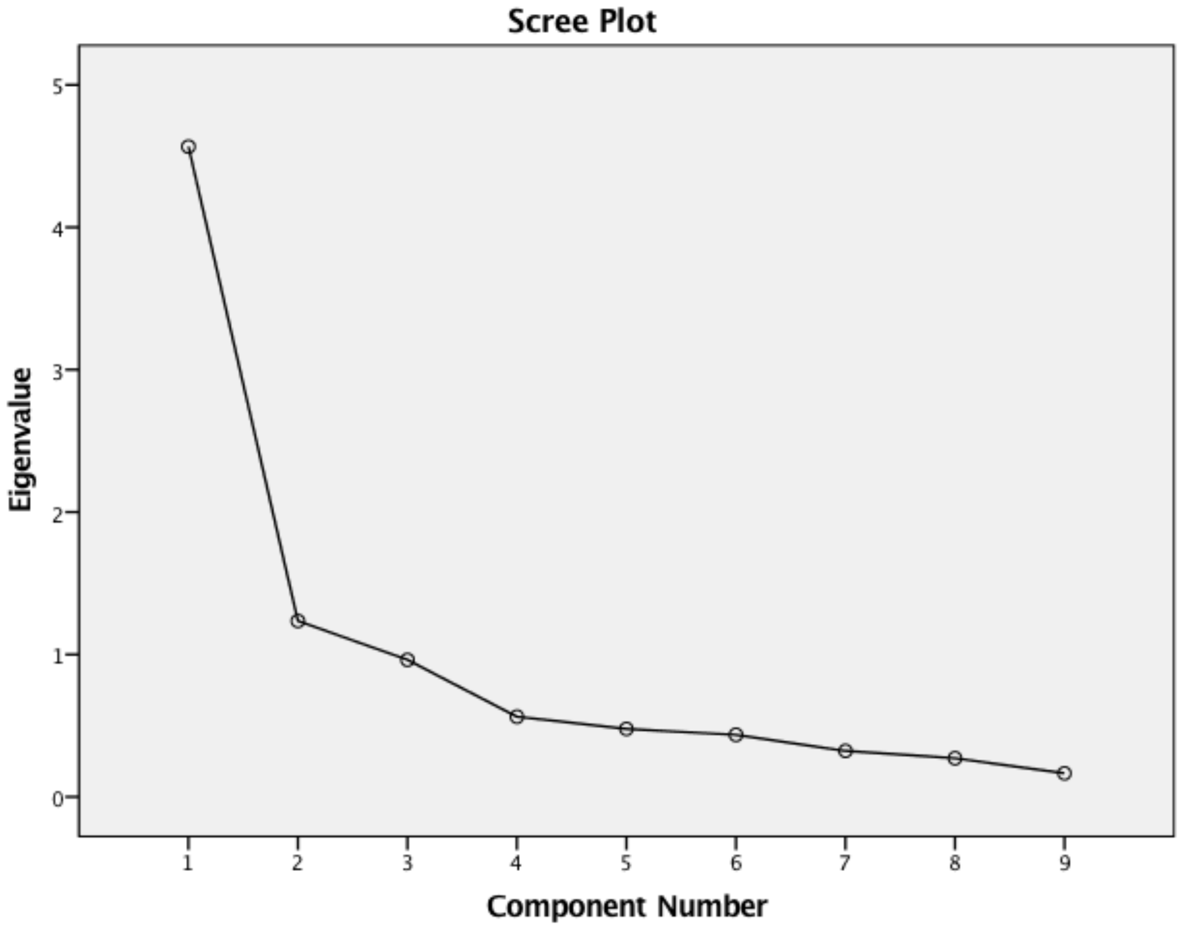
8.2.4 Digital Transformative Capability – Business Model Transformation

Table 31 : EFA DTC – Business Model Transformation

Kaiser-Meyer-Olkin Measure		0.831
Bartlett's Test of Sphericity	Approx. Chi-Square	460.014
	df	36
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	We are changing our marketing activities from transactional to relational marketing.	.513
2	We are changing our sales activities from selling multi-million dollar products to selling services capabilities.	.723
3	We are educating our customers from owning products to seeking a service.	.659
4	We are extending the timescale of our customer engagements by managing and delivering multi-year partnerships.	.755
5	We are extending the timescale of our customer engagements by managing and controlling long-term risk and exposure.	.812
6	We are extending the timescale of our customer engagement by modeling and understanding of cost and profit implications of long-term partnerships.	.728
7	We are changing our customer offerings by understanding what value means to them.	.439
8	We are changing our customer offerings by delivering services rather than products.	.763
9	We are promoting an organizational culture such that our employees have high concern for servicing customers.	.410

Extraction Method: Principal Component Analysis



Factor Loading (Rotated Component Matrix)			
Var. No	**Variable description**	**Component 1**	**Component 2**
1	We are changing our marketing activities from transactional to relational marketing.	.528	.484
2	We are changing our sales activities from selling multi-million dollar products to selling services capabilities.		.799
3	We are educating our customers from owning products to seeking a service.		.768
4	We are extending the timescale of our customer engagements by managing and delivering multi-year partnerships.	.820	
5	We are extending the timescale of our customer engagements by managing and controlling long-term risk and exposure.	.885	
6	We are extending timescale of our customer engagement by modeling and understanding of cost and profit implications of long-term partnerships.	.844	
7	We are changing our customer offerings by understanding what value means to them.	.584	

8	We are changing our customer offerings by delivering services rather than products.		.869
9	We are promoting an organizational culture such that our employees have high concern for servicing customers.	.442	.463

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Reliability Statistics

Digital Transformative Capability – Business Model Transformation (Customer Engagement) **(DTCBMT_CE)**	**Cronbach's Alpha – 0.844 (number of items 4)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	4	.765
	5	.753
	6	.798
	7	.879

Digital Transformative Capability – Business Model Transformation (Marketing & Sales) **(DTCBMT_MS)**	**Cronbach's Alpha – 0.822 (number of items 3)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	2	.701
	3	.773
	8	.789

The factor analysis was performed for all 9 variables of digital transformative capability – business model transformation (see Table 31). The KMO measure was 0.831 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables.

Based on factor loading (rotated component matrix), variables 1 and 9 were cross-loaded and loadings were closer to 0.5, so both variables were dropped. Variables 2, 3 and 8 were loaded only for component 2. Variables 4, 5, 6, and 7 were loaded only for component 1. So, based on these loading variables, 4, 5, 6 and 7 formed one factor, labelled Digital Transformative Capability – Business Model Transformation (Customer Engagement) and 2, 3, and 8 formed another factor, labelled Digital Transformative Capability (DTC) – Business Model Transformation (Marketing & Sales).

By analysing reliability statistics, the Cronbach's Alpha was 0.844 for factor 1. By dropping variable 7, the Cronbach's Alpha would increase to 0.879. So, variable 7 was dropped. Variable 7 was also not related to customer engagement directly so removing this variable might not have any significant impact on the regression analysis. The first factor, Digital Transformative Capability (DTC) – Business Model Transformation (Customer Engagement), was constructed from variables 4, 5 and 6.

Similarly, the Cronbach's Alpha for variables 2, 3 and 8 was 0.822. Dropping any other variable would not improve the Cronbach's Alpha, so the second factor, DTC – Business Model Transformation (Marketing & Sales) had 2, 3 and 8 variables.

8.2.5 Digital Transformative Capability (DTC) – Operating Model Transformation

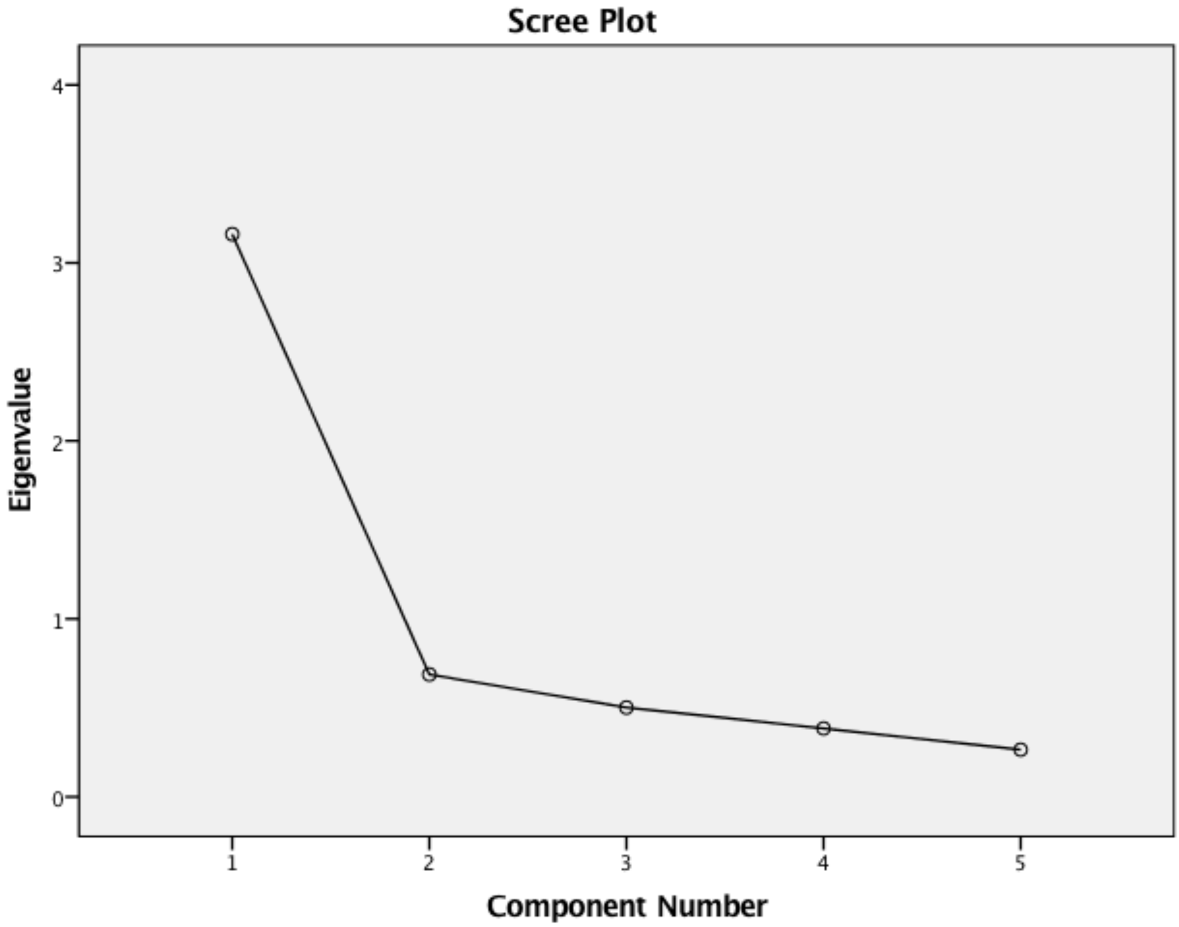
Table 32 : EFA DTC – Operating Model Transformation

Kaiser-Meyer-Olkin Measure		0.819
Bartlett's Test of Sphericity	Approx. Chi-Square	218.659
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	We are looking for business opportunities beyond our industry that are possible by Digital Transformation.	.593
2	We are experimenting with our ideas and launching them faster to transform our business.	.592
3	We are developing strategic relationships with our partners to augment our capabilities for Digital Transformation.	.558
4	We are gaining full support from our top executives for Digital Transformation.	.709
5	We are implementing digital traction metrics (such as number of unique users/active users, customer retention rate, abandon rate) to measure the performance of our digital business.	.708

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Digital Transformative Capability – Operating Model Transformation **(DCCOMT)**	**Cronbach's Alpha – 0.854 (number of items 5)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.831
	2	.830
	3	.838
	4	.807
	5	.808

The factor analysis was performed for all 5 variables of DTC – Operating Model Transformation (see Table 32). The KMO measure was 0.819 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables.

The Cronbach's Alpha for DTC – Operating Model Transformation was 0.854 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 5 were kept for DTC – Operating Model Transformation.

8.2.6 Digital Transformative Capability (DTC) – Cultural Transformation

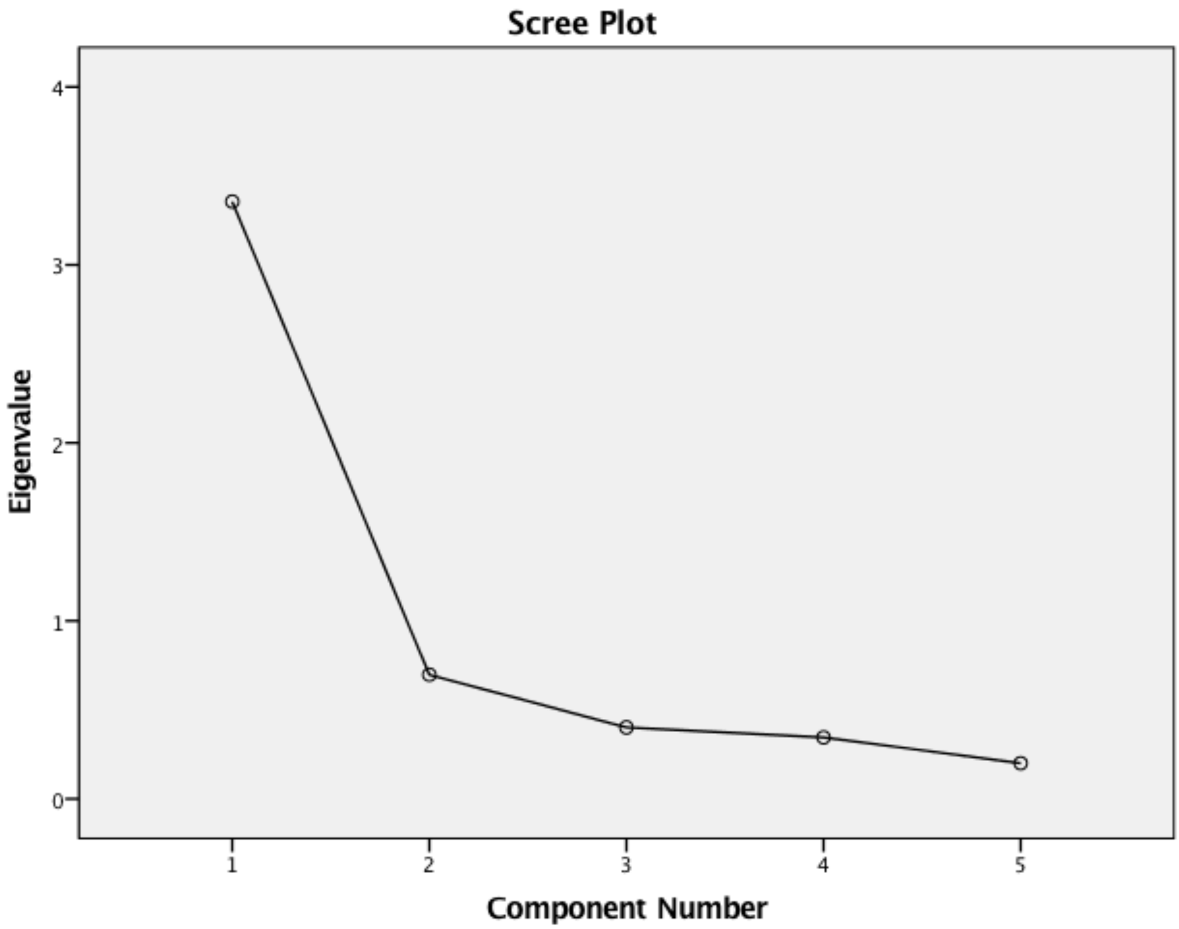
Table 32: EFA DTC – Cultural Transformation

Kaiser-Meyer-Olkin Measure		0.807
Bartlett's Test of Sphericity	Approx. Chi-Square	272.031
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	Our employees bring a high level of digital fluency to the workforce.	.662
2	Our employees can be utilized in many kinds of jobs since they have multiple skills.	.636
3	We are creating an open collaborative environment powered by digital collaboration tools such that employees can participate in decision making processes.	.790
4	Our employees are flexible and willing to change their working habits in response to external influences.	.697
5	We have created a digital workplace such that our employees can collaborate, communicate and connect with each other.	.571

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Digital Transformative Capability – Cultural Transformation **(DTCCLT)**	**Cronbach's Alpha – 0.876 (number of items 5)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.852
	2	.857
	3	.825
	4	.845
	5	.869

The factor analysis was performed for all 5 variables of DTC – Cultural Transformation (see Table 32). The KMO measure was 0.807 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the variables were factorable.

The Cronbach's Alpha for DTC – Cultural Transformation was 0.876 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 5 were kept for DTC – Cultural Transformation.

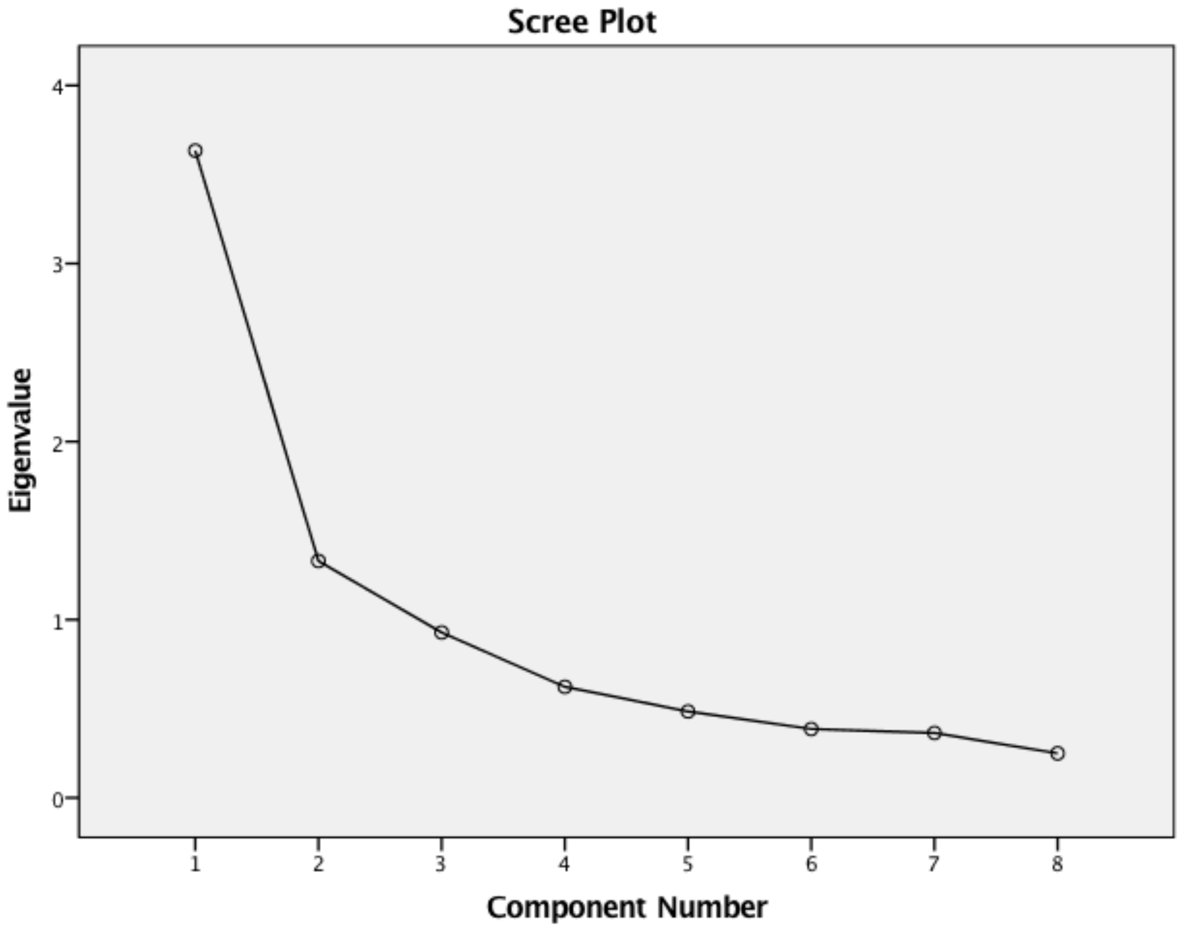
8.2.7 Market Turbulence

Table 33 : EFA DTC – Market Turbulence

Kaiser-Meyer-Olkin Measure		0.791
Bartlett's Test of Sphericity	Approx. Chi-Square	300.085
	df	28
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	The market activities of our competitors are not predictable.	.316
2	The rate of innovations of new operating processes in our industry has increased drastically.	.752
3	The rate of innovations of new products and services in our industry has increased drastically.	.710
4	The market activities of our key competitors now affect us in more ways than before.	.501
5	We are witnessing demand from a totally new group of customers who who did not previously buy our products/services.	.646
6	New customers have product-related needs that are very different from our existing customers.	.692
7	Environmental demands on us are constantly changing.	.569
8	Environmental changes in our industry are unpredictable.	.779

Extraction Method: Principal Component Analysis



Factor Loading (Rotated Component Matrix)			
Var. No	**Variable description**	**Component 1**	**Component 2**
1	The market activities of our competitors are not predictable.		.555
2	The rate of innovations of new operating processes in our industry has increased drastically.	.864	
3	The rate of innovations of new products and services in our industry has increased drastically.	.839	
4	The market activities of our key competitors now affect us in more ways than before.	.660	
5	We are witnessing demand from totally new group of customers who earlier never bought our products/services.	.705	
6	New customers have product-related needs that are very different from our existing customers.	.407	.725
7	Environmental demands on us are constantly changing.		.665

8	Environmental changes in our industry are unpredictable.		.883

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Reliability Statistics

market turbulence (Product)	Cronbach's Alpha – 0.810 (number of items 4)	
	Var. no	**Cronbach's Alpha, if item deleted**
	2	.719
	3	.745
	4	.804
	5	.766

market turbulence (Customer)	Cronbach's Alpha – 0.722 (number of items 4)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.722
	6	.611
	7	.669
	8	.585

The factor analysis was performed for all 8 variables of market turbulence (see Table 33). The KMO measure was 0.791 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables.

Based on the factor loading (rotated component matrix), two distinct factors emerged from the variables. The first factor, Market Turbulence, related to Products derived from variables 2, 3, 4 and 5. Variable 6 had a better loading for the second factor, so, it was included in the second factor and market turbulence related to Customers had variables 1, 6, 7 and 8.

Based on reliability analysis, any deletion of variables for market turbulence (Product) would not have any major impact on Cronbach's Alpha value, so variables 2, 3, 4 and 5 were considered for market turbulence (Product). Similar to previous factor, any deletion of variables for market turbulence (Customer) would not have any major impact on Cronbach's Alpha value, so variables 1, 6, 7 and 8 were considered for this factor.

8.2.8 Technology Turbulence

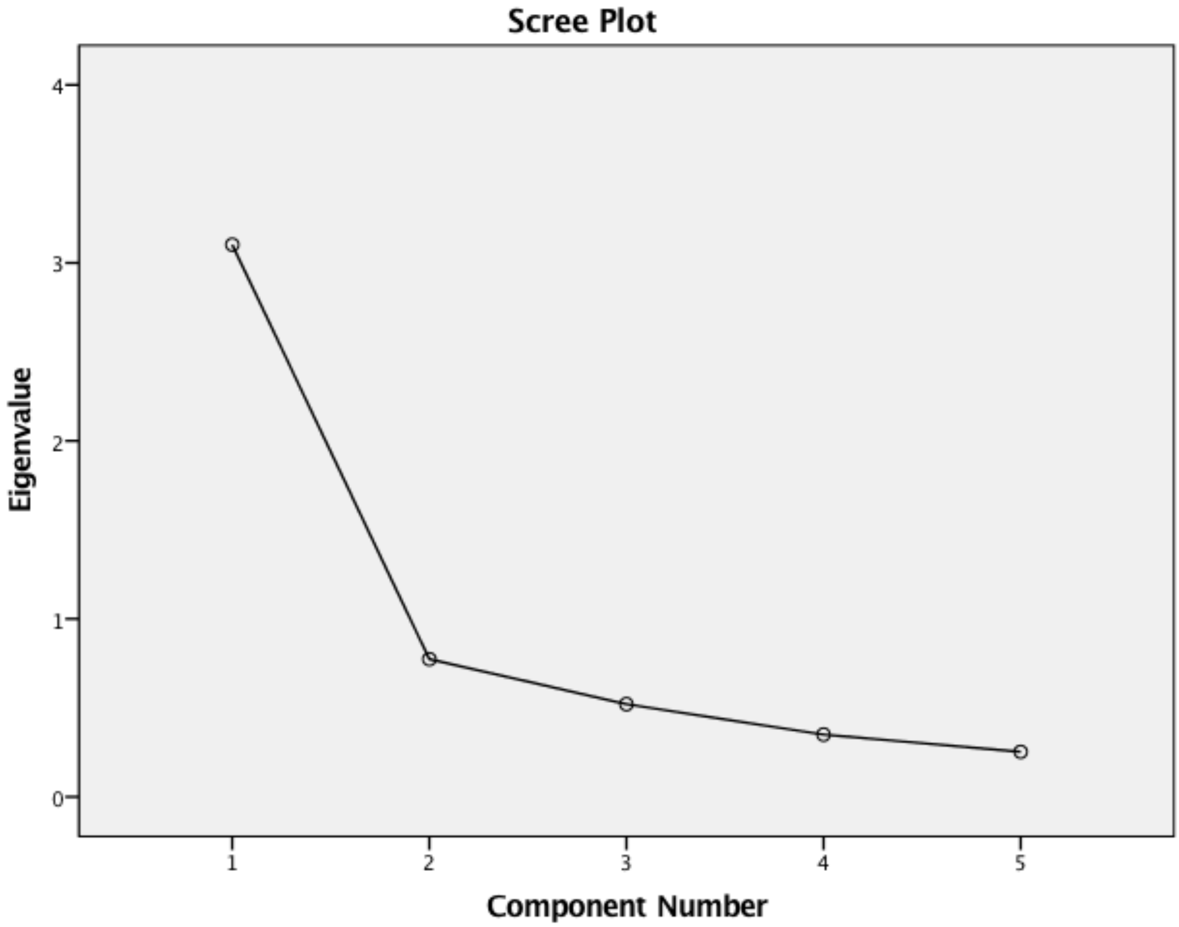
Table 34 : EFA DTC – Technology Turbulence

Kaiser-Meyer-Olkin Measure		0.760
Bartlett's Test of Sphericity	Approx. Chi-Square	218.974
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	Technology in our digital business is changing rapidly.	.583
2	Technology breakthroughs provide substantial opportunities in our digital business.	.668
3	A large number of new product ideas have been made possible through technological breakthroughs in our digital business.	.668
4	The rate of product/service obsolescence in the digital business is very high.	.579
5	In the digital business, our production and service technologies change often and in major ways.	.605

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Technology Turbulence	Cronbach's Alpha – 0.843 (number of items 5)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.821
	2	.805
	3	.801
	4	.820
	5	.810

The factor analysis was performed for all 5 variables of Technology Turbulence (see Table 34). The KMO measure was 0.760 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the variables were factorable.

Based on the reliability analysis, any deletion of variables would not have any significant impact on Cronbach's Alpha value, so all variables were considered for Technology Turbulence.

8.2.9 Competitive Turbulence

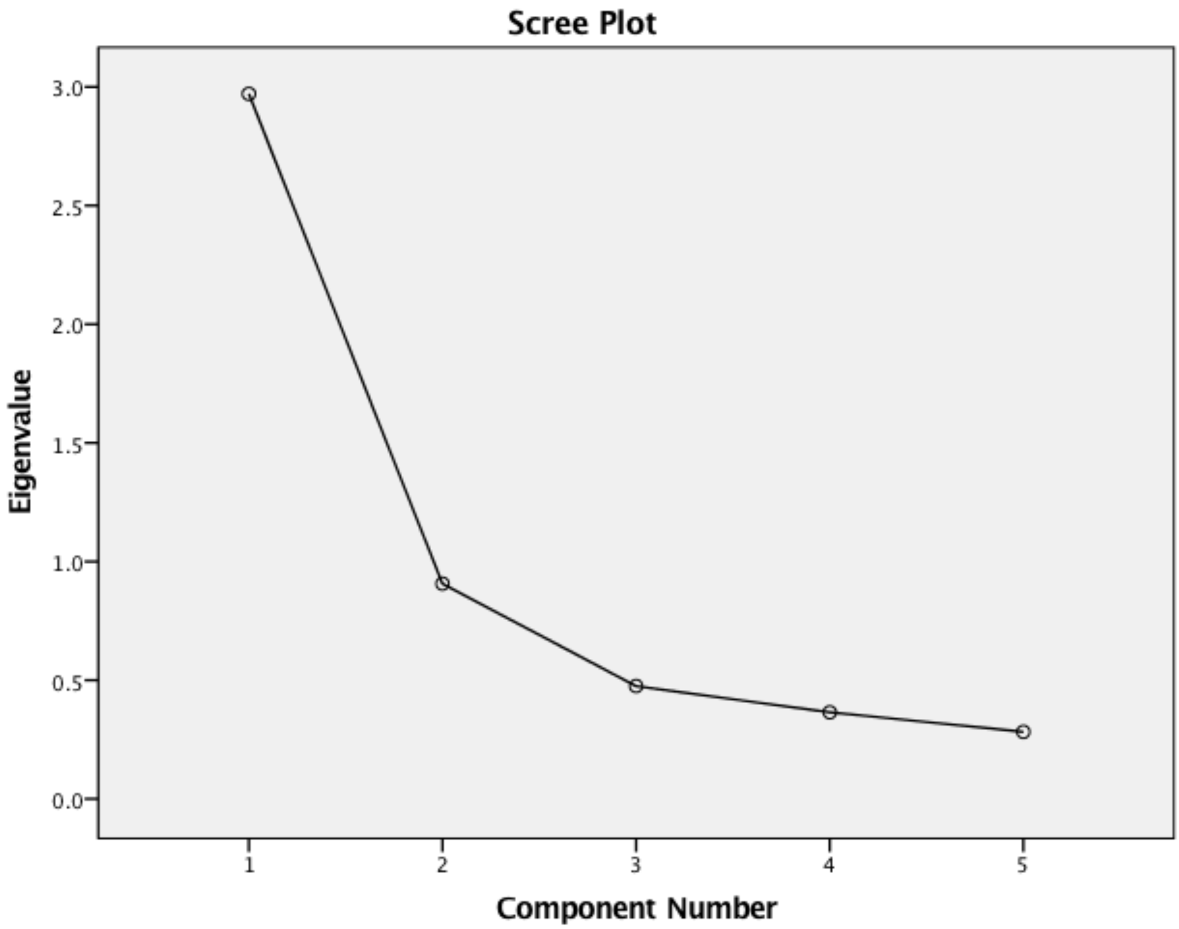
Table 35 : EFA DTC – Competitive Turbulence

Kaiser-Meyer-Olkin Measure		0.769
Bartlett's Test of Sphericity	Approx. Chi-Square	201.544
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	We encounter new competitors all the time.	.645
2	Competitors change their strategy constantly.	.591
3	Our competitors are not the same from previous years.	.559
4	Our customers have competing assets and capabilities.	.616
5	Our partners have competing assets and capabilities.	.560

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Competitive Turbulence	Cronbach's Alpha – 0.820 (number of items 5)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.762
	2	.778
	3	.795
	4	.787
	5	.799

The factor analysis was performed for all 5 variables of Competitive turbulence (see Table 35). The KMO measure was 0.769 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the variables were factorable.

Based on the reliability analysis, any deletion of variables would not have any significant impact on Cronbach's Alpha value, so all variables were considered for Competitive Turbulence.

8.2.10 Path Dependency

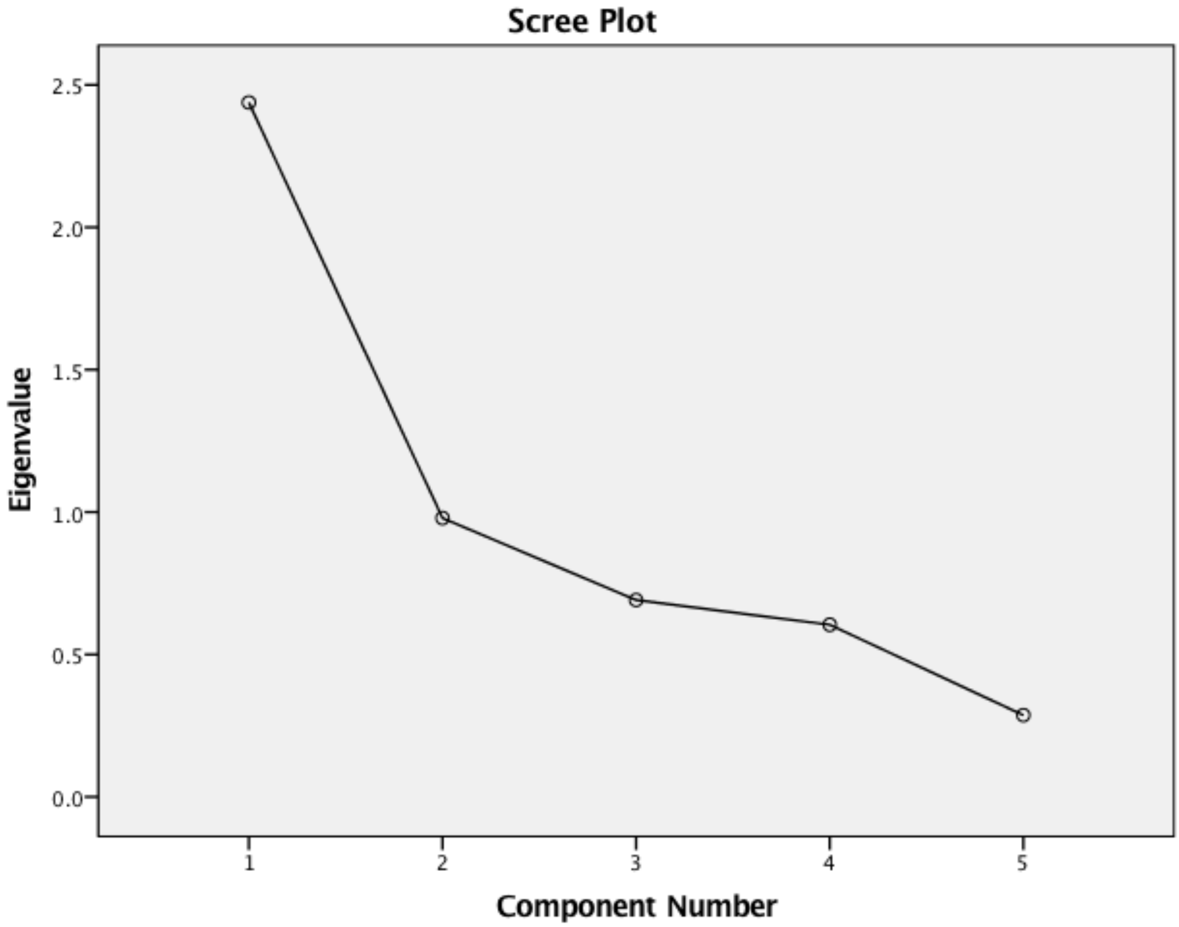
Table 36 : EFA DTC – Path Dependency

Kaiser-Meyer-Olkin Measure		0.689
Bartlett's Test of Sphericity	Approx. Chi-Square	124.467
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	We hold on to our current businesses which are profitable in the past.	.242
2	We seldom give discounts to our customers to move from our old products and services to new products and services.	.667
3	Our biggest challenge is to move from our existing systems to the new and improved systems.	.382
4	We seldom help our customers to move them from the old business model (e.g. licensing) to the new business model (e.g. cloud).	.714
5	We like to maintain strong relationship with our current partners and occasionally look for new partners.	.433

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Competitive Turbulence	Cronbach's Alpha – 0.735 (number of items 5)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.749
	2	.628
	3	.717
	4	.613
	5	.702

The factor analysis was performed for all 5 variables of Path Dependency (see Table 36). The KMO measure was 0.689 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the variables were factorable.

Based on the reliability analysis, any deletion of variables would not have any significant impact on Cronbach's Alpha value, so, all variables were considered for Path Dependency.

8.3 Collinearity Analysis – Front-End Model

The collinearity analysis was performed for all the independent variables of the front-end model (see Table 37). The VIFs for all these cases were less than 3, which indicated that there was no multi-collinearity among the independent variables for the front-end model.

Table 37 : Collinearity Analysis for Front-end Model

1) Dependent Variable: Digital Twin (Product Development)

Independent Variable	**Collinearity Statistics**	
	Tolerance	VIF
Digital Twin (Product Quality)	.585	1.709
Digital Thread	.599	1.669
Digital Mindset	.894	1.119

2) Dependent Variable: Digital Twin (Product Quality)

Independent Variable	**Collinearity Statistics**	
	Tolerance	VIF
Digital Thread	.528	1.893
Digital Mindset	.909	1.100
Digital Twin (Product Development)	.526	1.902

3) Dependent Variable: Digital Thread

Independent Variable	**Collinearity Statistics**	
	Tolerance	VIF
Digital Mindset	.894	1.118
Digital Twin (Product Development)	.546	1.832
Digital Twin (Product Quality)	.535	1.868

4) Dependent Variable: Digital Mindset

Independent Variable	Collinearity Statistics	
	Tolerance	VIF
Digital Twin (Product Development)	.439	2.278
Digital Twin (Product Quality)	.497	2.013
Digital Thread	.482	2.074

8.4 Harman's Single Factor Test for CMV – Front-End Model

Harman's single factor test was performed for the front-end model (Appendix A-9), where EFA was performed by loading all variables onto a single factor and analysis was constrained such that there was no rotation (Podsakoff et al. 2003).

The newly introduced common latent factor explained 26.93% of the variance (less than 50% of the variance), so there was no common method bias.

8.5 Descriptive Statistics and Correlation Matrix

The descriptive statistics of front-end and back-end model constructs are listed in appendix A-11.

There are variances in the data, however, in a 7 point likert scale, means (averages) for most of the constructs are 5 points or above, with a standard deviation between 1 and 1.5 (mostly). Based on these statistics, it could me inferred that there are dispersions in the data, however, the values are converging towards the higher value (5 or above), indicating respondents agreement with the measurements.

The correlation matrix of the front-end model is included in appendix A-12. According to Taylor (1990), the Pearson's correlation coefficient (r), less than or equal to 0.35 indicates a low or weak correlation, r value from 0.36 to 0.67 indicates modest correlation and the r value between 0.68 to 1.0 indicates high correlation. The positive or negative r values indicate positive or negative relationships.

The main observations and inferences from the correlation matrix are discussed in the subsequent paragraphs.

- Digital Twin (Product Development) and Digital Twin (Product Quality) are highly correlated. Digital Twin is modestly correlated with Digital Thread. And Digital Twin is modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. So, any positive changes in Digital Twins may have modest positive changes in DTCs.

- Digital Thread is highly correlated with Digital Twin and modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. So, any positive changes in Digital Threads may have modest positive changes in DTCs.

- Digital Mindset is weakly correlated with DTC – Business Model Transformation, DTC – Opereationg Model Transforemation and DTC - Cultiral Transformation. So, any positive changes in Digital Mindsets may have a positive weak changes in DTCs.

- DTC – Business Model Transformation is modestly correlated with Digital Twin, Digital Thread and Digital Mindset. It is also modestly correlated with DTC – Operating Model Transformation and DTC – Cultural Transformation. So, any positive changes in DTC – Business Model Transformation may have modest positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset).

- DTC – Operating Model Transformation is modestly correlated with Digital Twin, Digital Thread and Digital Mindset. It is also modestly correlated with DTC – Business Model Transformation and DTC – Cultural Transformation. So, any positive changes in DTC – Operating Model Transformation may have modest positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset).

- DTC – Cultural Transformation is modestly correlated with Digital Twin, Digital Thread and Digital Mindset. It is also moderately correlated with DTC – Business Model Transformation and DTC – Operating Model Transformation. So, it can be inferred that any positive changes in DTC – Cultural Transformation may have modest positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset).

- Market Turbulence is weak to modestly correlated with Digital Twin, Digital Thread and Digital Mindset. It is also weak to modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. So, any positive changes in Market Turbulence may have weak to modest positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset) and DTCs.

- Technology Turbulence is weak to modestly correlated with Digital Twin, Digital Thread and Digital Mindset. It is also modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. So, any positive changes in Technology Turbulence may have weak to modest positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset) and DTCs.

- Competitor Turbulence has weak to modest correlation with Digital Twin and Digital Thread and Digital Mindset. It also has weak to modest correlation with DTC – Business Model Transformation and DTC - Operating Model Transformation and low correlation with DTC – Cultural Transformation. So, any positive changes in Competitor Turbulence may have weak to modest positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset) and DTCs.

- Path Dependency has weak correlation with Digital Twin, Digital Thread and Digital Mindset. It has weak correlation with DTCs and weak correlation with Market Turbulence and Competitor Turbulence. Thus, it can be inferred that any positive changes in Path Dependency may have weak positive changes on digitalization profile (Digital Twin, Digital Thread and Digital Mindset) and DTCs.

The correlation matrix of the back-end model is included in appendix A-13. The main observations and inferences from the correlation matrix are as follows:

- DTC – Business Model Transformation is weak to modestly correlated with DC – Importance, DC – Improvement and DC – Comparison. It is weak to modestly correlated with Ecosystem Partnership, Customer & Market Demands and Digital Commitment. It is not correlated with Resource Constraints. So, any positive changes in DTC – Business Model Transformation may have weak to modest positive changes in DC – Importance, DC – Improvement and DC – Comparison.

- DTC – Operating Model Transformation is weak to modestly correlated with DC – Importance, DC – Improvement and DC – Comparison. It is modestly correlated with Ecosystem Partnership, Customer & Market Demands and Digital Commitment. It is not correlated with Resource Constraints. So, any positive changes in DTC – Operating Model Transformation may have weak to modest positive changes in DC – Importance, DC – Improvement and DC – Comparison.

- DTC – Cultural Transformation is weak to modestly correlated with DC – Importance, DC – Improvement and DC – Comparison. It is modestly correlated with Ecosystem Partnership, Customer & Market Demands and Digital Commitment. It is not correlated with Resource Constraints. So, any positive changes in DTC – Cultural Transformation may have weak to modest positive changes in DC – Importance, DC – Improvement and DC – Comparison.

- Ecosystem Partnership is modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. It is also modestly correlated with DC – Importance, DC – Improvement and DC – Comparison (DCS). It is modestly correlated with Customer & Market Demands and Digital Commitment. However it does not have any correlation with Resource Constraints. Thus any positive changes in Ecosystem Partnership may have modest positive changes in DCs and DTCs.

- Customer & Market Demands is modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. It is modestly correlated with DC – Importance, DC – Improvement and DC – Comparison. It is modestly correlated with Ecosystem Partnership and Digital Commitment. However it does not have any correlation with Resource Constraints. Thus any positive changes in Customer and Market Demand may have modest positive changes in DCs and DTCs.

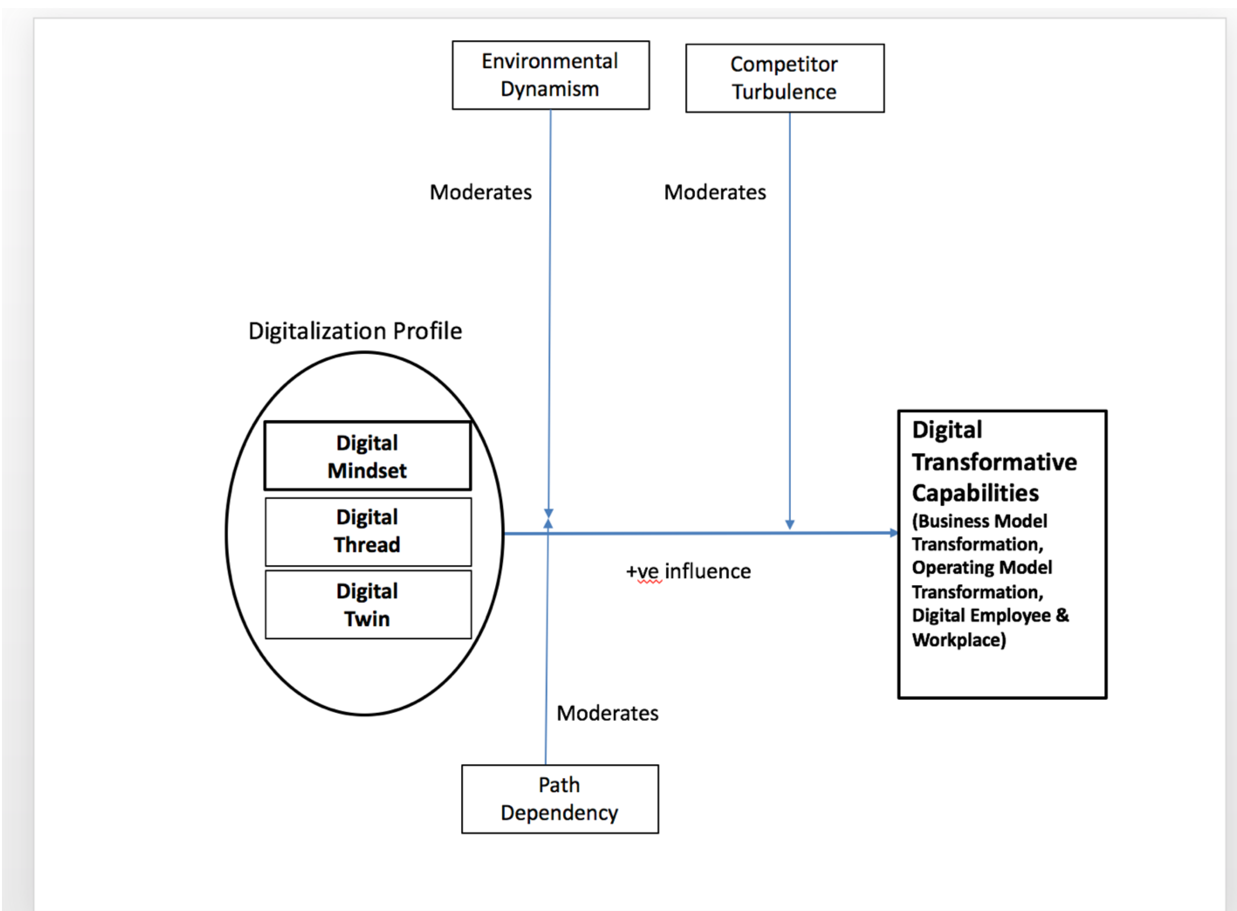
- Digital Commitment is modestly correlated with DTC – Business Model Transformation, DTC – Operating Model Transformation and DTC – Cultural Transformation. It is modestly correlated with DC – Importance, DC – Improvement and DC – Comparison. It is modestly correlated with Ecosystem Partnership and Customer and Market Demands. However it does not have any correlation with Resource Constraints. Thus any positive changes Digital Commitments may have modest positive changes in DCs and DTCs.

- Resource Constraints is not correlated with other constructs. Thus any changes in resource constranits may not have any effect on DCs and DTCs.

8.6 Hypotheses Testing – Front End Model

The hypotheses testing for the front-end model (see Chapter 6 for conceptualization of hypotheses) is discussed in this section. The analysis was conducted using SPSS with Linear Regression. As all hypotheses are directional, 1-tail test p-values are applied in interpreting the results.

Figure 15: Regression Analysis of the Front-end Conceptual Model



In the front-end conceptual model, regression analysis was performed with digitalization profile variables, Digital Twin (product development), Digital Twin (product quality), Digital Thread and digital mindset (see Section 8.2.1, 8.2.2 and 8.2.3) as independent variables.

The environmental dynamism moderating variable was further divided into three moderating variables: market turbulence (product), market turbulence (customer) and Technology Turbulence (see Section 8.2.7 and 8.2.8). Another two moderating variables were: competitive turbulence and Path Dependency (see Section 8.2.9 and 8.2.10).

All of the moderators were included in the regression analysis.

In the front-end conceptual model, two control variables were included: firm-age and firm-revenue. The dependent variable – digital transformative capability (DTC) – was divided into four separate dependent variables for hypotheses testing and these were digital transformative capability – business model transformation (customer engagement), digital transformative capability – business model transformation (marketing & sales), digital transformative capability – operating model transformation and digital transformative capability – cultural transformation (see Section 8.2.4, 8.2.5 and 8.2.6).

The front-end hypotheses testing is explained in the subsequent sections. The list of all the hypotheses is given in chapter 6.

8.6.1 Model 1

Dependent variable: Digital Transformative Capability (DTC) – Business Model Transformation (Marketing & Sales).

The following hypotheses were tested in this model:

Digitalization Profile Influences DTC – Business Model Transformation (Marketing & Sales)

H1-1A1 – Digital Twin (Product Development) has a positive influence on DTC – Business Model Transformation (Marketing & Sales).

H1-2A1 – Digital Twin (Product Quality) has a positive influence on DTC – Business Model Transformation (Marketing & Sales).

H2A1 – Digital Thread has a positive influence on DTC – Business Model Transformation (Marketing & Sales).

H3A1 – Digital Mindset has a positive influence on DTC – Business Model Transformation (Marketing & Sales).

Technology Turbulence as a Moderator

H4-1A1 – Technology Turbulence positively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Marketing & Sales).

H4-2A1 – Technology Turbulence positively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales).

H5A1 – Technology Turbulence positively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales).

H6A1 – Technology Turbulence positively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales).

market turbulence as a Moderator

H7-1A1 – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Marketing & Sales).

H7-2A1 – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Marketing & Sales).

H7-3A1 – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales).

H7-4A1 – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales).

H8-1A1 – market turbulence (Product) positively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales).

H8-2A1 – market turbulence (Customer) positively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales).

H9-1A1 – market turbulence (Product) positively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales).

H9-2A1 – market turbulence (Customer) positively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales).

Competitive Turbulence as a Moderator

H10-1A1 – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Marketing & Sales).

H10-2A1 – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales).

H11A1 – Competitive Turbulence negatively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales).

H12A1 – Competitive Turbulence negatively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales).

Path Dependency as a Moderator

H13-1A1 – Path Dependency negatively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Marketing & Sales).

H13-2A1 – Path Dependency negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales).

H14A1 – Path Dependency negatively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales).

H15A1 – Path Dependency negatively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales).

Table 38 : Regression Analysis, Model 1

		DTC – Business Model Transformation (Marketing & Sales) – A1	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		.117	.920
Firm Revenue (CV)		-.174	-1.396*
Digital Twin (Product Dev.) (IV)	H1-1A1	-.136	-.709
Digital Twin (Product Quality) (IV)	H1-2A1	-.030	-.172
Digital Thread (IV)	H2A1	.470	2.848***
Digital Mindset (IV)	H3A1	-.067	-.622
Moderators			
market turbulence (Product) – M1		-.169	-1.260
market turbulence (Customer) – M2		-.036	-.249
Technology Turbulence – M3		.304	1.931**
Competitive Turbulence – M4		.308	2.579***
Path Dependency – M5		.099	.781
Interaction Effects			
Technology Turbulence			
Digital Twin (Product Dev.) & Technology Turbulence	H4-1A1	.016	.059
Digital Twin (Product Quality) & Technology Turbulence	H4-2A1	-.383	-1.366*
Digital Thread & Technology Turbulence	H5A1	.474	1.934**
Digital Mindset & Technology Turbulence	H6A1	.281	1.598*
Market Turbulence			
Digital Twin (Product Dev.) & market turbulence (Product)	H7-1A1	.241	.853
Digital Twin (Product Dev.) & market turbulence (Customer)	H7-2A1	.045	.224
Digital Twin (Product Quality) & market turbulence (Product)	H7-3A1	.147	.586
Digital Twin (Product Quality) & market turbulence (Customer)	H7-4A1	.109	.732
Digital Thread & market turbulence (Product)	H8-1A1	-.255	-.988
Digital Thread & market turbulence (Customer)	H8-2A1	.168	.810
Digital Mindset & market turbulence (Product)	H9-1A1	-.260	-1.492*
Digital Mindset & market turbulence (Customer)	H9-2A1	-.282	-1.724**

Regression Analysis, Model 1 – Continued

		DTC – Business Model Transformation (Marketing & Sales) - A	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects (Continued)			
Competitive Turbulence			
Digital Twin (Product Dev.) & Competitive Turbulence	H10-1A1	-.390	-1.579*
Digital Twin (Product Quality) & Competitive Turbulence	H10-2-A1	.381	1.920**
Digital Thread & Competitive Turbulence	H11A1	-.325	-1.422*
Digital Mindset & Competitive Turbulence	H12A1	.176	1.083
Path Dependency			
Digital Twin (Product Dev.) & Path Dependency	H13-1A1	-.173	-.743
Digital Twin (Product Quality) & Path Dependency	H13-2A1	.060	.330
Digital Thread & Path Dependency	H14A1	.142	.828
Digital Mindset & Path Dependency	H15A1	.074	.702
Model Summary and F-Value			
R^2	.472		
Adjusted R^2	.241		
F-Value	2.044***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 39 : R2 Changes for Different Models for Model 1 Variables

DTC – Business Model Transformation (Marketing & Sales)		
Model	**R^2**	**Adjusted R^2**
1: CV + IV	.172	,120
2: CV + IV + Moderators	.270	.182
3: CV + IV + Moderators + Interaction terms	.472	.241

The following observations were made from model 1:

- The regression model was significant (F-Value of 2.044 and p-value ≤ 0.01) and the R^2 was 0.472, which indicated that 47.2% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 1 to model 3: it was 0.172 with control variables and independent variables, it increased to 0.270 when moderator variables were added and it increased to 0.472 when interaction items were added.
- In terms of control variable, firm revenue has a negative effect on DTC – Business Model Transformation (Marketing & Sales) ($\beta = -.174$; $p \leq 0.1$).
- In terms of independent variables' direct effects and moderator's effects, it was found that Digital Thread had a positive effect on DTC – Business Model Transformation (Marketing & Sales) ($\beta = .470$; $p \leq 0.01$). Hence, hypothesis, **H2A1 was supported.**
- In terms of moderators, Technology Turbulence had a positive effect on DTC – Business Model Transformation (Marketing & Sales) ($\beta = .304$; $p \leq 0.05$).
- In terms of moderators, Competitive Turbulence had a positive effect on DTC – Business Model Transformation (Marketing & Sales) ($\beta = .308$; $p \leq 0.01$).
- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales) negatively ($\beta = -.383$; $p \leq 0.1$). **Hence, H4-2A1 was not supported.**
- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales) positively ($\beta = .474$; $p \leq 0.05$). **Hence, H5A1 was supported.**

- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales) positively (β = .260; $p \leq 0.1$). **Hence, H6A1 was supported.**
- In terms of interaction effects, market turbulence (Product) moderated the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales) negatively (β = -.260; $p \leq 0.1$). **Hence, H9-1A1 was not supported.**
- In terms of interaction effects, market turbulence (Customer) moderated the relationship between Digital Mindset and DTC – Business Model Transformation (Marketing & Sales) negatively (β = -.282; $p \leq 0.1$). **Hence, H9-2A1 was not supported.**
- In terms of interaction effects, Competitive Turbulence moderated the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Marketing & Sales) negatively (β = -.390; $p \leq 0.1$). **Hence, H10-1A1 was supported.**
- In terms of interaction effects, Competitive Turbulence moderated the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Marketing & Sales) positively (β = .381; $p \leq 0.05$). **Hence, H10-2A1 was not supported.**
- In terms of interaction effects, Competitive Turbulence moderated the relationship between Digital Thread and DTC – Business Model Transformation (Marketing & Sales) negatively (β = -.325; $p \leq 0.1$). **Hence, H11A1 was supported.**

8.6.2 Model 2

Dependent variable: Digital Transformative Capability (DTC) - Business Model Transformation (Customer Engagement).

The following hypotheses were tested in this model:

<u>Digitalization Profile Influences DTC – Business Model Transformation (Customer Engagement)</u>

H1-1A2 – Digital Twin (Product Development) has a positive influence on DTC – Business Model Transformation (Customer Engagement).

H1-2A2 – Digital Twin (Product Quality) has a positive influence on DTC – Business Model Transformation (Customer Engagement).

H2A2 – Digital Thread has a positive influence on DTC – Business Model Transformation (Customer Engagement).

H3A2 – Digital Mindset has a positive influence on DTC – Business Model Transformation (Customer Engagement).

<u>Technology Turbulence as a Moderator</u>

H4-1A2 – Technology Turbulence positively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Customer Engagement).

H4-2A2 – Technology Turbulence positively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Customer Engagement).

H5A2 – Technology Turbulence positively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Customer Engagement).

H6A2 – Technology Turbulence positively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Customer Engagement).

<u>market turbulence as a Moderator</u>

H7-1A2 – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Customer Engagement).

H7-2A2 – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Customer Engagement).

H7-3A2 – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Customer Engagement).

H7-4A2 – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Customer Engagement).

H8-1A2 – market turbulence (Product) positively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Customer Engagement).

H8-2A2 – market turbulence (Customer) positively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Customer Engagement).

H9-1A2 – market turbulence (Product) positively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Customer Engagement).

H9-2A2 – market turbulence (Customer) positively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Customer Engagement).

Competitive Turbulence as a Moderator

H10-1A2 – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Customer Engagement).

H10-2A2 – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Customer Engagement).

H11A2 – Competitive Turbulence negatively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Customer Engagement).

H12A2 – Competitive Turbulence negatively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Customer Engagement).

Path Dependency as a Moderator

H13-1A2 – Path Dependency negatively moderates the relationship between Digital Twin (Product Development) and DTC – Business Model Transformation (Customer Engagement).

H13-2A2 – Path Dependency negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Customer Engagement).

H14A2 – Path Dependency negatively moderates the relationship between Digital Thread and DTC – Business Model Transformation (Customer Engagement).

H15A2 – Path Dependency negatively moderates the relationship between Digital Mindset and DTC – Business Model Transformation (Customer Engagement).

Table 40 : Regression Analysis, Model 2

		DTC – Business Model Transformation (Customer Engagement) – A2	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		-.078	-.633
Firm Revenue (CV)		-.063	-.519
Digital Twin (Product Dev.) (IV)	H1-1A2	-.104	-.560
Digital Twin (Product Quality) (IV)	H1-2A2	.037	.223
Digital Thread (IV)	H2A2	.399	2.505***
Digital Mindset (IV)	H3A2	.059	.568
Moderators			
market turbulence (Product) – M1		-.083	-.638
market turbulence (Customer) – M2		.231	1.661**
Technology Turbulence – M3		.389	2.562***
Competitive Turbulence – M4		-.165	-1.425*
Path Dependency – M5		.048	.389
Interaction Effects			
Technology Turbulence			
Digital Twin (Product Dev.) & Technology Turbulence	H4-1A2	.284	1.106
Digital Twin (Product Quality) & Technology Turbulence	H4-2A2	-.262	-.966
Digital Thread & Technology Turbulence	H5A2	-.076	-.323
Digital Mindset & Technology Turbulence	H6A2	.234	1.372*
Market Turbulence			
Digital Twin (Product Dev.) & market turbulence (Product)	H7-1A2	.233	.853
Digital Twin (Product Dev.) & market turbulence (Customer)	H7-2A2	-.260	-1.329*
Digital Twin (Product Quality) & market turbulence (Product)	H7-3A2	.097	.398
Digital Twin (Product Quality) & market turbulence (Customer)	H7-4A2	-.017	-.118
Digital Thread & market turbulence (Product)	H8-1A2	-.208	-.833
Digital Thread & market turbulence (Customer)	H8-2A2	.363	1.807**
Digital Mindset & market turbulence (Product)	H9-1A2	-.121	-.718
Digital Mindset & market turbulence (Customer)	H9-2A2	-.117	-.738

Regression Analysis, Model 2 – Continued

		DTC – Business Model Transformation (Customer Engagement) – A2	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects (Continued)			
Competitive Turbulence			
Digital Twin (Product Dev.) & Competitive Turbulence	H10-1A2	-.327	-1.370*
Digital Twin (Product Quality) & Competitive Turbulence	H10-2-A2	.207	1.080
Digital Thread & Competitive Turbulence	H11A2	.209	.943
Digital Mindset & Competitive Turbulence	H12A2	.025	.158
Path Dependency			
Digital Twin (Product Dev.) & Path Dependency	H13-1A2	-.190	-.841
Digital Twin (Product Quality) & Path Dependency	H13-2A2	.332	1.897**
Digital Thread & Path Dependency	H14A2	-.110	-.662
Digital Mindset & Path Dependency	H15A2	-.039	-.382
Model Summary and F-Value			
R^2	.507		
Adjusted R^2	.291		
F-Value	2.352***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 41 : R2 Changes for Different Models for Model 2 Variables

DTC – Business Model Transformation (Customer Engagement)		
Model	**R^2**	**Adjusted R^2**
1: CV + IV	.247	.200
2: CV + IV + Moderators	.329	.248
3: CV + IV + Moderators + Interaction terms	.507	.291

The following observations were made from model 2:

- The regression model was significant (F-Value of 2.352 and p-value ≤ 0.01) and the R^2 was 0.507, which indicated that 50.7% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 1 to model 3: it was 0.247 with control variables and independent variables, it increased to 0.329 when moderator variables were added, and it increased to 0.507 when interaction items were added.
- In terms of independent variables' direct effects and moderator's effects, it was found that Digital Thread had a positive effect on DTC – Business Model Transformation (Customer Engagement) ($\beta = .399$; $p \leq 0.01$). Hence, hypothesis, **H2-A2 was supported.**
- In terms of moderators, market turbulence (Customer) had a positive effect on DTC – Business Model Transformation (Customer Engagement) ($\beta = .231$; $p \leq 0.05$).
- In terms of moderators, Technology Turbulence had a positive effect on DTC – Business Model Transformation (Customer Engagement) ($\beta = .389$; $p \leq 0.01$).
- In terms of moderators, Competitive Turbulence had a negative effect on DTC – Business Model Transformation (Customer Engagement) ($\beta = -.165$; $p \leq 0.1$).
- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Mindset and DTC – Business Model Transformation (Customer Engagement) positively ($\beta = .234$; $p \leq 0.1$). **Hence, H6A2 was supported.**
- In terms of interaction effects, market turbulence (Customer) moderated the relationship between Digital Twin (Product Dev.) and DTC – Business Model Transformation

(Customer Engagement) negatively (β = -.260; $p \leq 0.1$). **Hence, H7-2A2 was not supported.**

- In terms of interaction effects, market turbulence (Customer) moderated the relationship between Digital Thread and DTC – Business Model Transformation (Customer Engagement) positively (β = .363; $p \leq 0.05$). **Hence, H8-2A2 was supported.**
- In terms of interaction effects, Competitive Turbulence moderated the relationship between Digital Twin (Product Dev.) and DTC – Business Model Transformation (Customer Engagement) negatively (β = -.327; $p \leq 0.1$). **Hence, H10-1A2 was supported.**
- In terms of interaction effects, Path Dependency moderated the relationship between Digital Twin (Product Quality) and DTC – Business Model Transformation (Customer Engagement) positively (β = .332; $p \leq 0.05$). **Hence, H13-2A2 was not supported.**

8.6.3 Model 3:

Dependent variable: Digital Transformative Capability (DTC) – Operating Model Transformation.

The following hypotheses were tested in this model:

<u>Digitalization Profile Influences DTC – Operating Model Transformation</u>

H1-1B – Digital Twin (Product Development) has a positive influence on DTC – Operating Model Transformation.

H1-2B – Digital Twin (Product Quality) has a positive influence on DTC – Operating Model Transformation.

H2B – Digital Thread has a positive influence on DTC – Operating Model Transformation.

H3B – Digital Mindset has a positive influence on DTC – Operating Model Transformation.

<u>Technology Turbulence as a Moderator</u>

H4-1B - Technology Turbulence positively moderates the relationship between Digital Twin (Product Development) and DTC – Operating Model Transformation.

H4-2B - Technology Turbulence positively moderates the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation.

H5B - Technology Turbulence positively moderates the relationship between Digital Thread and DTC – Operating Model Transformation.

H6B - Technology Turbulence positively moderates the relationship between Digital Mindset and DTC – Operating Model Transformation.

<u>market turbulence as a Moderator</u>

H7-1B – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Development) and DTC – Operating Model Transformation.

H7-2B – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Development) and DTC – Operating Model Transformation.

H7-3B – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation.

H7-4B – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation.

H8-1B– market turbulence (Product) positively moderates the relationship between Digital Thread and DTC – Operating Model Transformation.

H8-2B – market turbulence (Customer) positively moderates the relationship between Digital Thread and DTC – Operating Model Transformation

H9-1B – market turbulence (Product) positively moderates the relationship between Digital Mindset and DTC – Operating Model Transformation.

H9-2B – market turbulence (Customer) positively moderates the relationship between Digital Mindset and DTC – Operating Model Transformation.

Competitive Turbulence as a Moderator

H10-1B – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and DTC – Operating Model Transformation.

H10-2B – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation.

H11B – Competitive Turbulence negatively moderates the relationship between Digital Thread and DTC – Operating Model Transformation.

H12B – Competitive Turbulence negatively moderates the relationship between Digital Mindset and DTC – Operating Model Transformation.

Path Dependency as a Moderator

H13-1B – Path Dependency negatively moderates the relationship between Digital Twin (Product Development) and DTC – Operating Model Transformation.

H13-2B – Path Dependency negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation.

H14B – Path Dependency negatively moderates the relationship between Digital Thread and DTC – Operating Model Transformation.

H15B – Path Dependency negatively moderates the relationship between Digital Mindset and DTC – Operating Model Transformation.

Table 42 : Regression Analysis, Model 3

		DTC – Operating Model Transformation - B	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		-.112	-1.047
Firm Revenue (CV)		-.016	-.157
Digital Twin (Product Dev.) (IV)	H1-1B	.009	.055
Digital Twin (Product Quality) (IV)	H1-2B	-.014	-.095
Digital Thread (IV)	H2B	.381	2.748***
Digital Mindset (IV)	H3B	-.004	-.047
Moderators			
market turbulence (Product) – M1		-.051	-.457
market turbulence (Customer) – M2		.135	1.111
Technology Turbulence – M3		.114	.864
Competitive Turbulence – M4		-.081	-.809
Path Dependency – M5		.100	.946
Interaction Effects			
Technology Turbulence			
Digital Twin (Product Dev.) & Technology Turbulence	H4-1B	-.100	-.448
Digital Twin (Product Quality) & Technology Turbulence	H4-2B	-.443	-1.879**
Digital Thread & Technology Turbulence	H5B	-.179	-.869
Digital Mindset & Technology Turbulence	H6B	.296	1.999**
Market Turbulence			
Digital Twin (Product Dev.) & market turbulence (Product)	H7-1B	.069	.291
Digital Twin (Product Dev.) & market turbulence (Customer)	H7-2B	.116	.682
Digital Twin (Product Quality) & market turbulence (Product)	H7-3B	.522	2.467***
Digital Twin (Product Quality) & market turbulence (Customer)	H7-4B	-.096	-.768
Digital Thread & market turbulence (Product)	H8-1B	.025	.117
Digital Thread & market turbulence (Customer)	H8-2B	.337	1.929**
Digital Mindset & market turbulence (Product)	H9-1B	-.228	-1.557*
Digital Mindset & market turbulence (Customer)	H9-2B	-.212	-1.545*

Regression Analysis, Model 3 – Continued

		DTC – Operating Model Transformation - B	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects (Continued)			
Competitive Turbulence			
Digital Twin (Product Dev.) & Competitive Turbulence	H10-1B	-.347	-1.674**
Digital Twin (Product Quality) & Competitive Turbulence	H10-2B	.215	1.291*
Digital Thread & Competitive Turbulence	H11B	-.005	-.027
Digital Mindset & Competitive Turbulence	H12B	.156	1.144
Path Dependency			
Digital Twin (Product Dev.) & Path Dependency	H13-1B	.140	.717
Digital Twin (Product Quality) & Path Dependency	H13-2B	.220	1.446*
Digital Thread & Path Dependency	H14B	-.554	-3.840***
Digital Mindset & Path Dependency	H15B	-.016	-.178
Model Summary and F-Value			
R^2	.627		
Adjusted R^2	.464		
F-Value	3.854***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 43 : R2 Changes for Different Models for Model 3 Variables

DTC – Operating Model Transformation		
Model	**R^2**	**Adjusted R^2**
1: CV + IV	.301	.257
2: CV + IV + Moderators	.330	.248
3: CV + IV + Moderators + Interaction terms	.627	.464

The following observations were made from model 3:

- The regression model was significant (F-Value of 3.854 and p-value ≤ 0.01) and the R^2 was 0.627, which indicated that 62.7% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 1 to model 3: it was 0.301 with control variables and independent variables, it increased to 0.330 when moderator variables were added, and it increased to 0.627 when interaction items were added.
- In terms of independent variables' direct effects and moderator's effects, it was found that Digital Thread had a positive effect on DTC – Operating Model Transformation (β = .381; $p \leq 0.01$). Hence, hypothesis, **H2B was supported.**
- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation negatively (β = -.443; $p \leq 0.05$). **Hence, H4-2B was not supported.**
- In terms of interaction affects, Technology Turbulence moderated the relationship between Digital Mindset and DTC – Operating Model Transformation positively (β = .296; $p \leq 0.05$). **Hence, H6B was supported.**
- In terms of interaction effects, market turbulence (Product) moderated the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation positively (β = .522; $p \leq 0.01$). **Hence, H7-3B was supported.**
- In terms of interaction effects, market turbulence (Customer) moderated the relationship between Digital Thread and DTC – Operating Model Transformation positively (β = .337; $p \leq 0.05$). **Hence, H8-2B was supported.**

- In terms of interaction affects, Marketing Turbulence (Product) moderated the relationship between Digital Mindset and DTC – Operating Model Transformation negatively ($\beta = -.228$; $p \leq 0.1$). **Hence, H9-1B was not supported.**
- In terms of interaction affects, Marketing Turbulence (Customer) moderated the relationship between Digital Mindset and DTC – Operating Model Transformation negatively ($\beta = -.212$; $p \leq 0.1$). **Hence, H9-2B was not supported.**
- In terms of interaction effects, Competitive Turbulence, moderated the relationship between Digital Twin (Product Development) and DTC – Operating Model Transformation negatively ($\beta = -.347$; $p \leq 0.05$). **Hence, H10-1B was supported.**
- In terms of interaction effects, Competitive Turbulence moderated the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation positively ($\beta = .215$; $p \leq 0.1$). **Hence, H10-2B was not supported.**
- In terms of interaction effects, Path Dependency moderated the relationship between Digital Twin (Product Quality) and DTC – Operating Model Transformation positively ($\beta = .220$; $p \leq 0.1$). **Hence, H13-2B was not supported.**
- In terms of interaction affects, Path Dependency moderated the relationship between Digital Thread and DTC – Operating Model Transformation negatively ($\beta = -.554$; $p \leq 0.01$). **Hence, H14B was supported.**

8.6.4 Model 4:

Dependent variable: Digital Transformative Capability (DTC) – Cultural Transformation

The following hypotheses were tested in this model:

<u>Digitalization Profile Influences DTC – Cultural Transformation</u>

H1-1C – Digital Twin (Product Development) has a positive influence on DTC – Cultural Transformation.

H1-2C – Digital Twin (Product Quality) has a positive influence on DTC- Cultural Transformation.

H2C – Digital Thread has a positive influence on DTC – Cultural Transformation.

H3C – Digital Mindset has a positive influence on DTC – Cultural Transformation.

<u>Technology Turbulence as a Moderator</u>

H4-1C – Technology Turbulence positively moderates the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation.

H4-2C - Technology Turbulence positively moderates the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation.

H5C - Technology Turbulence positively moderates the relationship between Digital Thread and DTC – Cultural Transformation.

H6C - Technology Turbulence positively moderates the relationship between Digital Mindset and DTC – Cultural Transformation.

<u>market turbulence as a Moderator</u>

H7-1C – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation.

H7-2C – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation.

H7-3C – market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation.

H7-4C – market turbulence (Customer) positively moderates the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation.

H8-1C– market turbulence (Product) positively moderates the relationship between Digital Thread and DTC – Cultural Transformation.

H8-2C – market turbulence (Customer), positively moderates the relationship between Digital Thread and DTC – Cultural Transformation.

H9-1C – market turbulence (Product) positively moderates the relationship between Digital Mindset and DTC – Cultural Transformation.

H9-2C – market turbulence (Customer) positively moderates the relationship between Digital Mindset and DTC – Cultural Transformation.

Competitive Turbulence as a Moderator

H10-1C – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation.

H10-2C – Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation.

H11C – Competitive Turbulence negatively moderates the relationship between Digital Thread and DTC – Cultural Transformation.

H12C – Competitive Turbulence negatively moderates the relationship between Digital Mindset and DTC – Cultural Transformation.

Path Dependency as a Moderator

H13-1C – Path Dependency negatively moderates the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation.

H13-2C – Path Dependency negatively moderates the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation.

H14C – Path Dependency negatively moderates the relationship between Digital Thread and DTC – Cultural Transformation.

H15C – Path Dependency, negatively moderates the relationship between Digital Mindset and DTC – Cultural Transformation.

Table 44 : Regression Analysis, Model 4

		DTC – Cultural Transformation - C	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		-.049	-.424
Firm Revenue (CV)		.089	.785
Digital Twin (Product Dev.) (IV)	H1-1C	-.049	-.283
Digital Twin (Product Quality) (IV)	H1-2C	-.062	-.398
Digital Thread (IV)	H2C	.455	3.049***
Digital Mindset (IV)	H3C	.145	1.492*
Moderators			
market turbulence (Product) – M1		.028	.233
market turbulence (Customer) – M2		-.179	-1.375*
Technology Turbulence – M3		.321	2.257**
Competitive Turbulence – M4		.035	.327
Path Dependency – M5		.173	1.517*
Interaction Effects			
Technology Turbulence			
Digital Twin (Product Dev.) & Technology Turbulence	H4-1C	.396	1.648**
Digital Twin (Product Quality) & Technology Turbulence	H4-2C	-.528	-2.081**
Digital Thread & Technology Turbulence	H5C	-.084	-.377
Digital Mindset & Technology Turbulence	H6C	.207	1.299*
Market Turbulence			
Digital Twin (Product Dev.) & market turbulence (Product)	H7-1C	-.481	-1.880**
Digital Twin (Product Dev.) & market turbulence (Customer)	H7-2C	.267	1.462*
Digital Twin (Product Quality) & market turbulence (Product)	H7-3C	.445	1.957**
Digital Twin (Product Quality) & market turbulence (Customer)	H7-4C	-.179	-1.328*
Digital Thread & market turbulence (Product)	H8-1C	.313	1.342*
Digital Thread & market turbulence (Customer)	H8-2C	.066	.354
Digital Mindset & market turbulence (Product)	H9-1C	-.118	-.748
Digital Mindset & market turbulence (Customer)	H9-2C	.015	.100

Regression Analysis, Model 4 – Continued

		DTC – Cultural Transformation – C	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects (Continued)			
Competitive Turbulence			
Digital Twin (Product Dev.) & Competitive Turbulence	H10-1C	-.094	-.420
Digital Twin (Product Quality) & Competitive Turbulence	H10-2C	.024	.133
Digital Thread & Competitive Turbulence	H11C	.087	.422
Digital Mindset & Competitive Turbulence	H12C	-.007	-.046
Path Dependency			
Digital Twin (Product Dev.) & Path Dependency	H13-1C	-.507	-2.406***
Digital Twin (Product Quality) & Path Dependency	H13-2C	.436	2.663***
Digital Thread & Path Dependency	H14C	-.062	-.397
Digital Mindset & Path Dependency	H15C	-.026	-.276
Model Summary and F-Value			
R^2	.568		
Adjusted R^2	.380		
F-Value	3.016***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 45 : R2 Changes for Different Models for Model 4 Variables

DTC – Cultural Transformation		
Model	**R^2**	**Adjusted R^2**
1: CV + IV	.360	.320
2: CV + IV + Moderators	.372	.296
3: CV + IV + Moderators + Interaction terms	.568	.380

The following observations were made from the model 4:

- The regression model was significant (F-Value of 3.016 and p-value ≤ 0.01) and the R^2 was 0.568, which indicated that 56.8% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 1 to model 3: it was 0.360 with control variables and independent variables, it increased to 0.372 when moderator variables were added and it increased to 0.568 when interaction items were added.
- In terms of independent variables' direct effects and moderator's effects, it was found that Digital Thread had a positive effect on DTC – Cultural Transformation ($\beta = .455$; $p \leq 0.01$). Hence, hypothesis, **H2C was supported.**
- In terms of independent variables' direct effects and moderator's effects, it was found that Digital Mindset had a positive effect on DTC – Cultural Transformation ($\beta = .145$; $p \leq 0.1$). Hence, hypothesis, **H3C was supported.**
- In terms of moderators, market turbulence (Customer) had a negative effect on DTC – Cultural Transformation ($\beta = -.179$; $p \leq 0.1$).
- In terms of moderators, Technology Turbulence had a positive effect on DTC – Cultural Transformation ($\beta = .321$; $p \leq 0.05$).
- In terms of moderators, Path Dependency had a positive effect on DTC – Cultural Transformation ($\beta = .173$; $p \leq 0.1$).
- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation positively ($\beta = .396$; $p \leq 0.05$). **Hence, H4-1C was supported.**

- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation negatively (β = -.528; $p \leq 0.05$). **Hence, H4-2C was not supported.**
- In terms of interaction effects, Technology Turbulence moderated the relationship between Digital Mindset and DTC – Cultural Transformation positively (β = .207; $p \leq 0.1$). **Hence, H6C was supported.**
- In terms of interaction effects, market turbulence (Product), moderated the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation negatively (β = -.481 $p \leq 0.05$). **Hence, H7-1C was not supported.**
- In terms of interaction effects, market turbulence (Customer), moderated the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation positively (β = .267; $p \leq 0.1$). **Hence, H7-2C was supported.**
- In terms of interaction effects, market turbulence (Product), moderated the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation Positively (β = .445; $p \leq 0.05$). **Hence, H7-3C was supported.**
- In terms of interaction effects, market turbulence (Customer) moderated the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation negatively (β = -.179; $p \leq 0.1$). **Hence, H7-4C was not supported.**
- In terms of interaction effects, market turbulence (Product), moderated the relationship between Digital Thread and DTC – Cultural Transformation positively (β = .313; $p \leq 0.1$). **Hence, H8-1C was supported.**

- In terms of interaction effects, Path Dependency moderated the relationship between Digital Twin (Product Development) and DTC – Cultural Transformation negatively ($\beta = -.507$; $p \leq 0.01$). **Hence, H13-1C was supported.**
- In terms of interaction effects, Path Dependency moderated the relationship between Digital Twin (Product Quality) and DTC – Cultural Transformation positively ($\beta = .436$; $p \leq 0.01$). **Hence, H13-2C was not supported.**

Table 46 : Regression Analysis, Summary Result (Front-end Model)

		Dependent Variables			
Variables	**Hypothesis**	**DTCBMT_MS (A1)**	**DTCBMT_CE (A2)**	**DCCOMT (B)**	**DTCCLT (C)**
Firm Age (CV)					
Firm Revenue (CV)		-ve			
Digital Twin (Product Dev.) (IV)	H1-1A1-C				
Digital Twin (Product Quality) (IV)	H1-2A1-C				
Digital Thread (IV)	H2A1-C	√	√	√	√
Digital Mindset (IV)	H3A1-C				√
Moderators					
market turbulence (Product)	M1				
market turbulence (Customer)	M2		√		-ve
Technology Turbulence	M3	√	√		√
Competitive Turbulence	M4	√	-ve		
Path Dependency	M5				√
Interaction Effects					
Technology Turbulence					
Digital Twin (Product Dev.) & Technology Turbulence	H4-1A1-C				√
Digital Twin (Product Quality) & Technology Turbulence	H4-2A1-C	-ve		-ve	-ve
Digital Thread & Technology Turbulence	H5A1-C	√			
Digital Mindset & Technology Turbulence	H6A1-C	√	√	√	√
Market Turbulence					
Digital Twin (Product Dev.) & market turbulence (Product)	H7-1A1-C				-ve
Digital Twin (Product Dev.) & market turbulence (Customer)	H7-2A1-C		-ve		√
Digital Twin (Product Quality) & market turbulence (Product)	H7-3A1-C			√	√
Digital Twin (Product Quality) & market turbulence (Customer)	H7-4A1-C				-ve
Digital Thread & market turbulence (Product)	H8-1A1-C				√
Digital Thread & market turbulence (Customer)	H8-2A1-C		√	√	

Regression Analysis, Summary Result (Front-end Model) Continued

		Dependent Variables			
Variables	**Hypothesis**	**DTCBMT_MS (A1)**	**DTCBMT_CE (A2)**	**DCCOMT (B)**	**DTCCLT (C)**
Interaction Effects					
market turbulence (Continued)					
Digital Mindset & market turbulence (Product)	H9-1A1-C	-ve		-ve	
Digital Mindset & market turbulence (Customer)	H9-2A1-C	-ve		-ve	
Competitive Turbulence					
Digital Twin (Product Dev.) & Competitive Turbulence	H10-1A1-C	√	√	√	
Digital Twin (Product Quality) & Competitive Turbulence	H10-2A1-C	+ve		+ve	
Digital Thread & Competitive Turbulence	H11A1-C	√			
Digital Mindset & Competitive Turbulence	H12-A1-C				
Path Dependency					
Digital Twin (Product Dev.) & Path Dependency	H13-1A1-C				√
Digital Twin (Product Quality) & Path Dependency	H13-2A1-C		+ve	+ve	+ve
Digital Thread & Path Dependency	H14A1-C			√	
Digital Mindset & Path Dependency	H15A1-C				

DTCBMT_MS = DTC – Business Model Transformation (Marketing & Sales)
DTCBMT_CE = DTC – Business Model Transformation (Customer)
DCCOMT = DTC – Operating Model Transformation
DTCCLT = DTC – Cultural Transformation

8.7 Exploratory Factor Analysis (EFA) – Back-End Model

The EFA analyses for the back-end model are included in the subsequent sections.

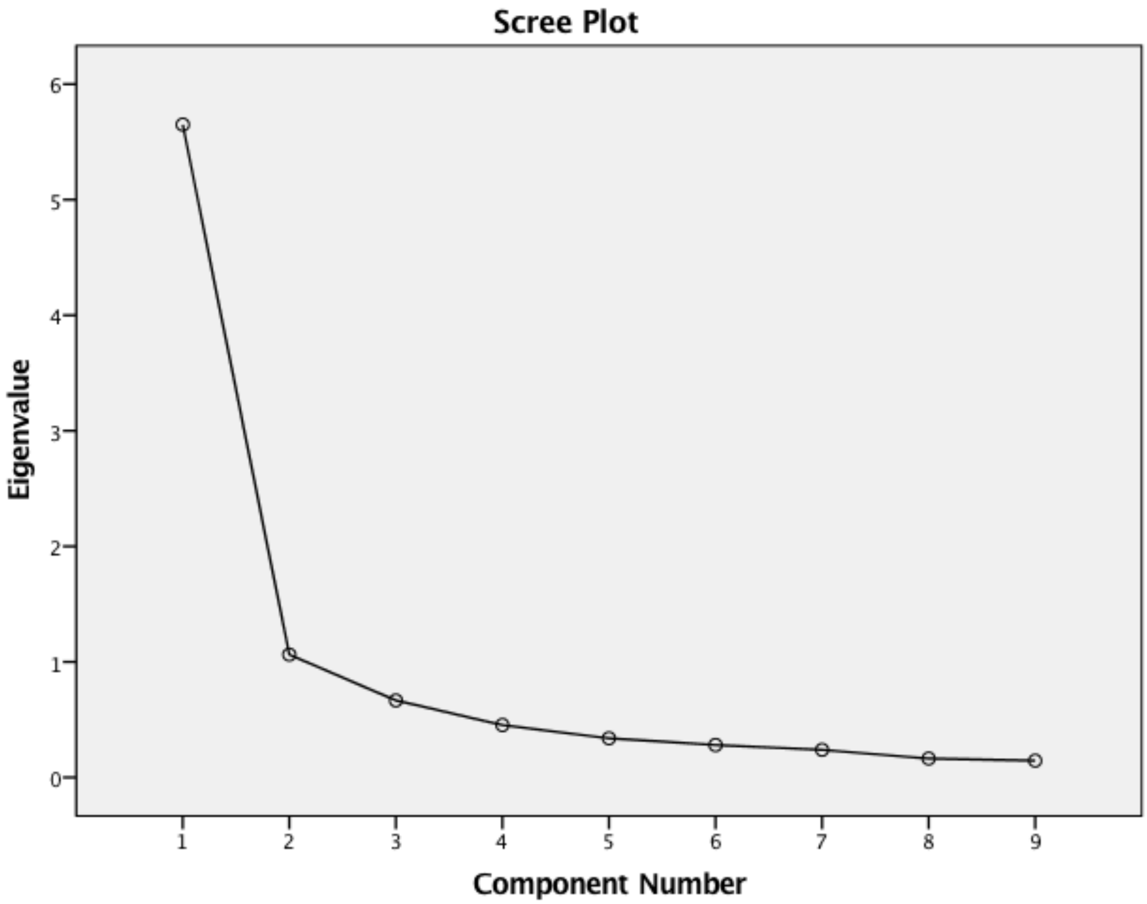
8.7.1 Ecosystem Partnership

Table 47 : EFA Ecosystem Partnership (ECOPART)

Kaiser-Meyer-Olkin Measure		0.905
Bartlett's Test of Sphericity	Approx. Chi-Square	680.291
	df	36
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	Our activities with alliance partners are well coordinated.	.769
2	There is a great deal of interaction with our alliance partners in most decisions.	.690
3	We ensure an appropriate coordination among the activities of our different alliances.	.849
4	We determine the area of synergy in our alliance portfolio.	.782
5	We ensure that interdependencies between our alliances are identified.	.827
6	We ensure that interdependencies between our alliances are identified.	.722
7	We can successfully integrate our existing knowledge with new information acquired from our alliance partners.	.725
8	Collaboration among ecosystem partners is a key success factor for Industrial IoT.	.776
9	Inter-firm collaboration is helping us to create specific intellectual property.	.573

Extraction Method: Principal Component Analysis



Factor Loading (Rotated Component Matrix)			
Var. No	**Variable description**	**Component 1**	**Component 2**
1	Our activities with alliance partners are well coordinated	.862	
2	There is a great deal of interaction with our alliance partners in most decisions.	.817	
3	We ensure an appropriate coordination among the activities of our different alliances.	.910	
4	We determine the area of synergy in our alliance portfolio.	.825	
5	We ensure that interdependencies between our alliances are identified.	.890	
6	We ensure that interdependencies between our alliances are identified.	.763	
7	We can successfully integrate our existing knowledge with new information acquired from our alliance partners.	.659	.539
8	Collaboration among ecosystem partners is a key		.881

	success factor for Industrial IoT.		
9	Inter-firm collaboration is helping us to create specific intellectual property.		.659

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Since the cross-loading of factor 7 is high, it is taken out from the analysis. Factor analysis was performed with 6 measures (1 through 6).

Factor Loading (Rotated Component Matrix) – Component 1		
Var. No	**Variable description**	**Only one component was extracted.**
1	Our activities with alliance partners are well coordinated	
2	There is a great deal of interaction with our alliance partners in most decisions.	
3	We ensure an appropriate coordination among the activities of our different alliances.	
4	We determine the area of synergy in our alliance portfolio.	
5	We ensure that interdependencies between our alliances are identified.	
6	We ensure that interdependencies between our alliances are identified.	

The factor analysis was performed for measures 8 and 9 for component 2.

Factor Loading (Rotated Component Matrix) – Component 1		
Var. No	**Variable description**	**Only one component was extracted.**
8	Collaboration among ecosystem partners is a key success factor for Industrial IoT.	
9	Inter-firm collaboration is helping us to create specific intellectual property.	

Reliability Statistics

Ecosystem Partnership (Component 1)	**Cronbach's Alpha – 0.939 (number of items 6)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.929
	2	.934
	3	.920
	4	.926
	5	.922
	6	.936

Ecosystem Partnership (Component 2)	**Cronbach's Alpha – 0.490 (number of items 2)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	8	.
	9	.

The factor analysis was performed for all 9 variables of Ecosystem Partnership (see Table 47). The KMO measure was 0.905 and the significance value of Bartlett's Test of Sphericity was 0.00, which indicated that the data was factorable.

Based on factor loading (rotated component matrix), variables 1 through 6 had better loadings on component 1. Variable 7 had cross-loadings more than 0.5 on both components so, it was dropped from the analysis.

Factor analyses were performed again for component 1 (variables 1 through 6) and it resulted in one factor. Factor analysis for component 2 (variables 8 and 9) also resulted in one factor. However, by carefully reviewing variable 9, it was decided to remove variable 9 as it was not a proper representation of ecosystem partnership. So, component 2 was eliminated entirely.

Based on the reliability statistics, Cronbach's Alpha for Ecosystem Partnership (component 1) was 0.939 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 6 were considered for component 1.

Based on the reliability statistics, Cronbach's Alpha for Ecosystem Partnership (component 2) was low (0.490) and carefully reviewing variable 9, it was decided to remove variable 9 as it was not a proper representation of ecosystem partnership. So, component 2 was eliminated entirely.

Thus, Ecosystem Partnership has 1 component and variables are 1 through 6.

8.7.2 Customer and Market Demands

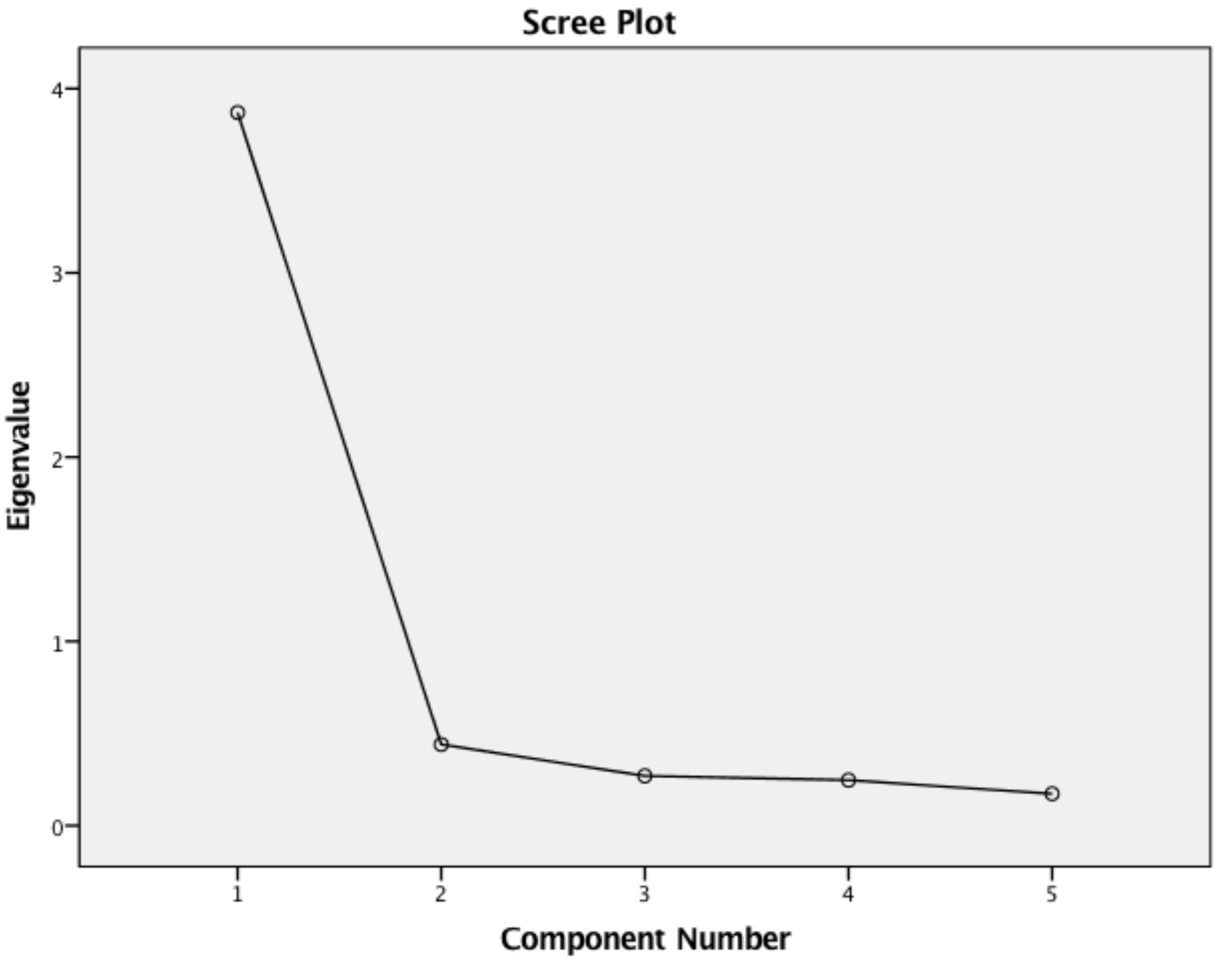
Table 48 : EFA Customer and Market Demands (CUSTMKT)

Kaiser-Meyer-Olkin Measure		0.873
Bartlett's Test of Sphericity	Approx. Chi-Square	391.293
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	We have significant demands from our customers for IIoT solutions.	.767
2	We are delivering significant number of IIoT-based products and services in the next year.	.749
3	Our competitors are delivering significant number of IIoT-based products and service in this year.	.749
4	Some of our customers have implemented IIoT solutions.	.767
5	Some of our customers have plans to use IIoT solution in the next year.	.838

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.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Component Number
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3
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5

Reliability Statistics

Customer and Market Demands	Cronbach's Alpha – 0.925 (number of items 5)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.908
	2	.911
	3	.912
	4	.909
	5	.899

The factor analysis was performed for all five variables of Customer and Market Demands (see Table 48). The KMO measure was 0.873 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables. Only one component was extracted.

The Cronbach's Alpha for Customer and Market Demands was 0.925 and there were no significant improvement in Cronbach's Alpha value by deleting items, so variables 1 through 5 were kept for Customer and Market Demands.

8.7.3 Digital Commitment

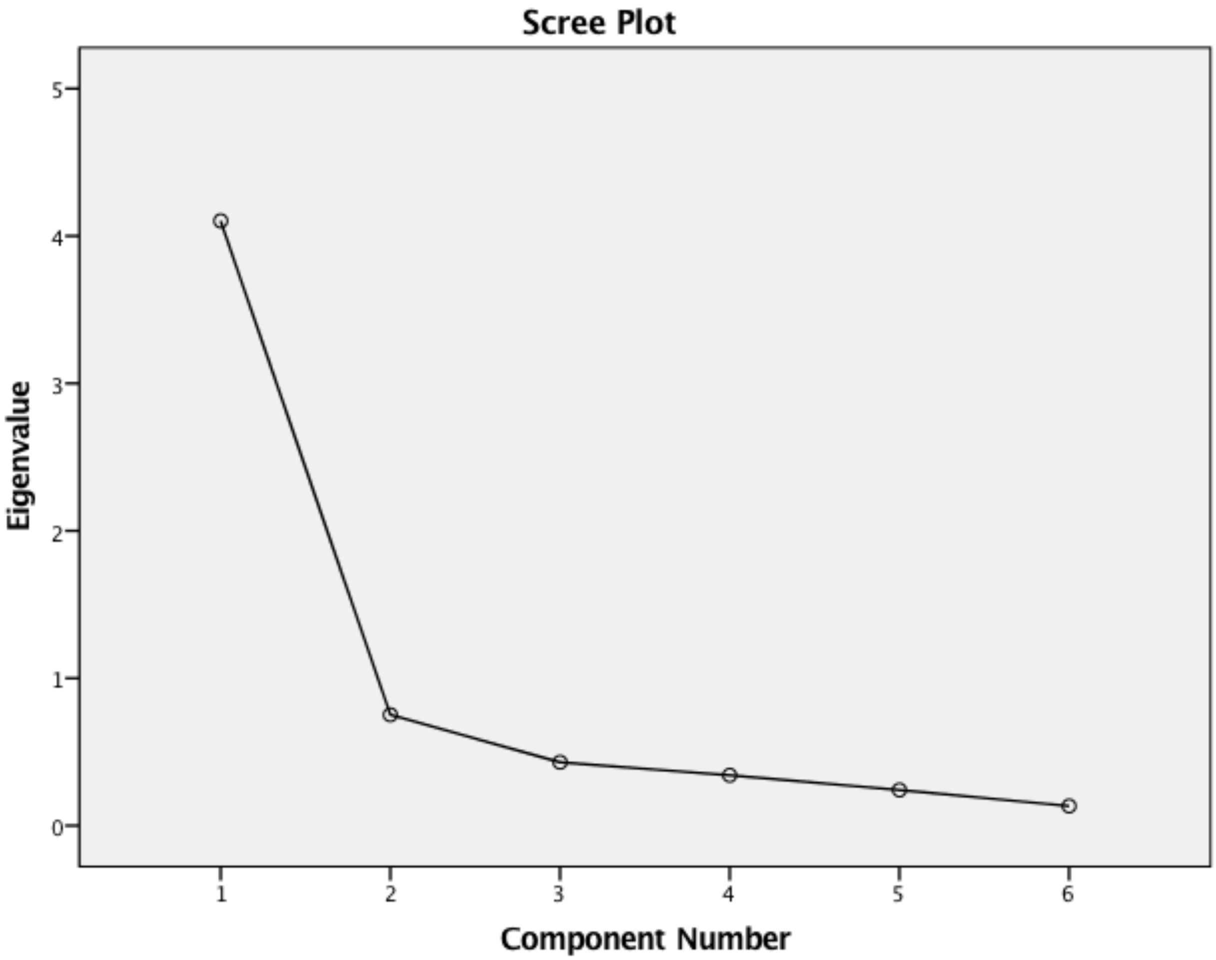
Table 49 : EFA Digital Commitment (DIGCOM)

Kaiser-Meyer-Olkin Measure		0.829
Bartlett's Test of Sphericity	Approx. Chi-Square	419.587
	df	15
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	Most of our business processes (generating leads, sales information, manufacturing information etc.) are digitized.	.638
2	Most of our business routines (new product development, after sales support, manufacturing execution system etc.) are digitized.	.662
3	Our senior executives are committed for Digital Transformation.	.688
4	We have developed digital strategies for the next three years	.761
5	We are implementing digital strategies for our groups/businesses.	.755
6	We have formed strategic partnerships for Digital Transformation.	.598

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.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6
Component Number

Reliability Statistics

Customer and Market Demands	Cronbach's Alpha – 0.904 (number of items 6)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.892
	2	.888
	3	.886
	4	.880
	5	.882
	6	.897

The factor analysis was performed for all six variables of Digital Commitment (see Table 49). The KMO measure was 0.904 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables. Only one component was extracted.

The Cronbach's Alpha for Digital Commitment was 0.904 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 6 were kept for Digital Commitment.

8.7.4 Resource Scarcity and Constraints

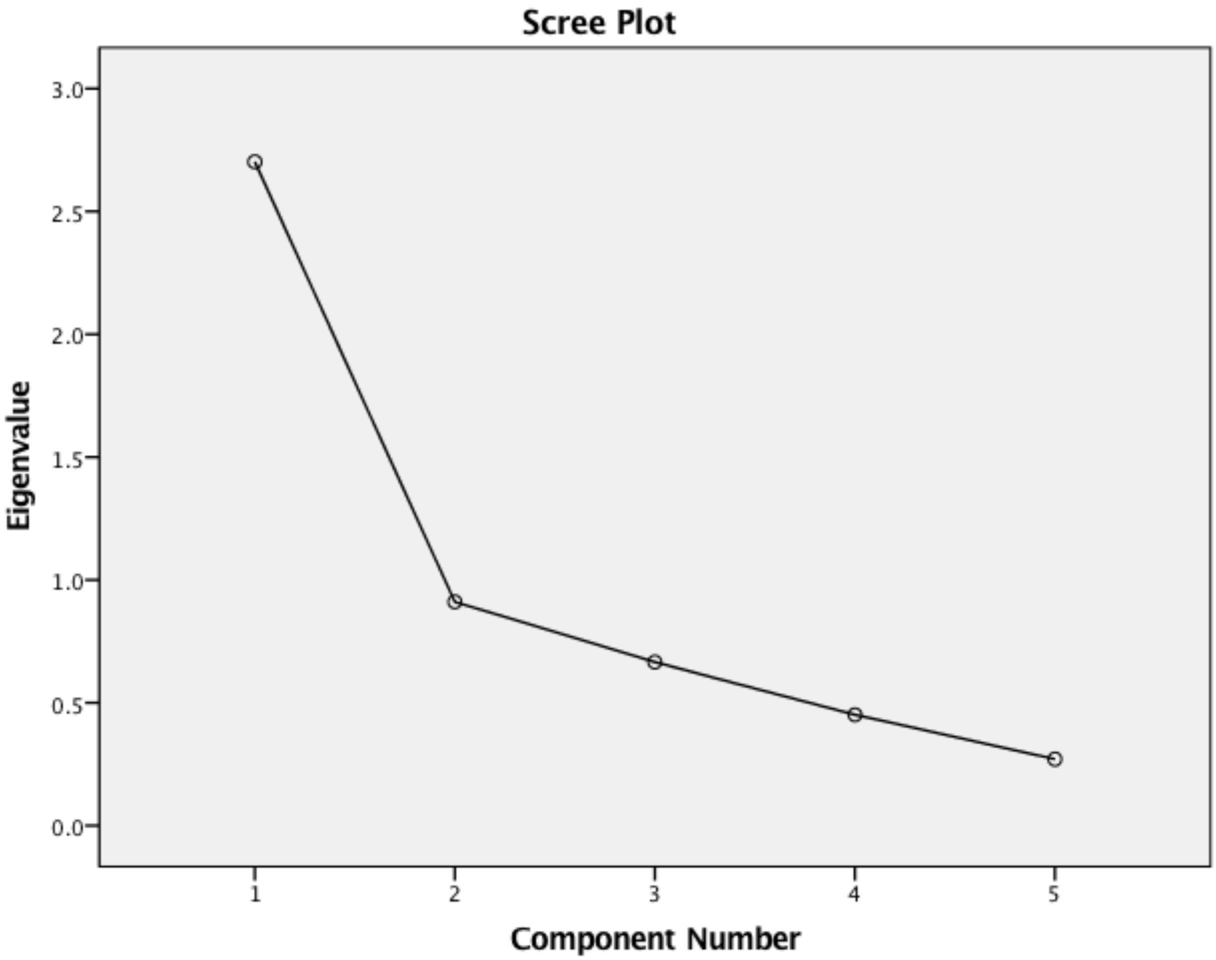
Table 50 : EFA Resource Scarcity and Constraints (RESCON)

Kaiser-Meyer-Olkin Measure		0.768
Bartlett's Test of Sphericity	Approx. Chi-Square	160.153
	df	10
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	We face a shortage of skilled personnel (proper software and domain knowledge) for implementing digital strategies in our organization.	.467
2	We face a shortage of financial resources for implementing digital strategies in our organization.	.575
3	We face a shortage of managerial capacity for implementing digital strategies in our organization.	.739
4	The shortage of resources is delaying our digital projects.	.738
5	We understand the Digital Transformation projects are resource intensive and multi-years projects.	.183

Extraction Method: Principal Component Analysis

Only one component was found (extracted), therefore that component represented the construct.



Reliability Statistics

Customer and Market Demands	Cronbach's Alpha – 0.775 (number of items 5)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.748
	2	.728
	3	.682
	4	.673
	5	.813

The factor analysis was performed for all five variables of Resource Scarcity and Constraints (see Table 50). The KMO measure was 0.768 and the significance value of Bartlett's Test of Sphericity was 0.00. So, the KMO and Bartlett's Test of Sphericity indicated that the factor analysis could be performed for these variables. Only one component was extracted.

The Cronbach's Alpha for Resource Scarcity and Constraints was 0.775 and there were no significant improvements in Cronbach's Alpha value by deleting items, so variables 1 through 5 were retained for Resource Scarcity and Constraints.

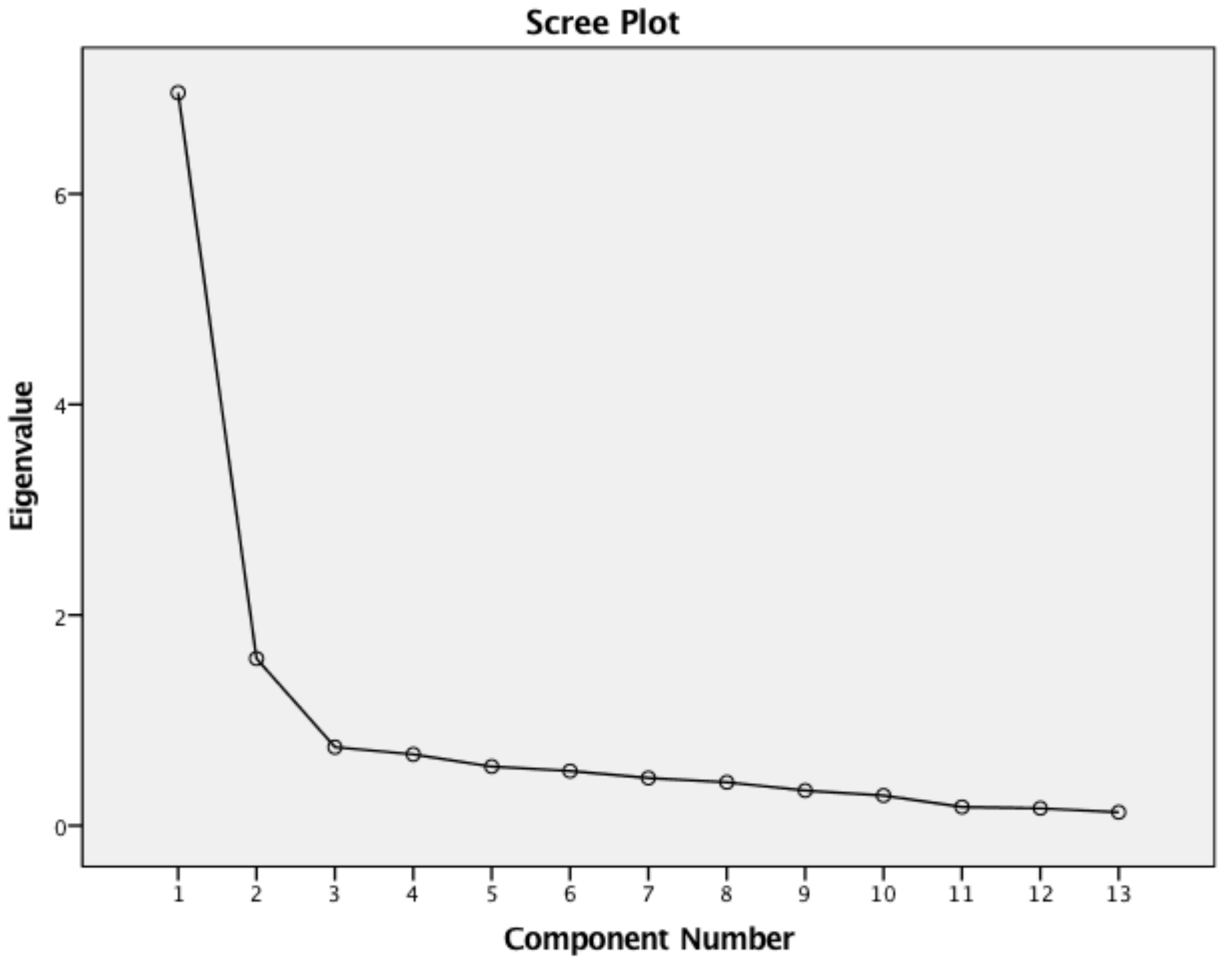
8.7.5 Importance of Dynamic Capabilities (DCs)

Table 51 : EFA Importance of DCs (DCImp)

Kaiser-Meyer-Olkin Measure		0.878
Bartlett's Test of Sphericity	Approx. Chi-Square	877.268
	df	78
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	New Product Development	.824
2	Product Innovation	.876
3	Service Innovation	.664
4	Sensing about opportunities/market/competitors	.672
5	Learning & knowledge management.	.711
6	Integration	.533
7	Coordination	.743
8	Exploration (for new products/services)	.614
9	Exploitation (of existing products and services)	.446
10	Strategic flexibility	.606
11	Market responsiveness	.641
12	Alliance management	.577
13	Research & Development (R&D)	.641

Extraction Method: Principal Component Analysis



Factor Loading (Rotated Component Matrix)			
Var. No	**Variable description**	**Component 1**	**Component 2**
1	New Product Development		.906
2	Product Innovation		.920
3	Service Innovation	.504	.641
4	Sensing about opportunities/market/competitors	.738	
5	Learning & knowledge management.	.816	
6	Integration	.726	
7	Coordination	.857	
8	Exploration (for new products/services)	.615	.485

9	Exploitation (of existing products and services)	.650	
10	Strategic flexibility	.688	
11	Market responsiveness	.670	.439
12	Alliance management	.681	
13	Research & Development (R&D)	.721	

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Two components were extracted. The variables 3, 8 and 11 were cross-loaded and were dropped from the analysis. So, based on the rotated component matrix, component 1 had variables 4, 5, 6, 7, 9, 10, 12 and 13. The component 2 had 2 variables, 1 and 2.

Factor analyses were performed again for component 1.

Factor Loading (Rotated Component Matrix) – Component 1		
Var. No	**Variable description**	**Only one component was extracted.**
4	Sensing about opportunities/ market/competitors	
5	Learning & knowledge management.	
6	Integration	
7	Coordination	
9	Exploitation (of existing products and services)	
10	Strategic flexibility	
12	Alliance management	
13	Research & Development (R&D)	

Factor analyses were performed again for component 2.

Factor Loading (Rotated Component Matrix) – Component 1		
Var. No	**Variable description**	**Only one component was extracted.**
1	New Product Development	
2	Product Innovation	

Reliability Statistics

DCImp_RECON	**Cronbach's Alpha – 0.908 (number of items 8)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	4	.890
	5	.889
	6	.906
	7	.890
	9	.905
	10	.896
	12	.898

	13	.893

DCImp_NPD	**Cronbach's Alpha – 0.710 (number of items 2)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.
	2	.

Based on the reliability analysis, two constructs, DCImp_RECON and DCImp_NPD were extracted.

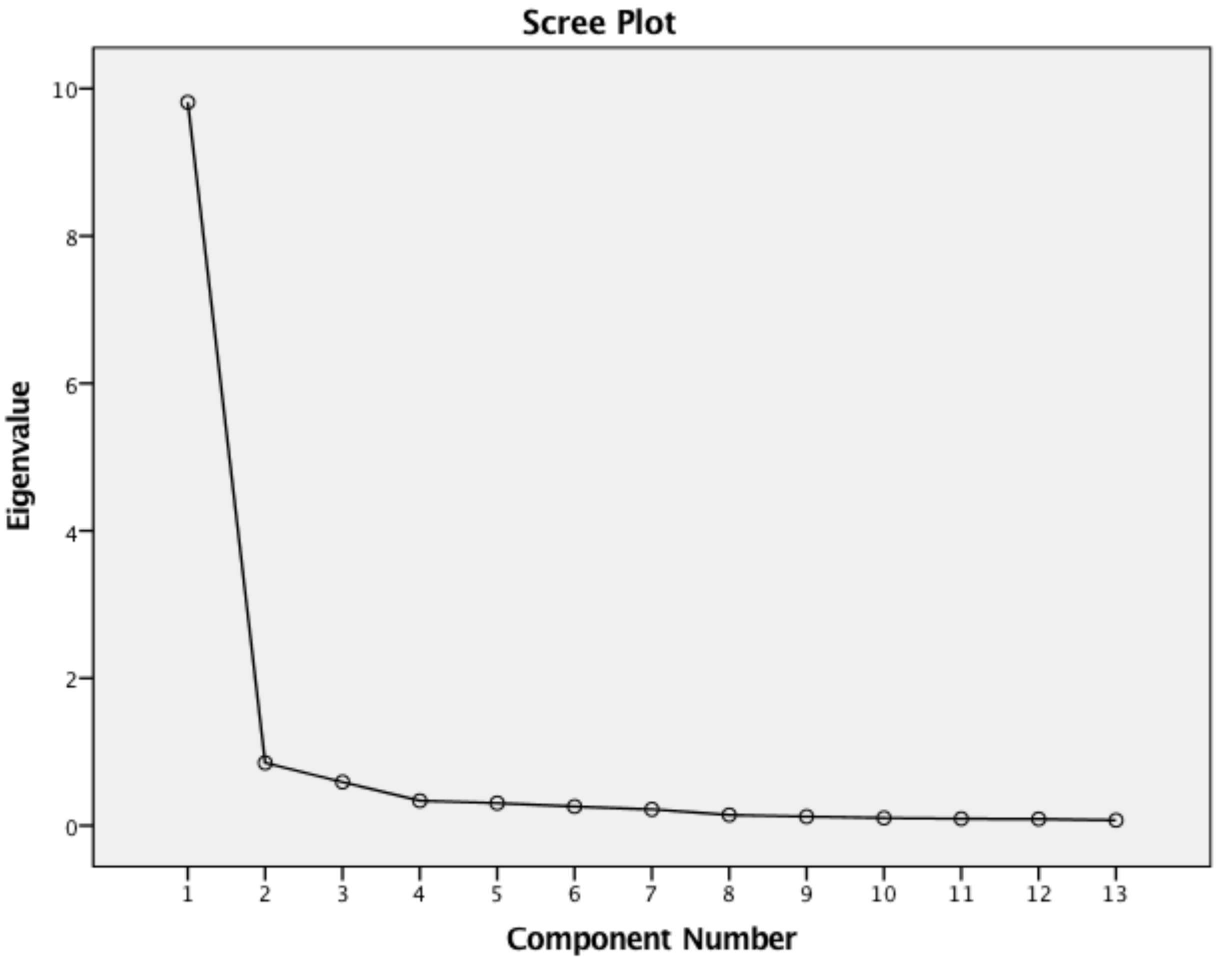
8.7.6 Improvements in Dynamic Capabilities (DCs)

Table 52 : EFA Improvements in DCs (DCIpr)

Kaiser-Meyer-Olkin Measure		0.938
Bartlett's Test of Sphericity	Approx. Chi-Square	1673.313
	df	78
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted Value**
1	New Product Development	.700
2	Product Innovation	.698
3	Service Innovation	.794
4	Sensing about opportunities/market/competitors	.774
5	Learning & knowledge management.	.799
6	Integration	.751
7	Coordination	.799
8	Exploration (for new products/services)	.835
9	Exploitation (of existing products and services)	.824
10	Strategic flexibility	.749
11	Market responsiveness	.744
12	Alliance management	.653
13	Research & Development (R&D)	.695

Extraction Method: Principal Component Analysis



Only one component was found (extracted), therefore that component represented the construct.

Factor Loading (Rotated Component Matrix)		
Var. No	**Variable description**	**Only one component was extracted.**
1	New Product Development	
2	Product Innovation	
3	Service Innovation	
4	Sensing about opportunities/ market/competitors	
5	Learning & knowledge management.	
6	Integration	
7	Coordination	
8	Exploration (for new products/services)	
9	Exploitation (of existing products and services)	
10	Strategic flexibility	
11	Market responsiveness	
12	Alliance management	
13	Research & Development (R&D)	

Reliability Statistics

"DCIPR"	Cronbach's Alpha – 0.973 (number of items 13)	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.971
	2	.971
	3	.970
	4	.970
	5	.970
	6	.970
	7	.969
	8	.970
	9	.971
	10	.971
	11	.971
	12	.972
	13	.971

Based on the reliability analysis, one construct for DCIpr was extracted.

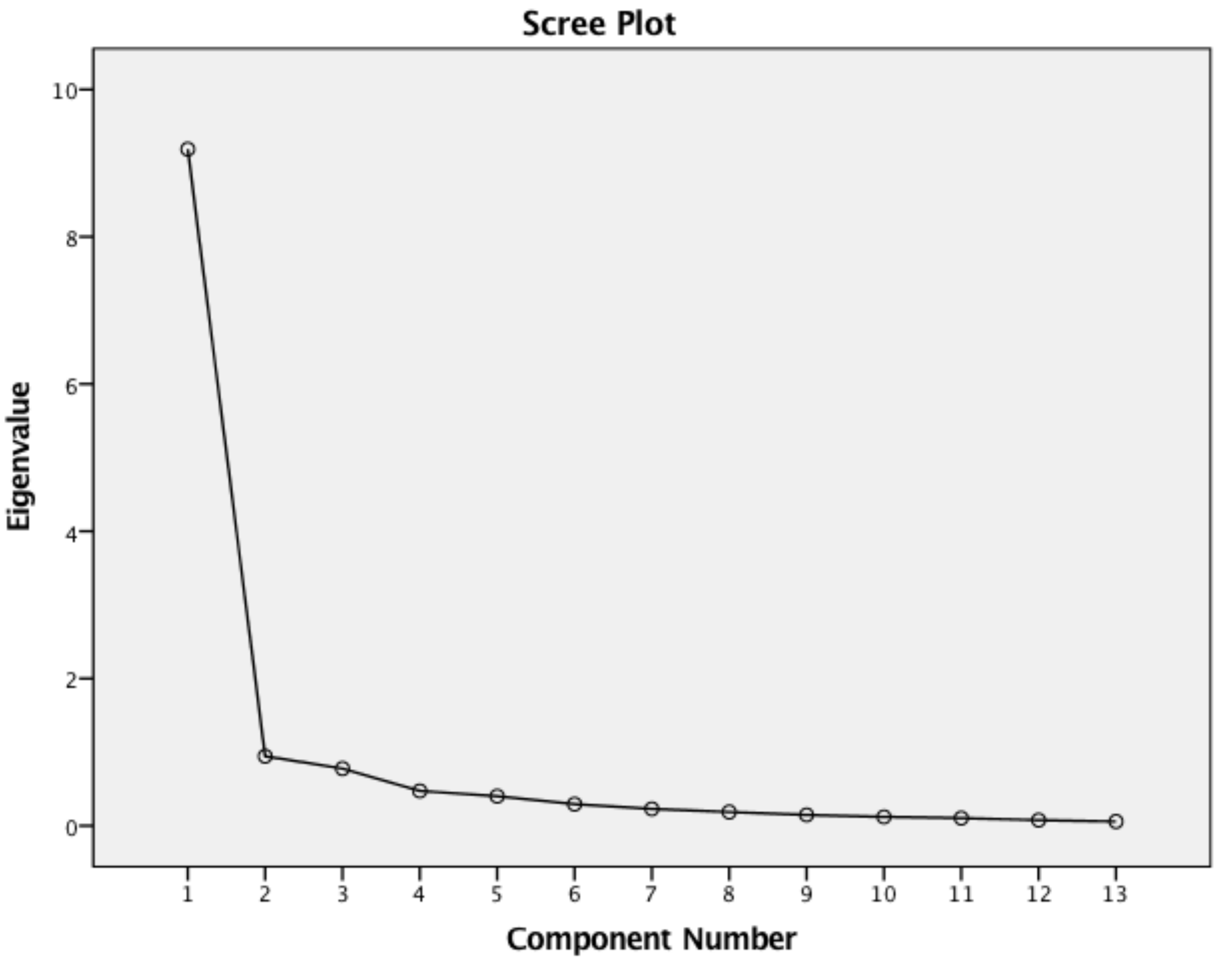
8.7.7 Comparison of Dynamic Capabilities (DCs)

Table 53 : EFA Comparison of DCs (DCCom)

Kaiser-Meyer-Olkin Measure		0.922
Bartlett's Test of Sphericity	Approx. Chi-Square	1534.922
	df	78
	Sig.	.000

Communalities		
Var. No	**Variable description**	**Extracted value**
1	New Product Development	.696
2	Product Innovation	.711
3	Service Innovation	.736
4	Sensing about opportunities/market/competitors	.673
5	Learning & knowledge management.	.722
6	Integration	.755
7	Coordination	.737
8	Exploration (for new products/services)	.774
9	Exploitation (of existing products and services)	.755

10	Strategic flexibility	.691
11	Market responsiveness	.689
12	Alliance management	.556
13	Research & Development (R&D)	.701



Only one component was found (extracted), therefore that component represented the construct.

Factor Loading (Rotated Component Matrix)		
Var. No	**Variable description**	**Only one component was extracted.**
1	New Product Development	
2	Product Innovation	
3	Service Innovation	
4	Sensing about opportunities/ market/competitors	
5	Learning & knowledge management.	
6	Integration	
7	Coordination	
8	Exploration (for new products/services)	

9	Exploitation (of existing products and services)	
10	Strategic flexibility	
11	Market responsiveness	
12	Alliance management	
13	Research & Development (R&D)	

Reliability Statistics

DCCOM	**Cronbach's Alpha – 0.965 (number of items 13)**	
	Var. no	**Cronbach's Alpha, if item deleted**
	1	.962
	2	.962
	3	.962
	4	.963
	5	.962
	6	.962
	7	.962
	8	.961
	9	.962
	10	.963
	11	.963
	12	.965
	13	.962

Based on the reliability analysis, one construct for DCCom was extracted.

8.8 Collinearity Analysis – Back-End Model

The collinearity analysis was performed for all the independent variables of the back-end model (see Table 54). The VIFs for all these cases were less than 3, which indicated that there was no multi-collinearity among the independent variables for the back-end model.

Table 54 : Collinearity Analysis for back-end model

1) Dependent Variable: DTC – Business Model Transformation (Marketing & Sales), DTCBMT_MS

Independent Variable	Collinearity Statistics	
	Tolerance	VIF
DTCBMT_CE	.619	1.616
DTCOMT	.570	1.755
DTCCLT	.560	1.786

2) Dependent Variable: DTC – Business Model Transformation (Customer Engagement), DTCBMT_CE

Independent Variable	Collinearity Statistics	
	Tolerance	VIF
DTCOMT	.627	1.595
DTCCLT	.591	1.692
DTCBMT_MS	.845	1.184

3) Dependent Variable: DTC – Operating Model Transformation, DTCOMT

Independent Variable	Collinearity Statistics	
	Tolerance	VIF
DTCCLT	.671	1.490
DTCBMT_MS	.750	1.333
DTCBMT_CE	.605	1.653

4) Dependent Variable: DTC – Cultural Transformation, DTCCLT

Independent Variable	Collinearity Statistics	
	Tolerance	VIF
DTCBMT_MS	.766	1.305
DTCBMT_CE	.592	1.688
DTCOMT	.698	1.434

8.9 Harman's Single Factor Test for CMV – Back-End Model

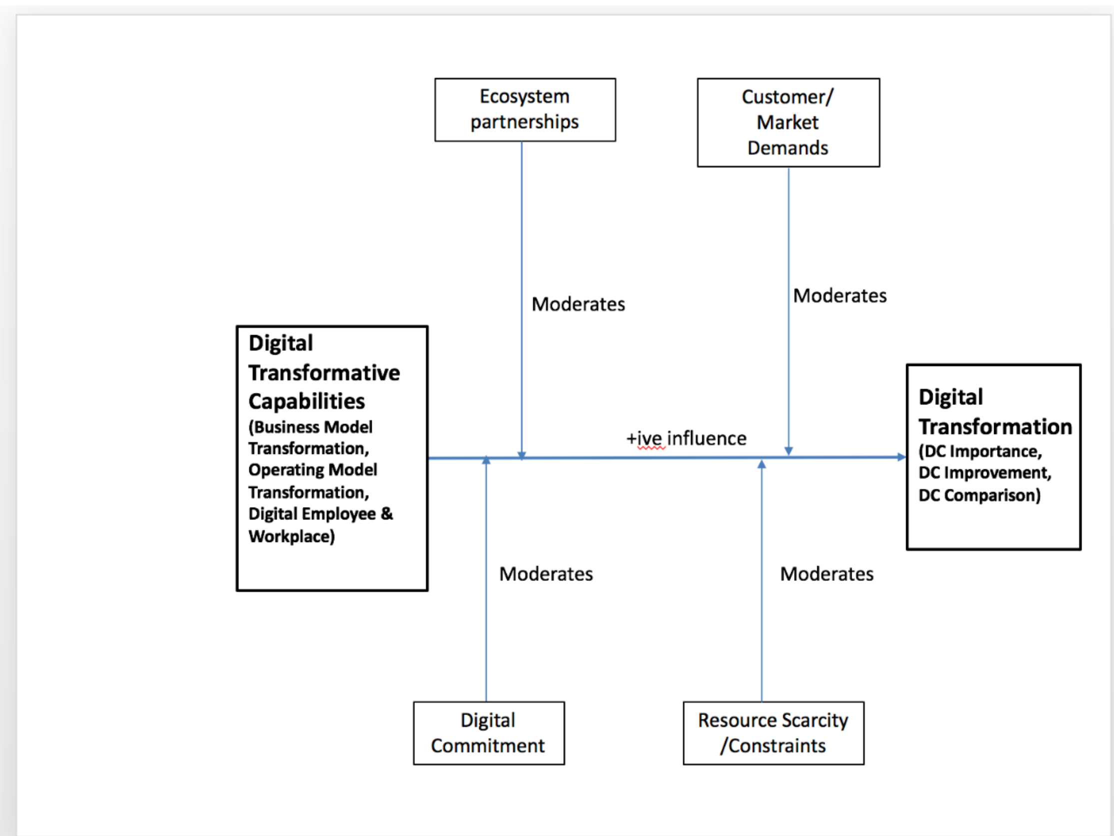
Harman's single factor test was performed for the front-end model (Appendix A-10), where EFA was performed by loading all variables onto a single factor and analysis was constrained such that there was no rotation (Podsakoff et al., 2003).

The newly introduced common latent factor explained 32.89% of the variance (less than 50% of the variance), so there was no common method bias.

8.10 Hypotheses Testing – Back-End Model

The hypotheses testing for the back-end model (see Chapter 6 for conceptualization of hypotheses) is discussed in this section. The analysis was conducted using SPSS with Linear Regression. As all hypotheses are directional, 1-tail test p-values are applied in interpreting the results.

Figure 16: Regression Analysis of the Bck-end Conceptual Model



In the back-end conceptual model, regression analysis was performed using the following variables:

Dependent variables:

DCImp_NPD & DCImp_RESCON (section 8.5.5).

DCIpr (section 8.5.6)

DCCom (section 8.5.7)

Independent variables:

Digital Transformative Capability – Business Model Transformation (Customer Engagement: DTCBMT_CE) and (Marketing and Sales: DTCBMT_MS) (section 8.2.4)

Digital Transformative Capability – Operating Model Transformation- DTCOMT (section 8.2.5)

Digital Transformative Capability – Cultural Transformation - DTCCLT (section 8.2.6)

And Moderating variables:

Ecosystem Partnership - ECOPART (section 8.5.1)

Customer and Market Demands - CUSTMKT (section 8.5.2)

Digital Commitment - DIGCOM (section 8.5.3)

Resource Scarcity and Constraint - RESCON (section 8.5.4)

All of the DVs, IVs, Control variables and interaction terms were included in the regression analysis.

The back-end hypotheses testing is explained in the subsequent sections. The list of all the hypothesis is given in chapter 6.2.4.8 and 6.3.4.5 but are noted individually below in relation to each test, as appropriate.

8.10.1 Model 5

Dependent variable: Importance of DCs – New Product Development (DCImp_NPD)

The following hypotheses were tested in this model:

The following hypotheses were tested in this model:

Digital Transformative Capability Influences Importance of DC (New Product Development)

H16-1A1 – DTC – Business Model Transformation (Marketing and Sales) has a positive influence on DCImp_NPD.

H16-2A1 – DTC – Business Model Transformation (Customer Engagement) has a positive influence on DCImp_NPD.

H17A1 – DTC – Operating Model Transformation has a positive influence on DCImp_NPD.

H18A1 – DTC – Cultural Transformation has a positive influence on DCImp_NPD.

Ecosystem Partnership as a Moderator

H19-1A1 – Ecosystem Partnership, positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_NPD.

H19-2A1 – Ecosystem Partnership, positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_NPD.

H20A1 – Ecosystem Partnership, positively moderates the relationship between DTC – Operating Model Transformation and DCImp_NPD.

H21A1 – Ecosystem Partnership, positively moderates the relationship between DTC – Cultural Transformation & DCImp_NPD.

Customer and Market Demands as a Moderator

H22-1A1 – Customer and Market Demands, positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_NPD.

H22-2A1 – Customer and Market Demands, positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_NPD.

H23A1 – Customer and Market Demands, positively moderates the relationship between DTC – Operating Model Transformation and DCImp_NPD.

H24A1 – Customer and Market Demands, positively moderates the relationship between DTC – Cultural Transformation & DCImp_NPD.

Digital Commitment as a Moderator

H25-1A1 – Digital Commitment, positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_NPD.

H25-2A1 – Digital Commitment, positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_NPD.

H26A1 – Digital Commitment, positively moderates the relationship between DTC – Operating Model Transformation and DCImp_NPD.

H27A1 – Digital Commitment, positively moderates the relationship between DTC – Cultural Transformation & DCImp_NPD.

Resource Scarcity and Constraints as a Moderator

H28-1A1 – Resource Scarcity and Constraints, negatively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_NPD.

H28-2A1 – Resource Scarcity and Constraints, negatively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_NPD.

H29A1 – Resource Scarcity and Constraints, negatively moderates the relationship between DTC – Operating Model Transformation and DCImp_NPD.

H30A1 – Resource Scarcity and Constraints, negatively moderates the relationship between DTC – Digital Cultural Transformation & DCImp_NPD.

Table 55 : Regression Analysis, Model

		DC Importance – New Product Development (DCImp_NPD) – A1	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		-.085	-.806
Firm Revenue (CV)		-.023	-.209
DTC – Business Model Transformation (Marketing and Sales) - IV	H16-1A1	-.051	-.447
DTC – Business Model Transformation (Customer Engagement) - IV	H16-2A1	.096	.806
DTC – Operating Model Transformation - IV	H17A1	.264	2.166**
DTC – Cultural Transformation - IV	H18A1	.113	.829
Moderators			
Ecosystem Partnership – M6		-.014	-.133
Customer and Market Demands – M7		.336	3.209***
Digital Commitment – M8		-.288	-1.850**
Resource Scarcity and Constraints – M9		.090	.983
Interaction Effects			
Ecosystem Partnership			
DTC – Business Model Transformation (Marketing and Sales) & Ecosystem Partnership	H19-1A1	.201	1.834**
DTC – Business Model Transformation (Customer Engagement) & Ecosystem Partnership	H19-2A1	-.203	-1.068
DTC – Operating Model Transformation & Ecosystem Partnership	H20A1	.464	2.779***
DTC – Cultural Transformation & Ecosystem Partnership	H21A1	-.223	-1.336*
Customer and Market Demands			
DTC – Business Model Transformation (Marketing and Sales) & Customer and Market Demands	H22-1A1	-.006	-.054
DTC – Business Model Transformation (Customer Engagement) & Customer and Market Demands	H22-2A1	.045	.356
DTC – Operating Model Transformation & Customer and Market Demands	H23A1	-.095	-.742
DTC – Cultural Transformation & Customer and Market Demands	H24A1	.006	.040

Regression Analysis, Model 5 Continued

		DC Importance – New Product Development (DCImp_NPD) – A1	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects			
Digital Commitment			
DTC – Business Model Transformation (Marketing and Sales) & Digital Commitment	H25-1A1	-.185	-1.014
DTC – Business Model Transformation (Customer Engagement) & Digital Commitment	H25-2A1	-.041	-.157
DTC – Operating Model Transformation & Digital Commitment	H26A1	-.604	-3.456***
DTC – Cultural Transformation & Digital Commitment	H27A1	.207	1.153
Resource Scarcity and Constraints			
DTC – Business Model Transformation (Marketing and Sales) & Resource Scarcity and Constraints	H28-1A1	-.333	-3.781***
DTC – Business Model Transformation (Customer Engagement) & Resource Scarcity and Constraints	H28-2A1	.049	.375
DTC – Operating Model Transformation & Resource Scarcity and Constraints	H29A1	.052	.380
DTC – Cultural Transformation & Resource Scarcity and Constraints	H30A1	-.073	-.544
Model Summary and F-Value			
R^2	.613		
Adjusted R^2	.481		
F-Value	4.632***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 56 : R2 Changes for Different Models for Model 5 Variables

DTC – Business Model Transformation (Marketing & Sales)		
Scenario	**R^2**	**Adjusted R^2**
5.1: CV + IV	.189	.138
5.2: CV + IV + Moderators	.240	.158
5.3: CV + IV + Moderators + Interaction terms	.613	.481

The following observations were made from model 5:

- The regression model was significant (F-Value of 4.632 and p-value $\leq$ 0.01) and the R^2 was 0.613, which indicated that 61.3% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 5.1 to model 5.3: it was 0.189 with control variables and independent variables, it increased to 0.240 when moderator variables were added and it increased to 0.613 when interaction items were added.
- In terms of independent variables' direct effects and moderator's effects, it was found that DTC – Operating Model Transformation had a positive effect on DCImp_NPD (β = .264; $p \leq 0.05$). Hence, hypothesis, **H17A1 was supported.**
- In terms of moderators, Digital Commitment had a negative effect on DCImp_NPD (β = -.288; $p \leq 0.1$).
- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_NPD (β = .201; $p \leq 0.05$). Hence, hypothesis **H19-1A1 was supported.**

- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Operating Model Transformation and DCImp_NPD positively (β = .464; $p \leq 0.01$). Hence, hypothesis **H20A1 was supported.**
- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Cultural Transformation & DCImp_NPD positively (β = -.223; $p \leq 0.1$). Hence, hypothesis **H21A1 was not supported.**
- In terms of interaction effects, Digital Commitment moderated the relationship between DTC – Operating Model Transformation and DCImp_NPD negatively (β = -.604; $p \leq 0.01$). Hence, hypothesis **H26A1 was not supported.**
- In terms of interaction effects, Market Scarcity and Constraints moderated the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_NPD negatively (β = -.333; $p \leq 0.01$). Hence, hypothesis **H28-1A1 was supported.**

8.10.2 Model 6

Dependent variable: Importance of DCs – Reconfiguration (DCImp_RECON)

The following hypotheses were tested in this model:

<u>Digital Transformative Capability Influences Importance of DC (Reconfiguration)</u>

H16-1A2 – DTC – Business Model Transformation (Marketing and Sales) has a positive influence on DCImp_RECON.

H16-2A2 – DTC – Business Model Transformation (Customer Engagement) has a positive influence on DCImp_RECON.

H17A2 – DTC – Operating Model Transformation has a positive influence on DCImp_RECON.

H18A2 – DTC – Cultural Transformation has a positive influence on DCImp_RECON.

<u>Ecosystem Partnership as a Moderator</u>

H19-1A2 – Ecosystem Partnership positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_RECON.

H19-2A2 – Ecosystem Partnership positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_RECON.

H20A2 – Ecosystem Partnership positively moderates the relationship between DTC – Operating Model Transformation and DCImp_RECON.

H21A2 – Ecosystem Partnership positively moderates the relationship between DTC – Cultural Transformation & DCImp_RECON.

<u>Customer and Market Demands as a Moderator</u>

H22-1A2 – Customer and Market Demands positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_RECON.

H22-2A2 – Customer and Market Demands positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_RECON.

H23A2 – Customer and Market Demands positively moderates the relationship between DTC – Operating Model Transformation and DCImp_RECON.

H24A2 – Customer and Market Demands positively moderates the relationship between DTC – Cultural Transformation & DCImp_RECON.

<u>Digital Commitment as a Moderator</u>

H25-1A2 – Digital Commitment positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_RECON.

H25-2A2 – Digital Commitment positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_RECON.

H26A2 – Digital Commitment positively moderates the relationship between DTC – Operating Model Transformation and DCImp_RECON.

H27A2 – Digital Commitment positively moderates the relationship between DTC – Cultural Transformation & DCImp_RECON.

<u>Resource Scarcity and Constraints as a Moderator</u>

H28-1A2 – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCImp_RECON.

H28-2A2 – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_RECON.

H29A2 – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Operating Model Transformation and DCImp_RECON.

H30A2 – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Cultural Transformation & DCImp_RECON.

Table 57 : Regression Analysis, Model 6

		DC Importance – New Product Development (DCImp_RECON) – A2	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		.166	1.518*
Firm Revenue (CV)		-.132	-1.166
DTC – Business Model Transformation (Marketing and Sales) - IV	H16-1A2	-.147	-1.243
DTC – Business Model Transformation (Customer Engagement) - IV	H16-2A2	.161	1.300
DTC – Operating Model Transformation – IV	H17A2	.078	.617
DTC – Cultural Transformation – IV	H18A2	.309	2.203**
Moderators			
Ecosystem Partnership – M6		.219	2.036**
Customer and Market Demands – M7		.186	1.712**
Digital Commitment – M8		-.265	-1.645**
Resource Scarcity and Constraints – M9		.143	1.510*
Interaction Effects			
Ecosystem Partnership			
DTC – Business Model Transformation (Marketing and Sales) & Ecosystem Partnership	H19-1A2	-.017	-.152
DTC – Business Model Transformation (Customer Engagement) & Ecosystem Partnership	H19-2A2	-.341	-1.737**
DTC – Operating Model Transformation & Ecosystem Partnership	H20A2	.292	1.690**
DTC – Cultural Transformation & Ecosystem Partnership	H21A2	.078	.451
Customer and Market Demands			
DTC – Business Model Transformation (Marketing and Sales) & Customer and Market Demands	H22-1A2	-.032	-.280
DTC – Business Model Transformation (Customer Engagement) & Customer and Market Demands	H22-2A2	.078	.588
DTC – Operating Model Transformation & Customer and Market Demands	H23A2	-.152	-1.149
DTC – Cultural Transformation & Customer and Market Demands	H24A2	-.167	-1.135

Regression Analysis, Model 6 Continued

		DC Importance – Reconfiguration (DCImp_RECON) – A2	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects			
Digital Commitment			
DTC – Business Model Transformation (Marketing and Sales) & Digital Commitment	H25-1A2	.073	.387
DTC – Business Model Transformation (Customer Engagement) & Digital Commitment	H25-2A2	.281	1.037
DTC – Operating Model Transformation & Digital Commitment	H26A2	-.130	-.721
DTC – Cultural Transformation & Digital Commitment	H27A2	-.355	-1.910**
Resource Scarcity and Constraints			
DTC – Business Model Transformation (Marketing and Sales) & Resource Scarcity and Constraints	H28-1A2	.014	.157
DTC – Business Model Transformation (Customer Engagement) & Resource Scarcity and Constraints	H28-2A2	-.437	-3.225***
DTC – Operating Model Transformation & Resource Scarcity and Constraints	H29A2	.369	2.589***
DTC – Cultural Transformation & Resource Scarcity and Constraints	H30A2	-.175	-1.261
Model Summary and F-Value			
R^2	.586		
Adjusted R^2	.444		
F-Value	4.133***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 58 : R2 Changes for Different Models for Model 6 Variables

DTC – Business Model Transformation (Marketing & Sales)		
Model	**R^2**	**Adjusted R^2**
6.1: CV + IV	.214	.165
6.2: CV + IV + Moderators	.311	.236
6.3: CV + IV + Moderators + Interaction terms	.586	.444

The following observations were made from model 6:

- The regression model was significant (F-Value of 4.133 and p-value ≤ 0.01) and the R^2 was 0.586, which indicated that 58.6% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 6.1 to model 6.3: it was 0.214 with control variables and independent variables, it increased to 0.311 when moderator variables were added and it increased to 0.586 when interaction items were added.
- The control variable firm age had a positive influence on DC Importance – Reconfiguration ($\beta = .166$; $p \leq 0.1$).
- In terms of independent variables' direct effects and moderator's effects, it was found that DTC – Cultural Transformation had a positive effect on DCImp_RECON ($\beta = .309$; $p \leq 0.05$). Hence, hypothesis, **H18A2 was supported.**
- In terms of moderators, Ecosystem Partnership had a positive effect on DCImp_RECON ($\beta = .219$; $p \leq 0.05$).
- In terms of moderators, Customer and Market Demands had a positive effect on DCImp_RECON ($\beta = .186$; $p \leq 0.05$).
- In terms of moderators, Digital Commitment had a negative effect on DCImp_RECON ($\beta = -.265$; $p \leq 0.05$).
- In terms of moderators, Resource Scarcity and Constraint had a positive effect on DCImp_RECON ($\beta = .143$; $p \leq 0.1$).
- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_RECON negatively ($\beta = -.341$; $p \leq 0.05$). Hence, hypothesis **H19-2A2 was not supported.**

- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Operating Model Transformation and DCImp_RECON positively (β = .292; $p \leq 0.05$). Hence, hypothesis **H20A2 was supported.**
- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Cultural Transformation & DCImp_RECON, positively (β = -.223; $p \leq 0.1$). Hence, hypothesis **H21A1 was not supported.**
- In terms of interaction effects, Digital Commitment moderated the relationship between DTC – Cultural Transformation and DCImp_RECON negatively (β = -.355; $p \leq 0.05$). Hence, hypothesis **H26A2 was not supported.**
- In terms of interaction effects, Market Scarcity and Constraints moderated the relationship between DTC – Business Model Transformation (Customer Engagement) and DCImp_RECON negatively (β = -.437; $p \leq 0.01$). Hence, hypothesis **H28-2A2 was supported.**
- In terms of interaction effects, Market Scarcity and Constraints moderated the relationship between DTC – Operating Model Transformation and DCImp_RECON positively (β = .369; $p \leq 0.01$). Hence, hypothesis **H29A2 was not supported.**

8.10.3 Model 7

Dependent variable: Improvement in DCs (DCIpr)

The following hypotheses were tested in this model:

<u>Digital Transformative Capability Influences DCIpr</u>

H16-1B – DTC – Business Model Transformation (Marketing and Sales) has a positive influence on DCIpr.

H16-2B – DTC – Business Model Transformation (Customer Engagement) has a positive influence on DCIpr.

H17B – DTC – Operating Model Transformation has a positive influence on DCIpr.

H18B – DTC – Cultural Transformation has a positive influence on DCIpr.

<u>Ecosystem Partnership as a Moderator</u>

H19-1B – Ecosystem Partnership positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCIpr.

H19-2B – Ecosystem Partnership positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr.

H20B – Ecosystem Partnership positively moderates the relationship between DTC – Operating Model Transformation and DCIpr.

H21B – Ecosystem Partnership positively moderates the relationship between DTC – Cultural Transformation & DCIpr.

<u>Customer and Market Demands as a Moderator</u>

H22-1B – Customer and Market Demands positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCIpr.

H22-2B – Customer and Market Demands positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr.

H23B – Customer and Market Demands positively moderates the relationship between DTC – Operating Model Transformation and DCIpr.

H24B – Customer and Market Demands positively moderates the relationship between DTC – Cultural Transformation & DCIpr.

Digital Commitment as a Moderator

H25-1B – Digital Commitment positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCIpr.

H25-2B – Digital Commitment positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr.

H26B – Digital Commitment positively moderates the relationship between DTC – Operating Model Transformation and DCIpr.

H27B – Digital Commitment positively moderates the relationship between DTC – Cultural Transformation & DCIpr.

Resource Scarcity and Constraints as a Moderator

H28-1B – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCIpr.

H28-2B – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr.

H29B – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Operating Model Transformation and DCIpr.

H30B – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Cultural Transformation & DCIpr.

Table 59 : Regression Analysis, Model 7

		DC Improvement (DCIpr) - B	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		.039	.355
Firm Revenue (CV)		-.182	-1.602*
DTC – Business Model Transformation (Marketing and Sales) – IV	H16-1B	.147	1.237
DTC – Business Model Transformation (Customer Engagement) – IV	H16-2B	-.009	-.075
DTC – Operating Model Transformation – IV	H17B	.193	1.530*
DTC – Cultural Transformation – IV	H18B	.165	1.170
Moderators			
Ecosystem Partnership – M6		.273	2.532***
Customer and Market Demands – M7		-.053	-.486
Digital Commitment – M8		.181	1.120
Resource Scarcity and Constraints – M9		-.091	-.953
Interaction Effects			
Ecosystem Partnership			
DTC – Business Model Transformation (Marketing and Sales) & Ecosystem Partnership	H19-1B	-.080	-.703
DTC – Business Model Transformation (Customer Engagement) & Ecosystem Partnership	H19-2B	-.550	-2.789***
DTC – Operating Model Transformation & Ecosystem Partnership	H20B	.258	1.489*
DTC – Cultural Transformation & Ecosystem Partnership	H21B	.209	1.209
Customer and Market Demands			
DTC – Business Model Transformation (Marketing and Sales) & Customer and Market Demands	H22-1B	-.044	-.387
DTC – Business Model Transformation (Customer Engagement) & Customer and Market Demands	H22-2B	-.062	-.470
DTC – Operating Model Transformation & Customer and Market Demands	H23B	-.090	-.674
DTC – Cultural Transformation & Customer and Market Demands	H24B	.175	1.182

Regression Analysis, Model 7 Continued

		DC Improvement (DCIpr) - B	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects			
Digital Commitment			
DTC – Business Model Transformation (Marketing and Sales) & Digital Commitment	H25-1B	.105	.554
DTC – Business Model Transformation (Customer Engagement) & Digital Commitment	H25-2B	.585	2.152**
DTC – Operating Model Transformation & Digital Commitment	H26B	-.466	-2.569***
DTC – Cultural Transformation & Digital Commitment	H27B	-.071	-.380
Resource Scarcity and Constraints			
DTC – Business Model Transformation (Marketing and Sales) & Resource Scarcity and Constraints	H28-1B	.107	1.166
DTC – Business Model Transformation (Customer Engagement) & Resource Scarcity and Constraints	H28-2B	-.189	-1.386*
DTC – Operating Model Transformation & Resource Scarcity and Constraints	H29B	.095	.666
DTC – Cultural Transformation & Resource Scarcity and Constraints	H30B	-.054	-.388
Model Summary and F-Value			
R^2	.582		
Adjusted R^2	.439		
F-Value	4.076***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 60 : R2 Changes for Different Models for Model 7 Variables

DTC – Business Model Transformation (Marketing & Sales)		
Model	**R^2**	**Adjusted R^2**
7.1: CV + IV	.353	.312
7.2: CV + IV + Moderators	.469	.411
7.3: CV + IV + Moderators + Interaction terms	.582	.439

The following observations were made from model 7:

- The regression model was significant (F-Value of 4.076 and p-value ≤ 0.01) and the R^2 was 0.582, which indicated that 58.2% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 7.1 to model 7.3: it was 0.353 with control variables and independent variables, it increased to 0.469 when moderator variables were added and it increased to 0.582 when interaction items were added.
- The control variable firm revenue had a negative influence on DCIpr (β = -.182; $p \leq 0.1$).
- In terms of independent variables' direct effects and moderator's effects, it was found that DTC – Operating Model Transformation had a positive effect on DCIpr (β = .193; $p \leq 0.1$). Hence, hypothesis, **H17B was supported.**
- In terms of moderators, Ecosystem Partnership had a positive effect on DCIpr (β = .273; $p \leq 0.01$).
- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr negatively (β = -.550; $p \leq 0.01$). Hence, hypothesis **H19-2B was not supported.**

- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Operating Model Transformation and DCIpr positively ($\beta = .258$; $p \leq 0.1$). Hence, hypothesis **H20B was supported.**
- In terms of interaction effects, Digital Commitment moderated the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr positively ($\beta = .585$; $p \leq 0.05$). Hence, hypothesis **H25-2B was supported.**
- In terms of interaction effects, Digital Commitment moderated the relationship between DTC – Operating Model Transformation and DCIpr negatively ($\beta = -.466$; $p \leq 0.01$). Hence, hypothesis **H26B was not supported.**
- In terms of interaction effects, Market Scarcity and Constraints moderated the relationship between DTC – Business Model Transformation (Customer Engagement) and DCIpr negatively ($\beta = -.189$; $p \leq 0.1$). Hence, hypothesis **H28-2B was supported.**

8.10.4 Model 8

Dependent variable: Comparison of DCs with its competitors (DCCom)

The following hypotheses were tested in this model:

Digital Transformative Capability Influences DCCom

H16-1C – DTC – Business Model Transformation (Marketing and Sales) has a positive influence on DCCom.

H16-2B – DTC – Business Model Transformation (Customer Engagement) has a positive influence on DCCom.

H17C – DTC – Operating Model Transformation has a positive influence on DCCom.

H18C – DTC – Cultural Transformation has a positive influence on DCCom.

Ecosystem Partnership as a Moderator

H19-1C – Ecosystem Partnership positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCCom.

H19-2C – Ecosystem Partnership positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCCom.

H20C – Ecosystem Partnership positively moderates the relationship between DTC – Operating Model Transformation and DCCom.

H21C – Ecosystem Partnership positively moderates the relationship between DTC – Cultural Transformation & DCCom.

Customer and Market Demands as a Moderator

H22-1C – Customer and Market Demands positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCCom.

H22-2C – Customer and Market Demands positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCCom.

H23C – Customer and Market Demands positively moderates the relationship between DTC – Operating Model Transformation and DCCom.

H24C – Customer and Market Demands positively moderates the relationship between DTC – Cultural Transformation & DCCom.

Digital Commitment as a Moderator

H25-1C – Digital Commitment positively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCCom.

H25-2C – Digital Commitment positively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCCom.

H26C – Digital Commitment positively moderates the relationship between DTC – Operating Model Transformation and DCCom.

H27C – Digital Commitment positively moderates the relationship between DTC – Cultural Transformation & DCCom.

Resource Scarcity and Constraints as a Moderator

H28-1C – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Business Model Transformation (Marketing and Sales) and DCCom.

H28-2C – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Business Model Transformation (Customer Engagement) and DCCom.

H29C – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Operating Model Transformation and DCCom.

H30C – Resource Scarcity and Constraints negatively moderates the relationship between DTC – Cultural Transformation & DCCom.

Table 61 : Regression Analysis, Model 8

		DC Comparison (DCCom) - C	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Firm Age (CV)		.016	.157
Firm Revenue (CV)		-.146	-.1366*
DTC – Business Model Transformation (Marketing and Sales) - IV	H16-1C	.025	.225
DTC – Business Model Transformation (Customer Engagement) – IV	H16-2C	.144	1.226
DTC – Operating Model Transformation – IV	H17C	.412	3.462***
DTC – Cultural Transformation – IV	H18C	.017	.127
Moderators			
Ecosystem Partnership – M6		.245	2.413***
Customer and Market Demands – M7		-.141	-1.374*
Digital Commitment – M8		.221	1.451*
Resource Scarcity and Constraints – M9		-.149	-1.662**
Interaction Effects			
Ecosystem Partnership			
DTC – Business Model Transformation (Marketing and Sales) & Ecosystem Partnership	H19-1C		.516
DTC – Business Model Transformation (Customer Engagement) & Ecosystem Partnership	H19-2C	-.262	-1.414*
DTC – Operating Model Transformation & Ecosystem Partnership	H20C	.186	1.140
DTC – Cultural Transformation & Ecosystem Partnership	H21C	.294	1.801**
Customer and Market Demands			
DTC – Business Model Transformation (Marketing and Sales) & Customer and Market Demands	H22-1C	-.008	-.077
DTC – Business Model Transformation (Customer Engagement) & Customer and Market Demands	H22-2C	-.079	-.630
DTC – Operating Model Transformation & Customer and Market Demands	H23C	-.102	-.815
DTC – Cultural Transformation & Customer and Market Demands	H24C	.092	.662

Regression Analysis, Model 8 Continued

		DC Comparison (DCCom) - C	
Variables	**Hypothesis**	**Standard Coefficient**	**t-value**
Interaction Effects			
Digital Commitment			
DTC – Business Model Transformation (Marketing and Sales) & Digital Commitment	H25-1C	.063	.351
DTC – Business Model Transformation (Customer Engagement) & Digital Commitment	H25-2C	.271	1.059
DTC – Operating Model Transformation & Digital Commitment	H26C	-.132	-.773
DTC – Cultural Transformation & Digital Commitment	H27C	-.131	-.742
Resource Scarcity and Constraints			
DTC – Business Model Transformation (Marketing and Sales) & Resource Scarcity and Constraints	H28-1C	.041	.480
DTC – Business Model Transformation (Customer Engagement) & Resource Scarcity and Constraints	H28-2C	-.059	-.462
DTC – Operating Model Transformation & Resource Scarcity and Constraints	H29C	.076	.563
DTC – Cultural Transformation & Resource Scarcity and Constraints	H30C	-.041	-.314
Model Summary and F-Value			
R^2	.630		
Adjusted R^2	.503		
F-Value	4.974***		

Critical t-values: ***p ≤ 0.01, t= 2.32; **p ≤ 0.05, t= 1.645; *p ≤ 0.1, t= 1.282

Table 62 : R2 Changes for Different Models for Model 8 Variables

DTC – Business Model Transformation (Marketing & Sales)		
Model	**R^2**	**Adjusted R^2**
8.1: CV + IV	.432	.397
8.2: CV + IV + Moderators	.548	.498
8.3: CV + IV + Moderators + Interaction terms	.630	.503

The following observations were made from model 8:

- The regression model was significant (F-Value of 4.974 and p-value ≤ 0.01) and the R^2 was 0.630, which indicated that 63% of the variance in the dependent variable was explained by the model.
- There was a gradual increase of R^2 value from model 8.1 to model 8.3: it was 0.432 with control variables and independent variables, it increased to 0.548 when moderator variables were added and it increased to 0.630 when interaction items were added.
- The control variable firm revenue had a negative influence on DCCom (β = -.146; $p \leq 0.1$).
- In terms of independent variables' direct effects and moderator's effects, it was found that DTC – Operating Model Transformation had a positive effect on DCCom (β = .412; $p \leq 0.01$). Hence, hypothesis, **H17C was supported.**
- In terms of moderators, Ecosystem Partnership had a positive effect on DCCom (β = .245; $p \leq 0.01$).
- In terms of moderators, Customer and Market Demands had a negative effect on DCCom (β = -.141; $p \leq 0.1$).
- In terms of moderators, Digital Commitment had a positive effect on DCCom (β = .221; $p \leq 0.1$).
- In terms of moderators, Resource Scarcity and Constraints had a negative effect on DCCom (β = -.149; $p \leq 0.05$).

- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Business Model Transformation (Customer Engagement) and DCCom negatively ($\beta = -.262$; $p \leq 0.1$). Hence, hypothesis **H19-2C was not supported.**
- In terms of interaction effects, Ecosystem Partnership moderated the relationship between DTC – Cultural Transformation & DCCom positively ($\beta = .294$; $p \leq 0.05$). Hence, hypothesis **H21C was supported.**
- In terms of moderators, Customer and Market Demands had a negative effect on DCCom ($\beta = -.141$; $p \leq 0.1$).

Table 63 : Regression Analysis, Summary Result (Back-end Model)

		Dependent Variables			
Variables	**Hypothesis**	**DCImp_ NPD (A1)**	**DCImp_RECON (A2)**	**DCIpr (B)**	**DCCom (C)**
Firm Age (CV)			√		
Firm Revenue (CV)				-ve	-ve
DTC – Business Model Transformation (Marketing and Sales) - IV	H16-1A1-C				
DTC – Business Model Transformation (Customer Engagement) – IV	H16-2A1-C				
DTC – Operating Model Transformation – IV	H17A1-C	√		√	√
DTC – Cultural Transformation – IV	H18A1-C		√		
Moderators					
Ecosystem Partnership	M6		√	√	√
Customer and Market Demands	M7	√	√		-ve
Digital Commitment	M8	-ve	-ve		√
Resource Scarcity and Constraints	M9		√		√
Interaction Effects					
Ecosystem Partnership					
DTC – Business Model Transformation (Marketing and Sales) & Ecosystem Partnership	H19-1A1-C	√			
DTC – Business Model Transformation (Customer Engagement) & Ecosystem Partnership	H19-2A1-C		-ve	-ve	-ve
DTC – Operating Model Transformation & Ecosystem Partnership	H20A1-C	√	√	√	
DTC – Cultural Transformation & Ecosystem Partnership	H21A1-C	-ve			√

Regression Analysis, Summary Result (Back-end Model) Continued

		Dependent Variables			
Variables	**Hypothesis**	**DCImp_ NPD (A1)**	**DCImp_RECON (A2)**	**DCIpr (B)**	**DCCom (C)**
Interaction Effects					
Customer and Market Demands					
DTC – Business Model Transformation (Marketing and Sales) & Customer and Market Demands	H22-1A1-C				
DTC – Business Model Transformation (Customer Engagement) & Customer and Market Demands	H22-2A1-C				
DTC – Operating Model Transformation & Customer and Market Demands	H23A1-C				
DTC – Cultural Transformation & Customer and Market Demands	H24A1-C				
Digital Commitment					
DTC – Business Model Transformation (Marketing and Sales) & Digital Commitment	H25-1A1-C				
DTC – Business Model Transformation (Customer Engagement) & Digital Commitment	H25-2-A1-C			√	
DTC – Operating Model Transformation & Digital Commitment	H26A1-C	-ve		-ve	
DTC – Cultural Transformation & Digital Commitment	H27A1-C		-ve		
Resource Scarcity and Constraints					
DTC – Business Model Transformation (Marketing and Sales) & Resource Scarcity and Constraints	H28-1A1-C	√			
DTC – Business Model Transformation (Customer Engagement) & Resource Scarcity and Constraints	H28-2-A1-C		√	√	
DTC – Operating Model Transformation & Resource Scarcity and Constraints	H29A1-C		+ve		
DTC – Cultural Transformation & Resource Scarcity and Constraints	H30A1-C				

8.11 Conclusion

In this chapter, two conceptual models – front-end model and back-end model – are presented. For each model, Exploratory Factor Analysis (EFA), collinearity analysis and hypothesis testing are presented. At the end of each model, a summary result of regression analysis is presented such that readers can get a summary view of 30 different hypotheses. In the following discussion chapter, the findings of the analyses with proper reasoning are presented.

Chapter 9: Discussions

9.1 Introduction

This chapter presents a discussion based on the interpretation of the regression analysis models presented in the previous chapter (Chapter 8). The discussion considers the results from the front-end model and all hypotheses related to that model and the results from back-end models are then discussed. These discussions focus on a comparison of results from this study with relevant management theories and literature related to Digital Transformation and digital transformative capabilities (DTCs), the information received during the qualitative study and industry knowledge available from appropriate business sources. Digital Transformation for industrial businesses started within the last five years and most businesses are still scrambling to develop their Digital Transformation strategies. As presented in the Industry Review (Chapter 3), a comprehensive digitalization strategy is required for successful Digital Transformation and transformation is being accelerated by IIoT technologies. In today's industrial environment, Digital Transformation is not for innovation or developing new businesses but a necessity for survival. As Jeff Immelt, the former CEO and Chairman of GE, stated[38] "*I chose Digital Transformation at GE to improve performance of our products for our customers. If we did not lead, these new technologies would allow third parties to come between us and our customers. It was about overcoming an existential threat*". At present, there is no management theory of Digital Transformation and for how firms are developing or should develop DTCs for Digital Transformation. By applying the

[38] https://www.linkedin.com/pulse/digital-transformation-requires-leadership-jeff-immelt/

lens of dynamic capability theory (DC), this study has deduced some of its variables, causal mechanisms and its effect in a framework of Digital Transformation. This study has also identified digital constructs such as Digital Twin, Digital Thread and digital mindset as key components for a wider system view of DTC and DC.

Specifically, and to the author's best knowledge, it represents the first attempt to delineate a nomological network of Digital Transformation in terms of a Digital Transformation capability, its antecedents and contingencies, and effects in changing organizational capabilities.

9.2 Front-end Model Discussion

The front-end model examines the influence of the digitalization profile (Digital Twin, Digital Thread and digital mindset) on DTCs. The factors which affect DTCs, including the moderating effects, are also discussed.

9.2.1 Hypotheses – 1A1 – 1C (Digital Twin and its effect on DTCs)

The study hypothesized that Digital Twin positively influences DTCs, however, the results did not support this general effect because the influence of Digital Twin on all four forms of DTCs was not significant.

Digital Twin was expected to represent a key input for DTC – Business Model Transformation, however, and no support was found for this relationship. Digital Twin is the digital representation of business systems (including assets/machines, processes, systems etc.) and lauded for its potential to optimize business processes and develop new products and services that were not possible earlier. A possible reason for the lack of any apparent effect on business model transformation for this study may be attributed to the types of projects and products being developed by an organization using NPD capabilities. Though Digital Twin may facilitate new product development (NPD) (Haag and Anderi, 2018; Tao, Cheng, Qi, Zhang, Zhang and Sui, 2018), not all NPD projects can transform business models (Gronlund, Sjodin and Frishammar, 2010; Chesbrough, 2003), especially those NPD projects which involve open innovations with partners. Other researchers, Shi, Li and Bigdeli (2016) for example, also confirmed that not all NPD initiatives transform business models and the NPD context has shifted from traditional business models to newer models. Industrial businesses are collaborating with partners for developing new products and services by leveraging Digital Twins and the effects of these projects for transforming business models may not be apparent.

Digital Twin was also expected to represent a key input to DTC – Operating Model Transformation, however, the result did not support this hypothesis. By leveraging Industrial Internet and transforming operating models, a firm may expand its customer boundaries, experiment and launch products and services faster, develop data-centric monetization capabilities and integrate with partners for service delivery (Section 6.2.2). A possible explanation for this result could be attributed to the lack of managerial consensus for Digital Twin management within the organization. Alfonso Velosa[39], the research Vice President of leading market research firm Gartner, suggested that to get the true value of Digital Twin, chief information officers (CIOs) need to work with business leaders to get proper business value against the cost of developing and maintaining Digital Twin. Another possible explanation could

[39] https://www.gartner.com/smarterwithgartner/prepare-for-the-impact-of-digital-twins/

relate to the availability of suitable information infrastructure within the organization. The firm needs to develop a proper information technology (IT) infrastructure to manage and analyse vast amounts of data generated through Digital Twin[40]. In the absence of a proper information architecture, the firm may not be able to utilize Digital Twin effectively. So, a lack of managerial consensus and availability of proper information infrastructure may be a hindrance for Digital Twin adoption within an organization and its effect on operating models.

Digital Twin was expected to represent a key input for 'DTC – Cultural Transformation', however, the result did not support the current hypothesis. Based on the discussions in Section 6.2.3, firms may be developing transformative capabilities with a desire to transform their workforce into a digital workforce. Although a direct academic study is absent, a possible explanation for the result could be attributed to the advanced data science skill set requirement for Digital Twin development and lack of skilled personnel in the industry. To implement Digital Twin[41], a firm requires advanced skill sets related to artificial intelligence (AI), machine learning (ML) and data science and needs to acquire these skills from outside or retrain their own employees. As firms are maturing more digitally, they are building necessary skills to transform their employees and workplaces (Kane, Palmer, Phillips, Kiron and Buckley, 2015). According to these researchers (Kane et al., 2015), digital maturities of the firms are still evolving and digitally skilled employees are still a small part of the workforce. This maturity is lacking to date and may explain the outcomes observed in this study.

[40] https://info.microsoft.com/rs/157-GQE-382/images/Digital%20Twin%20Vision.pdf
[41] https://www.networkworld.com/article/3280225/internet-of-things/what-is-digital-twin-technology-and-why-it-matters.html

9.2.2 Hypotheses – 2A1 – 2C (Digital Thread and its effect on DTCs)

The study hypothesized that Digital Thread positively influences DTCs, and the results supported that effect because the influence of Digital Thread on all four forms of DTCs was significant.

Digital Thread was expected to be a key input for DTC – Business Model Transformation and the results supported this hypothesis. Despite no direct academic study on this matter to date, one may look through the lens of coordination, integration and learning dynamic capabilities to interpret the impact of Digital Thread on business model transformation. According to Accenture[42], Digital Thread coordinates the information with multiple partners and integrates the data to create a digital record of the entire business processes. In doing so, Digital Thread may help a firm to develop new products and services which were not possible earlier. Heldberg, Lubell, Fischer, Maggiano and Feeney (2016) suggested that Digital Thread enables real time design, analysis and collaboration with partners to develop new products and services which has the potential to increase manufacturing efficiency. Thus, Digital Thread facilitates business model transformation by enabling new business models. Chesbrough and Rosenbloom (2002) suggested that an organization may develop new business models by coordinating across different parts of the organization and with external partners. Zott, Amit and Massa (2011) noted that a firm creates value in a digital economy by coordinating with a plethora of partners and users. According to Linder and Willander (2017), companies should develop new business models where both value creation and value capture occur in a value network which includes the company and its ecosystem partners. Thus, by looking at Digital Thread through the coordination

[42] https://www.accenture.com/t20171211T045641Z__w__/us-en/_acnmedia/PDF-67/Accenture-Digital-Thread-Aerospace-And-Defense.pdf

and integration DC lens, it can be suggested that Digital Thread is a key input for DTC – Business Model Transformation. Moreover, Digital Thread may help in developing smart connected products. Porter and Heppelmann (2014), for instance, suggest that smart connected products are transforming industrial businesses by offering new product-as-a-service business models. Based on these discussions, then, it may be suggested that Digital Thread is a key input for 'DTC – Business Model Transformation'. Thus, the current study adds to the discussion of Digital Thread and its impact on 'DTC – Business Model Transformation'.

Digital Thread was expected to be a key input for 'DTC – Operating Model Transformation' and the result again supported the hypothesis relationship. This follows recent empirical investigation, for instance, Wortmann and Fluchter (2015), who suggested that smart connected products are helping the companies to extend their customer boundaries such that they can serve a new set of customers in different industries. Hartmann, King and Narayanan (2015) provide further support with their observation that smart connected products which are developed by leveraging Digital Thread, are sending customer experience data to product managers to help them anticipate demands and maintenance needs and in turn design better products and launch them faster than the competition. As another illustration, GE and Pivotal[43] developed the first industrial-scale aviation data lake by storing the data from different Digital Threads of the airline industry and monetized the data by selling a subscription-based service to airline customers. So, based on these discussions, it may be suggested that Digital Thread is a key input for 'DTC – Operating Model Transformation' and the current study adds to the discussion of Digital Thread and its impact on 'DTC – Operating Model Transformation'.

[43] https://www.ge.com/reports/post/94170227900/angling-in-the-data-lake-ge-and-pivotal-pioneer-4/

Digital Thread was expected to represent a key input for 'DTC – Cultural Transformation' and the result supported the proposed hypothesis. McAfee and Brynjolfsson (2012) argued for the importance of culture and suggested that the vast amount of data collected by digital companies may radically improve their performance provided they have a data-driven culture. Digital Thread gives a holistic view of the business processes and allows managers to make data-driven decisions such that they may be able to change a workplace to a digital workplace. The emergence of Big Data and Data Science enables a firm to make data-driven decisions which were not possible earlier (Provost, Fawcett, 2013); now firms can develop data-driven business systems for their employees, for example, firms are building business data lakes (Richstein, 2017[44]) by leveraging Digital Thread from different enterprise systems. Based on these discussions, it is asserted that Digital Thread helps in transforming the workplace into a digital workplace and the current study adds to the discussion of Digital Thread and its impact on 'DTC – Cultural Transformation'.

9.2.3 Hypotheses – 3A1 – 3C (Digital Mindset and its effect on DTCs)

The study hypothesized that Digital Mindset positively influences DTCs, and the results partially supported that expectation because the influence of digital mindset was significant for one form of DTC and not significant for the other three forms of DTCs.

Digital Mindset was expected to represent a key input for 'DTC – Business Model Transformation' but the hypothesis was not supported by the findings. Though there is no comparable scholarly work regarding this hypothesis, the business model innovation and

[44] http://www.semi.org/eu/sites/semi.org/files/events/presentations/06_JorgRichstein_Jabil.pdf

organizational change literature provides possible reasons for this result. Digitally-oriented mindset alone may not help a firm to develop business model transformation capabilities. For instance, Chesbrough (2010) argued that to overcome the barriers of business model innovations, process of experimentation and effectuation, and successful leadership capabilities, organizational changes must be implemented. To test his empirical findings, Chesbrough (2010) analysed the business models at Xerox and noted that though Xerox had good technologies, the management of Xerox did not know what to do with those technologies and slowly those technologies became orphans within the company. Similarly, the industrial businesses have started digitization initiatives by adopting emerging Digital Transformation technologies, however, strong leadership capabilities from the top management are required to transform the business model. Amit and Zott (2001) observed that novelty, lock-in, complementarity and efficiency are four sources for business model innovation and organization structure plays a critical role in such innovation. So, all these discussions are suggesting that digital mindset alone may not be sufficient for developing business model transformation capabilities. Also, the industrial businesses are currently structured as profit business groups (see chapters 4 & 5), and the digital mindset of managers alone may not be sufficient for business model transformation. Borrowing from servitization (transforming the business model from product to service-based) literature, it can be noted that organization structure and culture is a barrier for servitization (Hou and Neely, 2013). The mindset among managers in industrial businesses is changing, however, changes in organization structure and culture will take some time for business model transformation[45] ot be realised.

[45] https://www.gartner.com/en/newsroom/press-releases/2018-02-26-gartner-says-digital-business-requires-growth-mindset-and-not-just-technology

Digital Mindset was expected to represent a key input for 'DTC – Operating Model Transformation', however, no support was found for this hypothesis. The organizational change literature related to organizational climate and culture offers possible explanations for this finding, given that significant organizational changes are required to transform the operating model[46]. Schneider, Brief and Guzzo (1996) argued that significant organization climate and cultural changes are needed for sustained organizational change. According to these researchers, organization climate is about how the organization performs its daily business and whether an organization is innovative, flexible or 'stodgy'? The organizational culture is related to the beliefs and the values of an employee of the organization. Though mindset changes have just started in industrial businesses, it seems it may take some time to change the organizational climate and culture and its effect on operating model transformation capabilities.

Digital Mindset was expected to represent a key input for 'DTC – Cultural Transformation' and the result supported the proposed hypothesis. For instance, Koffer (2015) has identified four key concepts for the digital workplace: collaboration, mobility, compliance and stress & overloads. Modern technology has positively impacted collaboration among employees at digital workplaces and the digitally-oriented mindset helps such collaboration. However, technology alone is not enough and mindset and cultural changes are needed for a collaborative workplace (Kane, Palmer, Phillips, Kiron and Buckley, 2015). Usage of mobile technology and a mobile workforce are changing the digital workplace and digital mindset is a key influencer for mobility. The digital workplace has created compliance issues (Bamberger, 2009): for example, since digital and mobile collaborations are common within the organization, safeguarding

[46]https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Introducing%20the%20next-generation%20operating%20model/Introducing-the-next-gen-operating-model.ashx

intellectual property is a significant challenge for the organization. So, digital managers should develop policies and procedures to mitigate the compliance risk. Lastly, the digital workplace has created information overload and work-related stress among employees has increased in recent years. Digital managers should develop workplace practices and procedures to overcome this risk (Dave, Dave and Shishodia, 2013). The digital mindset is helping a manager to become a digital manager, which in turn may change the workplace to a digital workplace. Based on these discussions, it may be suggested that Digital Mindset may be a key input for 'DTC – Digital Cultural Transformation'. Thus, the current study adds to the discussion of Digital Mindset and its impact on 'DTC – Cultural Transformation'.

9.2.4 Moderating Effects of Technology Turbulence

Hypothesis H4A1 – H4C posited that Technology Turbulence positively moderates the relationship between Digital Twin and DTCs. The results supported only one form of DTC, and were not significant for other three forms of DTCs. These hypotheses are described in the following paragraphs.

Based on the discussions in Section 6.2.4.4, the current study hypothesized that Technology Turbulence positively moderates the relationship between Digital Twin (product development) and 'DTC – Cultural Transformation'. The result supported the proposed hypothesis. The organizational culture literature offers possible explanations. For instance, Brenner and Hummel (2017) observed that increased Technology Turbulence, caused by increased demands of the individual products, challenges a company to think about new ways of responding to customer demands; companies are adopting more Digital Twins to meet those demands. By drawing attention from innovation and culture literatures, it may be observed that with increase in technological advancements, firms tend to increase their products and services innovations and these innovations impact organizational cultures so that firms with more entrepreneurial cultures are more successful (Brown and Ulijn, 2004). Based on these discussions, it may be suggested that Technology Turbulence positively moderates the relationship between Digital Twin (Product Development) and 'DTC – Cultural Transformation' and the current study adds to the discussion of the impact of Technology Turbulence on Digital Twin and its relationship with 'DTC – Cultural Transformation'. Thus, higher degrees of Technology Turbulence support the use of Digital Twin to effect change in digitalizing the employee and workplace. The relationship has further importance given the absence of an initial direct effect between Digital Twin and 'DTC – Cultural Transformation' as reported earlier.

Based on the hypothesis, H4-2A1, Technology Turbulence positively moderates the relationship between Digital Twin (Product Quality) and 'DTC – Business Model Transformation' and the result did not support the proposed relationship. Instead of significantly positive moderation effects, the result showed significantly **negative** moderation effects instead. One possible explanation could be the pace of adoption of Digital Twin and pace of Business Model Transformation in industrial businesses. This is a significant observation as, intuitively, it seems technology disruption should create an urgency to accelerate Digital Twin projects and to develop appropriate business models to support such initiatives. In contrast, we can observe that though companies are rapidly adopting Digital Twins in their NPD and product quality improvement initiatives to gain operational efficiency and reduce costs (Woods, 2018), the pace of business model transformation is relatively slow and may catch up in the coming years[47]. Based on the findings of Brown and Eisenhardt (1995), in rapidly changing and intensely

[47] https://www.forbes.com/sites/adigaskell/2018/06/08/the-slow-pace-of-digital-transformation/#7a72254b491b

competitive industries, successful companies change their business models proactively through regular deadlines. The authors (Brown et al., 1995) further observe two essential elements for time pacing: firstly, managing transitions and secondly, the right rhythm for change. It seems industrial businesses are still adjusting to technological turbulence and companies may need to adjust their business models for such profound changes. Though there is a promise of developing new businesses using Digital Twin, it is still an emerging technology and has captured the imagination of manufacturers, however, is not yet ready for the main stage (Keane, 2018). This finding may be a good observation for industrial managers.

Though the study hypothesized that Technology Turbulence positively moderates the relationship between Digital Twin and 'DTC – Operating Model Transformation', the result did not support the proposed relationship. Instead of significantly positive moderation effects, the result showed significantly **negative** moderation effects again. This is another significant finding. As discussed in the previous section, intuitively it seems, Technology Turbulence may accelerate Digital Twin projects, which in turn may accelerate the transformation of the operating models within the company, but instead of a proposed positive moderation effect, a negative moderation effect was observed. Though there may not be any direct academic reference at this point, the possible explanation may be found by looking at this relationship through a strategic alliance lens. Extending customer boundaries and integrating with strategic partners (alliances) for product and service delivery (alliance performance) are two important measures for 'DTC – Operating Model Transformation' (Section 8.2.1). Recent findings by researchers like Woods (2018) have shown that companies are rapidly developing Digital Twin with their alliance partners and increasing the alliance orientations for Digital Transformation.

However, researchers like Kandemir, Yaprak and Cavusgil (2006) argue that the Technology Turbulence does not have any significant moderating effect on alliance orientation and alliance performance. Based on the empirical research, Chatterjee (2004) observes that the Technology Turbulence has a negative effect on partner dependency (developing Digital Twins jointly with partners) and partner's intention to continue the alliance (perhaps due to poor alliance performance). Thus, from these discussions, it may be inferred that excessive Technology Turbulence may have negative a moderation effect on strategic partnership, which is a key to develop operating models with partners, hence the proposed relationship was not supported for the current study. This may be another important observation for the industrial managers.

According to hypotheses H5A1 – H5C, Technology Turbulence positively moderates the relationship between Digital Thread and DTCs, however, the results supported only one form of DTC, and are not significant for the other three forms of DTCs. These hypotheses are described in the following paragraphs.

Based on hypotheses H5-A1 and H5-A2, Technology Turbulence positively moderates the relationship between Digital Thread and 'DTC – Business Model Transformation (Marketing and Sales)' and the result supported this relationship. According to Richstein (2017), increasing technology disruptions augmented with shorter and shorter product life cycles have encouraged the companies to develop Digital Threads for customized products. It can be extrapolated that the customized products need different marketing and sales models than mass products. Industrial businesses are trying to capture early market shares in the Industrial Internet area and hence they concentrate on marketing and sales capabilities. The CEO of a leading Industrial Internet solution provider, Heppelmann of PTC, highlights in corporate literature how IIoT is changing marketing and sales[48]. Thus, it can be inferred from this discussion that Technology Turbulence accelerates the use of digital threads within the organization and in turn accelerates the adoption of new business models. So, it may be suggested that Technology Turbulence positively moderates the relationship between Digital Thread and 'DTC – Business Model Transformation (Marketing and Sales)' and the current study adds to the discussion of the impact of Technology Turbulence on Digital Thread and its relationship with 'DTC – Business Model Transformation (Marketing and Sales)'.

Hypotheses H5-B and H5-C posited that Technology Turbulence positively moderates the relationship between Digital Thread and 'DTC – Operating Model Transformation' and 'DTC – Cultural Transformation', however, the results indicated that the relationships were not significant. One possible explanation could be the adoption of digital threads within the industry. Deloitte and Manufacturer's Alliance for Productivity and Innovation (MAPI) conducted a survey and noted that though the companies are interested in implementing digital initiatives, during technology disruptions (like Industrial Internet), the adoption of Digital Thread is slow[49] and it can be extrapolated that slow adoption is also impacting transformation capabilities for operating model and digital workplace. The survey also found out that the lack of proper organizational funding and the lack of support from top management are barriers for such adoption. So, based on these discussions, it may be suggested that though the relationship is not significant at this time, as digital adoption increases there is a good possibility that the relationship will be significant in the future. Another possible explanation could be the state of

[48] https://www.ptc.com/en/product-lifecycle-report/how-the-iot-is-changing-sales-and-marketing
[49] https://deloitte.wsj.com/cfo/2018/07/02/many-manufacturers-slow-to-adopt-digital-supply-networks-survey/

current digitalization initiatives within the industrial businesses. Though the businesses understand that a comprehensive and holistic digitalization strategy should be implemented to develop a proper Digital Thread using the IIoT technologies, the convergence of OT and IT data are slow, time consuming and can take multiple years[50]. So, it might be expected that the moderating effect of Technology Turbulence on Digital Thread and its relationship with DTC – Operating Model Transformation may be significant in the near future.

It was proposed in the hypotheses H6A1 – H6C that, Technology Turbulence positively moderates the relationship between Digital Mindset and DTCs, and the results supported that because influence of digital mindset on all four forms of DTCs were significant. These hypotheses are described in the following paragraphs.

The study hypothesized that Technology Turbulence positively moderates the relationship between Digital Mindset and 'DTC – Business Model Transformation', and the result supported this relationship. Borrowing from servitization literature, it may be noted that a service oriented organizational culture is a prerequisite for servitization (Bowen et al., 1989; Bowen & Schneider, 1995; Kinnunen and Turunen, 2012). In addition, Baines, Lightfoot, Bendettini and Kay (2009), suggested that servitization is the innovation of the organization's capability to shift from selling products to selling products and services and servitization is influenced by technology disruption. So, it is expected that organizational culture and mindset of the managers might have a direct influence on servitization or service model innovation, which leads to new business model. In reference to cultural aspect of transformation, Kane, Palmer, Phillips, Kiron and Buckley (2015), observe that, as businesses are going through digital disruptions, digitally

[50] https://www.gartner.com/smarterwithgartner/when-it-and-operational-technology-converge/

reimaging of the businesses are determined by the digital strategies supported by the business leaders who could help in fostering new culture. So, based on these discussions, it may be suggested that Technology Turbulence (digital disruption), moderates the relationship between Digital Mindset (manager's intervention for cultural change) and DTC – Business Model transformation (digitally reimaging the business).

According to hypothesis H6B, Technology Turbulence positively moderates the relationship between Digital Mindset and 'DTC – Operating Model Transformation', and the result supported the proposed relationship. As explained in the Chapter, 8.2.1, operating model transformation may help a firm to extend its customer boundaries, to experiment and launch products and services faster, to develop data centric monetization capabilities and integrate with partners for product and service delivery. Borrowing from the partner integration and alliance performance literature, inter-firm organization culture has direct effect on alliance performance (Pothukuchi, Damanpour, Choi, Chen and Park, 2002). Based on the empirical research on technological alliances, Duysters and De Man (2003) observe that, in high technology industry with high technological turbulence, firms tends to develop more transitory (short-lived) alliances to solve particular technical issues within the industry. The leading software technology and solution provider, SAP[51] suggests that in the digital economy, digital partnerships are key to success for Digital Transformation at this turbulent technological era. So, based on these discussions, it may be suggested that Technology Turbulence positively moderates the relationship between Digital Mindset and 'DTC – Operating Model Transformation' and the current study adds to the discussion of the impact of Technology Turbulence on Digital Mindset and its relationship with

[51] https://ebooks-sap.com/downloads/SAP_eBook_DigitalEconomy.pdf

'DTC – Operating Model Transformation'. Greater Technology Turbulence supports efforts of a digital mindset to effect change in operating models.

Based on hypothesis H6C, Technology Turbulence positively moderates the relationship between Digital Mindset and 'DTC – Cultural Transformation', and the result supported that as the relationship was significant. As discussed in the previous section (Chapter, 8.2.3), Digital Mindset is a key input for 'DTC – Cultural Transformation' and Digital Mindset may influence 'DTC – Cultural Transformation' positively. Burrus (2018) observes that the digital disruption (technological and market turbulence) is changing the mindset of the employee and transforming the workplaces to digital workplaces. Boulton (2017), notes that the digital disruption is influencing the organizational culture and in turn affecting the formation of digital workplaces for Digital Transformation. Based on these discussions, it may be suggested that Technology Turbulence (digital disruption) is moderating the relationship between Digital Mindset (Organizational culture of the firm going through Digital Transformation) and 'DTC – Cultural Transformation'. And the current study adds to the discussion of the impact of Technology Turbulence on Digital Mindset and its relationship with 'DTC – Cultural Transformation'.

9.2.5 Moderating Effects of Market Turbulence

Hypotheses H7-3 A1 – H7-3C posited that, market turbulence (Product) positively moderates the relationships of Digital Twin and DTCs, however, two hypotheses were supported and two were not supported as the relationships were not significant. These hypotheses are explained in the following paragraphs.

The study hypothesized that market turbulence (Product) positively moderates the relationship between Digital Twin and ‘DTC – Business Model Transformation’ but the results did not support that as the relationships were not significant. Though Digital Twin fosters innovation in the Industrial Internet (IIoT) environment[52], according to Tsai and Yang (2013), firms’ innovativeness facilitates firm performance through new business models, when market turbulence and competitive intensity are high. Tsai et al. (2013) suggest that moderating effect of market turbulence and competitive intensity is mutually dependent. Thus, market turbulence alone may not have a significant moderating effect by itself. According to Datta (2017), Digital Twin is already defining new business models, however, shifting to a cloud-based deployment model is still a barrier and environmental factors have strong influence in the adoption of Digital Twin. Thus, the moderating effect of market turbulence (Product) on the relationship of Digital Twin and ‘DTC – Business Model Transformation’ may not be significant at this time.

According to the hypothesis H7-3B, market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and ‘DTC – Operating Model Transformation’ and the result supported that as the relationship was significant. As explained in Section 8.2.1, Digital Twin may affect the operating model of a firm, provided there is a consensus, managerial trust among business leaders is high and they believe that Digital Twin is the right approach for them. Also, Dayan (2010) suggests that the impact of managerial trust and team commitment is high when environmental turbulence (technological and market) is high. During digital disruption (when technology and market turbulence are high), Digital Twin helps a company to optimize their assets, operations and business[53]. Thus, based on these discussions,

[52] https://www.ibm.com/blogs/internet-of-things/iot-digital-twins-foster-innovation/
[53] https://www.ge.com/digital/sites/default/files/Digital-Twin-for-the-digital-power-plant-.pdf

it may be suggested that market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and 'DTC – Operating Model Transformation' and the study adds to the debate about the effect of market turbulence (Product) and its impact on the relationship between Digital Twin (Product Quality) and 'DTC – Operating Model Transformation'.

Based on the hypothesis H7-3C, market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and 'DTC – Cultural Transformation' and the result supported that as the relationship was significant. According to Wang, Duo, Zhu and Zhao (2015), market turbulence positively moderates the relationship between innovation dynamic and information dynamic capabilities. The innovation dynamic capability is a feature of Digital Twin, whereas, information dynamic capability is a feature of Cultural Transformation. The consulting firm Deloitte[54] suggested that during market volatility firms should develop new and innovative operating models for their products and services and the business leaders should focus on developing new organizational capabilities for change. So, based on these discussions, it may be suggested that market turbulence (Product) positively moderates the relationship between Digital Twin (Product Quality) and 'DTC – Cultural Transformation' and this study adds to the debate about the effect of market turbulence and its impact on the relationship between Digital Twin and DTC – Cultural Transformation.

Hypotheses H8-1 A1 – H8-1C and H8-2 A1 – H8-2C posited that market turbulence (Customer) positively moderates the relationships between Digital Thread and DTCs, however, two out of

[54] https://www2.deloitte.com/us/en/pages/operations/articles/operating-models-that-navigate-business-volatility.html#

four hypotheses were supported and two hypotheses were not significant. These hypotheses are described in the subsequent paragraphs.

It was proposed in hypothesis H8-2A2 that market turbulence (Customer) positively moderates the relationship between Digital Thread and ‘DTC – Business Model Transformation (Customer Engagement)’ and the result supported that as the relationship was significant. Based on the discussions in Section 8.2.2, it may be suggested that Digital Thread positively influences ‘DTC – Business Model Transformation’. According to Huang and Christensen (2008), as the pace of digital disruption (technology and market disruption) in the US healthcare industry is increasing, newer digital business models are being created. Hartman, King and Narayanan (2015) suggested that Digital Thread is allowing the companies to connect physical assets and exchanging real-time information and developing new service-based business models. Based on these discussions, it may be suggested that market turbulence (Customer) positively moderates the relationship between Digital Thread and ‘DTC – Business Model Transformation (Customer Engagement)’ and this study adds to the debate about the effect of market turbulence and its impact on the relationship between Digital Thread and ‘DTC – Business Model Transformation’.

Based on the hypothesis H8-2B, market turbulence (Customer) positively moderates the relationship between Digital Thread and DTC – Operating Model Transformation and the result supported that as the relationship was significant. Based on the discussions in Section 8.2.2, it may be suggested that Digital Thread positively influences ‘DTC – Operating Model Transformation’. Accenture[55] conducted a survey in the Aerospace & Defense (A&D) industry

[55] https://www.businesswire.com/news/home/20180716005661/en/

and they observed that as digital disruption (technological and market turbulence) is increasing, the A&D executives are overwhelmed by the volume of the data about their products and services and they are developing more and more Digital Threads and operating models to contextualize the data to make better business decisions. During digital disruption (technology and market turbulence), companies are forming more and more alliances (and changing their operating models) to deliver digital threads to transform supply chains for digital manufacturing[56]. Based on these discussions, it may be suggested that market turbulence (Customer) positively moderates the relationship between Digital Thread and 'DTC – Operating Model Transformation' and this study adds to the debate about the effect of market turbulence and its impact on the relationship between Digital Thread and 'DTC – Operating Model Transformation'.

According to the hypothesis H8-2C, market turbulence (Product) positively moderates the relationship between Digital Thread and 'DTC- Cultural Transformation'. The result supported that as the relationship was significant. Based on the discussions in Section 8.2.2, it may be suggested that Digital Thread positively influences 'DTC – Cultural Transformation'. As suggested by Burruss (2018) and Boulton (2017), digital disruption (technological and market turbulence) is influencing the organizational culture and in turn affecting the formation of digital workplaces for Digital Transformation. As the digital revolution is becoming mainstream, Digital Threads are connecting more and more data in digital manufacturing and digital skills sets for the employees are becoming more critical for business success (Hartmann, King and Narayanan, 2015). Based on these discussions, it may be suggested that market turbulence

[56] https://press.ext.hp.com/us/en/press-releases/2017/hp-and-deloitte-announce-alliance-to-accelerate--digital-transfo.html

(Product) positively moderates the relationship between Digital Thread and 'DTC – Cultural Transformation'. Also, this study adds to the debate about the effect of market turbulence and its impact on the relationship between Digital Thread and 'DTC – Cultural Transformation'.

Hypotheses H9-1 A1 – H9-1C and H9-2 A1 – H9-2C posited that market turbulence positively moderates the relationships between Digital Mindset and DTCs, however, none of the hypotheses was supported and, on the contrary, market turbulence had negative moderation effects on the relationships of 'DTC – Business Model Transformation' and 'DTC – Operating Model Transformation'. The relationship was not significant for Digital Mindset and 'DTC – Cultural Transformation'.

It was proposed in the hypotheses H9-1A1 and H9-2A1 that market turbulence positively moderates the relationship between Digital Mindset and 'DTC- Business Model Transformation', however, the result did not support this relationship and the moderation effect was **negative**. This is a significant observation and the possible explanation may be due to intervening factors hitherto unforeseen or unpredicted in theory. Conceivably, there may be intermediate effects. One possible explanation could be similar to the hypothesis described in Section 8.2.4, that market turbulence is changing the business model faster (Prem, 2015, Mithas, Tafti and Mitchell, 2013), however, the pace of change of digital mindset[57] is slower or has just started and managers are focusing more on technology transformation than on changes in organizational culture/mindset. It is expected that in the coming years, as Digital Transformation across industrial businesses gain momentum, the pace of change of organization culture may

[57] https://www.forbes.com/sites/forbestechcouncil/2018/01/26/creating-a-culture-of-digital-transformation-in-2018/#7ef82d6c36bd

catch up and the moderation effect may be significant. Fundamentally, managers experiencing greater degrees of market turbulence find it harder to predict what actions will best suit the future market state and this uncertainty or confusion is likely at the heart of its negative moderation of the ability of a digital mindset to effect cultural change.

Based on hypotheses H9-1B and H9-2B, market turbulence positively moderates the relationship between Digital Mindset and 'DTC – Operating Model Transformation', however, the result did not support this relationship and on the contrary and moderation effect was **negative**. This is a significant observation. Similar to business model transformation, the operating model is changing faster than the organizational culture and mindset. Due to more and more environmental turbulence (Technological and Market Turbulence), companies are changing their operating models (Bollard, Larrea, Singla and Sood, 2017), however, as mentioned in the previous section, the pace of change of organizational culture/mindset is slower or has just started. This discrepancy may cause the negative moderation effect. It is expected that in the coming years, as Digital Transformation across industrial businesses gains momentum, the pace of change of organization culture may catch up with operating model changes and the moderation effect may be significant and this may be a significant observation for digital managers.

According to hypotheses H9-1C and H9-2C, market turbulence positively moderates the relationship between Digital Mindset and 'DTC – Cultural Transformation', however, the result did not support this relationship. As mentioned in the previous sections, due to environmental turbulence, the mindset changes have just started for the industrial businesses and their effect on workplace transformation to the digital workplace may take more time; as mentioned in the previous sections, it is expected that in the coming years, as Digital Transformation across industrial businesses gains momentum, the pace of change of organization culture may be significant enough to transform the workplace by developing new digital skills and by retraining existing employees with digital skills.

9.2.6 Moderating Effects of Competitive Turbulence

The study hypothesized that Competitive Turbulence (H10-1A1 – H10-1C and H10-2A1 – H10-2C) negatively moderates the relationship between Digital Twin and DTCs. Three out of four hypotheses were supported. These hypotheses are explained in the subsequent paragraphs.

Based on hypothesis H10-1A1, Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and 'DTC – Business Model Transformation' and the results supported that as the relationship was significant. Based on the discussion in Section 8.2.1, Digital Twin may facilitate new product development (NPD) (Haag and Anderi, 2018; Tao, Cheng, Qi, Zhang, Zhang and Sui, 2018), however, the pace of new product development may be negatively impacted by Competitive Turbulence. According to Hardaker, Ahmed and Graham (1998), firms need to be responsive to market conditions in a highly competitive situation as it might have an adverse effect on rapid delivery of new products. Also, Tsai and Hsu (2014) observed that competitive intensity weakens the effect of cross-functional collaboration for new product development and performance. Based on these discussions, it may be suggested that Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and 'DTC – Business Model Transformation'. Also, this study adds to the debate about the effect of Competitive Turbulence and its impact on the relationship between Digital Twin and ‘DTC – Business Model Transformation’.

It was proposed in the hypothesis H10-1B, that Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and ‘DTC – Operating Model Transformation’ and the results supported that as the relationship was significant. Based on the recent business report, Digital Twin automates business processes and increases collaboration both within and outside the organization[58]. The researchers Tsai and Hsu (2014) pointed out that competitive intensity has a negative effect on cross-functional collaboration and knowledge integration. Based on these discussions, it may be suggested that Competitor Turbulence may negatively moderate the relationship between Digital Twin and ‘DTC – Operating Model Transformation’. Also, this study adds to the debate about the effect of Competitive Turbulence and its impact on the relationship between Digital Twin and ‘DTC – Operating Model Transformation’.

Based on the hypothesis H10-1C, Competitive Turbulence negatively moderates the relationship between Digital Twin (Product Development) and ‘DTC – Cultural Transformation’, however, the result did not support this relationship as it was not significant. Borrowing from market orientation and culture studies, the market orientation and culture has a positive effect on firm performance but the relationship is inhibited by competitive intensity (González-Benito, González-Benito and Muñoz-Gallego, 2013). Also, the firms may develop joint digital projects with partners and competitors. Though GE and Microsoft develop their own IIoT platforms, they

[58] https://www.forbes.com/sites/sap/2018/06/22/the-digital-twin-effect-four-ways-it-can-revitalize-your-business/#2ad263258356

plan to work together in digital projects which may turn the workplace into a digital workplace[59]. Based on the discussion in Section 8.2.1, Digital Twin may not positively influence 'DTC – Cultural Transformation'. Thus, Competitive Turbulence may not have negative moderation effect on the relationship between Digital Twin and 'DTC – Cultural Transformation'.

It was proposed in the hypotheses H11A1 – H11C that Competitive Turbulence negatively moderates the relationship of Digital Thread and DTCs. The result from the current study supported only one out of four forms of DTCs. These hypotheses are explained in the subsequent paragraphs.

Based on the hypothesis, H11A1, Competitive Turbulence negatively moderates the relationship between Digital Thread and 'DTC – Business Model Transformation' and the results supported that as the relationship was significant. Based on the discussions in Section 8.2.2, it may be noted that Digital Thread positively influences 'DTC – Business Model Transformation'. According to Casadesus-Masanell and Zhu (2012), when competitive intensity is high, a new firm strategically needs to conceal its new business model and work with a traditional business model to compete in the market. Auh and Menguc (2005) further supported the same notion and argued that when competition intensifies, exploration (for developing new products and business models) is negatively related to firm performance. Based on these discussions it may be suggested that Competitor Turbulence may have a negative moderation effect between the relationship of Digital Thread and 'DTC – Business Model Transformation'. Also, this study adds to the debate about the effect of Competitive Turbulence and its impact on the relationship between Digital Thread and 'DTC – Business Model Transformation'.

[59] https://www.ge.com/digital/partners

According to the hypothesis H11B, Competitive Turbulence negatively moderates the relationship between Digital Thread and 'DTC – Operating Model Transformation' and the result did not support that as the relationship was not significant. One possible explanation for this result may be related to the effect of competitive intensity and organizational collaboration for operating model transformation. As Ang (2008) suggested, once Technology Turbulence is high, competitive intensity has an inverted U-shaped association with organizational collaboration. The author also noticed that firms would collaborate more when they faced moderate level of competitive intensity. So, it seems that competitive intensity may not have a definitive effect on the collaborative capabilities of a firm. Wu and Pangarkar (2010) observed an inverted U-shaped relationship between competitive intensity and firm collaboration capabilities. Based on these discussions, it may be suggested that influence of market turbulence on the relationship between Digital Thread and DTC – Operating model transformation is still evolving and not transparent at this time.

Based on the hypothesis, H11C, Competitive Turbulence negatively moderates the relationship between Digital Thread and 'DTC – Cultural Transformation'; the result did not support that as the relationship was not significant. However, based on the discussions in Section 8.2.2, it may be suggested that Digital Thread positively influences 'DTC – Cultural Transformation'; the discussion in the previous section (effect of market turbulence on the relationship of Digital Twin and 'DTC – Cultural Transformation'), market turbulence may not have any impact on 'DTC – Cultural Transformation'at this time.

Based on the hypotheses H12A1 and H12A2, Competitive Turbulence negatively moderates the relationship between Digital Mindset and 'DTC – Business Model Transformation' and the results did not support that as the relationship was not significant. Based on the discussions in Section 8.2.3, Digital Mindset did not represent a key input for 'DTC – Business Model Transformation'. Casadesus-Masanell and Zhu (2013) argued that competitive intensity may or may not support new business models. Soto-Accosta, Popa and Palacios-Marques (2015) also endorsed that and noted that, in e-business, the business model emerges from the use of technologies and internal organizational resources and it has less impact from external factors like competitive intensity. Thus, at this time, Competitive Turbulence may not have any moderation effect on the relationship between Digital Mindset and 'DTC – Business Model Transformation'.

It was proposed in the hypotheses H12B that Competitive Turbulence negatively moderates the relationship between Digital Mindset and 'DTC – Operating Model Transformation' and the results did not support that as the relationship was not significant. Based on the discussions in Section 8.2.3, Digital Mindset did not represent a key input for 'DTC – Operating Model Transformation'. As discussed in the previous section, market turbulence may not have any effect on 'DTC – Operating Model transformation'. So, the result may be explained from these discussions and, at this time, Competitive Turbulence may not have any moderation effect on the relationship between Digital Mindset and 'DTC – Operating Model Transformation'.

Based on the hypotheses H12C, Competitive Turbulence negatively moderates the relationship between Digital Mindset and 'DTC – Cultural Transformation', however, the result did not support that as the relationship was not significant. Dan Glessner, VP Digital of Genpact [60], suggested that Digital Transformation is more about digital mindset and less about technology. Since industry boundaries are getting blurred and competitors are entering from different industries (McGrath, 2013), it is logical that during such competition, the industrial businesses should develop more capabilities to transform their workplaces into digital workplaces. The result did not show any significant moderation relationship, which suggests that industrial managers are still going through the initial phases of Digital Transformation and cultural transformations are not their priority at this time.

9.2.7 Moderating Effects of Path Dependency

It was proposed in the hypotheses H13-1A1 – H13-1C and H13-2A1 – H13-2C that Path Dependency Hypotheses H13-1A1 – H13-1C and H13-2A1 – H13-2C negatively moderates the relationship of Digital Twin and DTCs. However, the result only supported one component of DTC and did not support three other forms of DTC as the relationships were not significant. The following paragraphs explain these hypotheses.

Based on the hypotheses H13-A1 and H13-A2, Path Dependency negatively moderates the relationship between Digital Twin and 'DTC – Business Model Transformation', but the result did not support that as the relationship was not significant. As discussed in Chapter 8.2.1, Digital Twin may not have any effect on 'DTC – Business Model Transformation'. DaSilva and Trkman (2014) observed that there is less clarity whether business model innovation is path dependent or

[60] http://www.genpact.com/insight/blog/digital-transformation-more-about-mindset-than-technology

not. As mentioned by Bernard Marr[61], though Digital Twin has been around since 2002, the impact of Digital Twin is becoming slowly cost effective due to Industrial Internet and its applicability is on the rise. So, the Digital Twin is becoming mainstream and the effect of Path Dependency may be significant at a later stage. The firm might have been placed in some kind of flux or new state, which temporarily destabilizes the effects we would normally anticipate with Path Dependency as reasoned in our hypothesis. This may explain our lack of effect here and in turn may suggest that the effect of Path Dependency is lagged by comparison.

According to the hypothesis H13-1B, Path Dependency negatively moderates the relationship between Digital Twin and 'DTC – Operating Model Transformation', but the result did not support that as the relationship was not significant. As discussed in Section 8.2.1, Digital Twin may not have any effect on 'DTC – Operating Model Transformation'. The leading manufacturing expert of NASA's National Center for Advanced Manufacturing, John Vickers, suggested that "The ultimate vision of the Digital Twin is to create, test and build our equipment in a virtual environment"[62]. So, it may be suggested from these discussions that Digital Twin may be more significant in the future and Path Dependency may influence the relationship between Digital Twin and 'DTC – Operating Model Transformation'.

Based on the hypothesis H13-1C, Path Dependency negatively moderates the relationship between Digital Twin (Product Development) and 'DTC – Cultural Transformation' and the result supported that as the relationship was significant. According to recent empirical research

[61] https://www.forbes.com/sites/bernardmarr/2017/03/06/what-is-digital-twin-technology-and-why-is-it-so-important/#56b1e8792e2a
[62] https://www.forbes.com/sites/bernardmarr/2017/03/06/what-is-digital-twin-technology-and-why-is-it-so-important/#56b1e8792e2a

by Sydow, Schreyogg and Koch (2009), Path Dependency creates a self-reinforcing mechanism within an organization and it leads the organization into a lock-in. Barnes, Gartland and Stack (2004) further reinforced the observation and argued that old habits die hard and Path Dependency creates a behavioural lock-in within the organization. Based on these discussions, it may be suggested that Path Dependency negatively moderates the relationship between Digital Twin (Product Development) and 'DTC – Cultural Transformation', and adds to the debate about the effect of Path Dependency and its impact on the relationship between Digital Twin (Product Development) and 'DTC – Cultural Transformation'.

It was proposed in the hypotheses H14A1 and H14A2, Path Dependency negatively moderates the relationship between Digital Thread and 'DTC – Business Model Transformation', but the result did not support that as the relationship was not significant. As mentioned in the previous section, the Path Dependency may not have a significant effect on business model transformation. Though Digital Thread promises to bring new operating models for firms as in the industrial sectors like Aerospace & Defence (A&D) industry[63], making Digital Thread-related initiatives successful in the firm is still doubtful at this time. So, industrial managers are not making these projects their priority. Analysts from market research firm Forrester surveyed industrial businesses and found out that due to lack of technical skills, the maturity of the technologies and security concerns are preventing industrial managers to fund Digital Thread projects[64]. Though Digital Thread may revolutionize the digital supply chain, integrating multiple terabytes and petabytes of data is still computing resource intensive and needs special data science skills. So, at this time, Path Dependency may not have any effect on the relationship

[63] http://www.dxc.technology/manufacturing/insights/145414-digital_thread_a_path_to_adopt_innovative_and_transformative_capabilities_for_a_d_companies
[64] https://www.aras.com/-/media/Files/Resources/Whitepapers/aras-forrester-digital-transformation.ashx

between Digital Thread and ‘DTC – Business Model Transformation’, however, as more and more Digital Thread projects are adopted by companies, negative moderation effects of Path Dependency may be significant.

Hypothesis H14B posited that Path Dependency negatively moderates the relationship between Digital Thread and ‘DTC – Operating Model Transformation’, and the result supported that as the relationship was significant. As mentioned in Section 8.2.2, Digital Thread is a key input to ‘DTC – Operating Model Transformation’. Based on empirical M&A research by Hagedoorn and Duysters (2002), companies reinforce their existing innovative capabilities by concentrating on technology alliances and M&A activities or a combination of both as they are locked into a particular set of preferences. Thus, the companies cannot easily change their strategic alliances even if the innovative processes (like Digital Thread) are shifting to a new direction. While analysing, exploration and exploitation and its effect on alliance formation, Lavie and Rosenkopf (2006) noted that Path Dependency reinforces either exploration or exploitation within an organization. So, when in the exploitation phase, Path Dependency does not allow the organization to exploit using new inputs like Digital Thread. Based on these discussions, it may be suggested that Path Dependency negatively moderates the relationship between Digital Thread and ‘DTC – Operating Model Transformation’ and the current study adds to the debate of the effect of Path Dependency on Digital Thread and ‘DTC – Operating Model Transformation’.

According to the hypothesis H14C, Path Dependency negatively moderates the relationship between Digital Thread and ‘DTC – Cultural Transformation’, and the result did not support that as the relationship was not significant. As discussed in Section 8.2.2, Digital Thread is a key input to ‘DTC – Cultural Transformation’. The industry researchers suggested that changing the internal culture of an organization is the biggest barrier to change for a workplace and transforming that to a digital workplace[65], so ideally Path Dependency should influence the relationship between Digital Thread and 'DTC – Cultural Transformation'. The possible explanation for this result may be due to the pace of Digital Thread adoption; the pace of cultural changes in the organization are not synchronized at this time and the relationship may be significant in the coming years.

Based on hypotheses H15A1 and H15A2, Path Dependency negatively moderates the relationship between Digital Mindset and 'DTC – Business Model Transformation', but the result did not support that as the relationship was not significant. Based on the discussions in Section 8.2.3, Digital Mindset is not a key input for 'DTC – Business Model Transformation'. Also, based on the discussion in the previous section, it can be inferred that Path Dependency may not have any significant effect on business model transformation. So, based on these discussions, it may be suggested that Path Dependency may not have any significant effect between the relationship of Digital Mindset and 'DTC – Business Model Transformation'.

It was proposed in hypothesis H15B that Path Dependency negatively moderates the relationship between Digital Mindset and 'DTC – Operating Model Transformation', but the result did not support that as the relationship was not significant. Based on the discussions in Section 8.2.3, Digital Mindset is not a key input for 'DTC – Operating Model Transformation'. Researchers (Levitt and March, 1988; Rothaermel and Deeds, 2006) suggested that alliance management capability is a path dependent capability which is built over time with repeated engagements in strategic alliances. From this discussion, we can infer that Path Dependency for operating models

[65] https://go.forrester.com/blogs/prioritize-culture-change-to-accelerate-digital-transformation/

may be created by repeated engagement with strategic alliances. Since the Digital Transformation has just started in industrial businesses, the effect of Path Dependency may not be significant at this time.

Based on the hypothesis H15C, Path Dependency negatively moderates the relationship between Digital Mindset and ‘DTC – Cultural Transformation’, but the result did not support that as the relationship was not significant. Based on the discussions in Section 8.2.3, Digital Mindset is a key input for ‘DTC – Cultural Transformation’. As mentioned in the previous discussion, changing the internal culture of the organization is the biggest barrier for any changing the workplace to a digital workplace so ideally Path Dependency should have a negative effect on ‘DTC - Cultural Transformation’. Similar to the previous discussion, the pace of cultural changes in an organization and the pace of workplace changes may not be taking place at the same time and the moderation effect may not be apparent at this time.

9.3 Back-end Model Discussion

The back-end model hypothesizes the influence of Digital Transformative Capabilities (DTCs) on the core dynamic capabilities, which this thesis conceptualizes as indicative of the degree of Digital Transformation (DT) within a firm (DCImp: importance of DCs, DCIpr: improvements in DCs and DCCom, comparison of DCs). The back-end model includes relationships about factors which affect these DCs and the moderation effects acting on these relationships.

As discussed in Section 6.3, DTCs (‘DTC – Business Model Transformation’, ‘DTC – Operating Model Transformation’ and ‘DTC – Cultural Transformation’) may influence core sensing, seizing and reconfiguration DCs. The core sensing DCs are (see Section 5.3.1), R&D

capabilities, NPD/NPI capabilities and Organizational Sensing capabilities. The core seizing DCs are (see Section 5.3.2), Learning & Knowledge Management, Exploration & Exploitation, Strategic Flexibility and Market Responsiveness. And the core reconfiguration DCs are (see Section 5.3.3), Integration, Coordination and Alliance Management capabilities.

9.3.1 Hypotheses – 16A1 – 16C (DTC – Business Model Transformation and its effect on DCs)

The study hypothesized that 'DTC – Business Model Transformation' positively influences DCImp (Importance of DCs), DCIpr (Improvements in DCs) and DCCom (Comparison of DCs), however, the results did not support this general effect because the influence of DTC – Business Model Transformation on all four forms of DCs was not significant.

To explain this result, we draw attention to the business model transformations in industrial businesses which are going through DT by leveraging Industrial Internet. According to reports in the industry publication CIO magazine[66], industrial businesses are going through technological innovations, but how that will impact businesses overall and how the business model will change is not clear. According to Chen (2017), IoT technologies are disrupting industrial businesses, however business models and operational processes within a firm will shift gradually to align with IoT technologies. Based on the empirical research, Palattella et al. (2016) suggested that uncertainties in business models are hindering IoT adoption in industries. The suggestions of Sund et al. (2016) for managing tensions across new and existing business models provide some insights here. For instance, they suggest that companies evolving their business models from an existing to a new model, such as done by GE in moving into digitization, should not settle too

[66] https://www.cio.com/article/3161284/internet-of-things/iot-and-business-model-transformation-were-not-there-yet.html

quickly on a new structure and welcome experimentation in the model. As such, business model transformation in itself may not generate changes (or new) DCs in itself but may be moderated or mediated by other factors. Thus, from these discussions, it may be inferred that 'DTC – Business Model Transformation' may not have significant effects on DCImp, DCIpr and DCCom.

9.3.2 Hypotheses – 17A1 – 17C (DTC – Operating Model Transformation and its Effect on DCs)

The study hypothesized that 'DTC – Operating Model Transformation' positively influences DCImp (Importance of DCs), DCIpr (Improvements in DCs) and DCCom (Comparison of DCs), and the results supported that as the relationships were significant.

As mentioned by leading business journal Forbes[67], in most companies, Digital Transformation initiatives were not started by the top executives but by employees across the organization who observed that the business world was changing and competitors and partners were engaged in adopting new emerging technologies in their business operations, which in turn may influence and improve DCs which may be indicative of the degree of Digital Transformation in the firm. According to McKinsey[68], firms are adopting a new generation of operating models which may influence DCs; this may be indicative of the degree of Digital Transformation. Zimmermann et al. (2015) suggested that in leveraging IIoT, a firm may transform its business systems, interaction with partners and improve operational processes which may influence and improve

[67] https://www.forbes.com/sites/peterbendorsamuel/2017/08/15/when-and-how-a-digital-transformation-opportunity-appears/#11b9433d4856

[68] https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Introducing%20the%20next-generation%20operating%20model/Introducing-the-next-gen-operating-model.ashx

DCs. Based on these discussions, it may be suggested that 'DTC – Operating Model Transformation' positively influences the importance and improvements (including comparison with competitors) of DCs which may be indicative of the degree of Digital Transformation within firms.

9.3.3 Hypotheses – 18A1 – 18C (DTC – Cultural Transformation and its Effect on DCs)

The study hypothesized that 'DTC – Cultural Transformation' positively influences DCImp (Importance of DCs), DCIpr (Improvements in DCs) and DCCom (Comparison of DCs), however, the results supported only one form of DC.

It was proposed in the hypothesis H18A2 that 'DTC – Cultural Transformation' positively influences DCImp (Reconfiguration) and the result supported that as the relationship was significant. As discussed in Section 6.2.3, a company needs to transform its organizational culture, leadership and employee mindsets to transform its workplace to a digital workplace. The possible explanation may be found in the dynamic capability literature. Chirico and Nordqvist (2010) suggested that organizational culture has a positive effect on DCs which are responsible for firm performance. Helfat et al. (2009) argue that organizational culture influences DCs. Different environmental conditions require different types of DCs, operational capabilities and organizational culture (Wilden, Devinney, Dowling, 2016). The business literature also emphasizes the importance of culture for Digital Transformation. According to BCG[69], Digital Transformation is not possible without a digital culture. The market research firm Forrester[70]

[69] https://www.bcg.com/en-us/publications/2018/not-digital-transformation-without-digital-culture.aspx

[70] https://go.forrester.com/blogs/prioritize-culture-change-to-accelerate-digital-transformation/

suggested that companies should prioritize cultural changes which may influence capabilities needed for Digital Transformation. Based on these discussions, it may be suggested that organizational culture may influence a company to pay attention to DCs, which may be indicative of the degree of Digital Transformation in a firm.

Based on hypotheses H18B and H18C, 'DTC – Cultural Transformation' positively influences DCIpr and DCCom, however the results did not support that as the relationships were not significant. The possible explanation may be attributed by the pace of digital cultural changes within an organization. McConnell (2015) suggested that company culture helps or hinders capabilities for Digital Transformation and that cultural change is a gradual process. Forrester also suggested that companies must fix cultural gaps to accelerate Digital Transformation. Reports in Forbes[71] noted that the slow pace of Digital Transformation is due to the cultural gaps and resistant for change at the leadership and employee levels. Based on these discussions, it may be suggested that industrial businesses are developing capabilities for Digital Transformation and the organization culture is gradually transforming to a digital culture. So, 'DTC – Cultural Transformation' may not significantly influence improvements and comparisons of DCs against competitors.

9.3.4 Moderating Effects of Ecosystem Partnership

According to the hypotheses H19-2A1 – H19-2C, Ecosystem Partnership positively moderates the relationships between 'DTC – Business Model Transformation (Customer Engagement)' and

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[71] https://www.forbes.com/sites/adigaskell/2018/06/08/the-slow-pace-of-digital-transformation/#27e85175491b

DCImp, DCIpr & DCCom. However, the results did not support that and instead of positive relationships, the results indicated **negative** relationships contrary to expectations. This is an important observation. A possible explanation may be the pace of DTC – Business Model Transformation and its effect on core DCs which may be indicative of the degree of Digital Transformation within a firm. As mentioned in Section 8.3.1, 'DTC – Business Model Transformation' did not influence DCImp, DCIpr and DCCom.

Trust is an important driver for ecosystem partnership as alliance managers need to be actively involved, committed and dedicated for joint alliance performance (Meier, Lutkewitte, Mellewigt and Decker, 2015). However, industrial businesses are going through initial phases of business model transformation and the partners may not have a common and trusted relationship and may explain the influence of ecosystem partners exhibiting a negative effect on DCs. Borrowing from the open innovation literature, it may be suggested that a company's business model may not be attuned to open innovation (Saebi and Foss, 2015) and in such cases ecosystem partnership may not be effective or may have a negative effect on a firm's business model and its effect on DCs. This may be a good observation for industrial managers as they may realize that ecosystem partnership may not moderate the relationship between business model transformation and DCs which may be indicative of Digital Transformation in a firm.

Based on the hypotheses H20A1 – H20C, Ecosystem Partnership positively moderates the relationships between 'DTC – Operating Model Transformation' and DCImp, DCIpr & DCCom. The results supported these relationships as they were significant.

Based on the discussions in Section 8.3.2, 'DTC – Operating Model Transformation' positively influences DCs which may be indicative of the degree of DT in a firm. Based on the survey conducted by Accenture[72], Digital Transformation is about digital ecosystems, which are communities that use shared and scalable resources to address important challenges in Digital Transformation. A digital ecosystem is comprised of a company and its ecosystem partners who work in tandem (operating model) and by which they can accelerate Digital Transformation in a company. Newman (2017) argued that ecosystem partnership may allow a company to develop new and enhanced operating models which in turn may accelerate Digital Transformation in the company. Based on the empirical research by Forman, Huang and Wu (2012) independent software vendors (ISVs) gained operational efficiencies and improved product performance by changing their operating model and adopting the ecosystem partner's platform as their development platform, which in turn helped them to develop DCs which may be indicative of Digital Transformation. From these discussions, we can suggest that ecosystem partnership moderates the relationship between 'DTC – Operating Model Transformation' and DCs may be indicative of the degree of Digital Transformation in a firm.

9.3.5 Moderating Effects of Customer and Market Demands

It was proposed in the hypotheses H22A1 – H22C, Customer and Market Demands positively moderate the relationships between 'DTC – Business Model Transformation' and DCImp, DCIpr & DCCom. However, the results did not support that as the relationships were not significant. As discussed in Section 8.3.1 'DTC – Business Model Transformation' did not influence DCImp, DCIpr and DCCom. Though there is no scholarly study on this matter to date, one possible

[72] https://www.accenture.com/us-en/insight-digital-platform-economy

explanation may be discovered from the state of IIoT in industrial businesses. Chui, Ganesan and Patel (2017) suggested that though there is a surge of IIoT in industrial businesses, IIoT faces uncertainty related to regulations, customer and market demands and technological advances. There is another uncertainty in the IIoT industry related to ownership of data, as uncertainty persists who owns the data, the customer or the vendor who provides IIoT solutions.[73] Since the uncertainty surrounding the customer and market demands are higher, firms are less able to predict customer and market demands, which are affecting business model transformation. This may be a possible explanation for the result.

Based on the hypotheses H23A1 – H23C, Customer and Market Demands positively moderates the relationships between 'DTC – Operating Model Transformation' and DCImp, DCIpr & DCCom. However, the results did not support that as the relationships were not significant. As discussed in Section 8.3.2, 'DTC – Operating Model Transformation' positively influences DCImp, DCIpr and DCCom. However, McKinsey[74] suggested that next generation operating models are required for the digital world to satisfy customer and market demands and these models are evolving gradually. According to the Society of Information Management (SIM) survey[75], chief technical officers (CTOs) and chief information officers (CIOs) are interested in Digital Transformation based on customer and market demands. However, due to resource constraints (financial and human resources) and different corporate priorities, they cannot execute those DT initiatives and cannot develop capabilities which may be indicative of the

[73] https://internetofbusiness.com/uncertainty-ownership-value-iot-data-persists/

[74] https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-next-generation-operating-model-for-the-digital-world

[75] https://medium.com/@SIMInt/why-are-so-many-companies-so-slow-to-make-the-digital-jump-ec535518975f

degree of DT in a firm. Though ‘DTC – Operating Model Transformation’ positively influences the relationships of DCs, due to resource constraints, customer and market demands for Digital Transformation-related initiatives may not be the top priority for industrial managers and hence the moderating relationship was not significant.

It was proposed in hypotheses H24A1 – H24C that Customer and Market Demands positively moderates the relationships between ‘DTC – Cultural Transformation’ and DCImp, DCIpr & DCCom. However, the results did not support that as the relationships were not significant. A possible explanation for this result may be derived from the previous discussions. Though with evolving customer experiences by 24/7 connectivity, the digital market and customers are driving Digital Transformation initiatives in the organizations[76], as discussed in Section 8.3.3, the changes in digital culture are slow and companies are gradually developing capabilities and transforming their workplaces into digital workplaces. So, there was no moderation effect of customer and market demands on the relationship between ‘DTC - Cultural Transformation’ and DCs which may be indicative of the degree of Digital Transformation in a firm.

9.3.6 Moderating Effects of Digital Commitment

Based on hypotheses H25A-1 – H25C, Digital Commitment positively moderates the relationships between ‘DTC – Business Model Transformation (Marketing & Sales)’ and DCImp, DCIpr & DCCom. However, the results did not support that as the relationships were not significant. A possible explanation for this result may be derived from the previous discussion. Kane, Palmer, Phillips, Kiron and Buckley (2015) suggested that digital strategy and commitment from top executives are keys for success in Digital Transformation, symptomatic of

[76] https://www.adweek.com/digital/5-market-forces-that-are-driving-digital-transformation/

the wider idea that executive buy-in from C-suite is essential for Digital Transformation[77]. Davenport and Westerman (2018) suggested that given the uncertainty in customer and market demand in industrial businesses, and recent challenges faced by GE, Nike, Procter & Gamble and others, executives responsible for Digital Transformation are hesitant to make any commitment to Digital Transformation. So, even if there is market and customer demand for Digital Transformation products and services, executives are reluctant to make any serious commitment for change and develop DCs which may be indicative of Digital Transformation. Hence customer and market demand may not have any moderation effect on the relationship between 'DTC – Business Model Transformation' and DCs which may be indicative of the degree of Digital Transformation in a firm.

According to hypotheses H26A1 – H26C, Digital Commitment positively moderates the relationships between 'DTC- Operating Model Transformation' and DCImp, DCIpr & DCCom. However, the results did not support that and, on the contrary, the result showed a **negative** moderation effect. This is an important observation for industrial managers. A possible explanation for this result may be borrowed from the current state of the Digital Transformation journeys of leading industrial companies. As discussed in the previous section, Davenport and Westerman (2018) suggested that time and again top executives of companies (GE, Nike, Proctor & Gamble and others) have promised big successes by developing digital capabilities which may be indicative of the degree of Digital Transformation, and they have been met with basic financial performance problems. GE started an ambitious Digital Transformation initiative throughout GE businesses, invested multi-billion dollars, started a new business – GE Digital –

[77] https://www.informationweek.com/strategic-cio/digital-business/get-the-c-suite-on-board-with-digital-transformation/a/d-id/1332446

and finally decided to scale it down[78]. Hirst (2018) noted that one in five executives secretly thinks that Digital Transformation projects are a waste of time. So, it seems, executives are not taking Digital Transformation initiatives seriously; perhaps they are approaching them negatively and are not ready to change the business operations or to invest in developing DCs which may be indicative of the degree of Digital Transformation. The result of the current study may be indicative of that.

Based on hypotheses H27A1 – H27C, Digital Commitment positively moderates the relationships between 'DTC – Cultural Transformation' and DCImp, DCIpr & DCCom. However, the results did not support that; on the contrary, the result showed **negative** moderation effect for DCImp. As mentioned in the previous section, excessive digital commitment from top executives may have some negative effect on cultural transformation, because they may face extreme pressure to generate substantial revenues from digital businesses and the companies may not have actionable strategies and capabilities to accomplish revenue objectives[79]. Also, borrowing from the organizational change literature, some executives are more interested to maintain the status quo of their current strategy and the commitment to the status quo (CSQ) depends on the psychological orientation of the executives (Hambrick, Geletkanycz and Fredrickson, 1993). So, even if there may be digital commitment from top executives, managers in industrial businesses may not be aligned and executives may not be interested to develop DCs which may be indicative of the degree of Digital Transformation in a firm.

[78] https://www.wsj.com/articles/ge-puts-digital-assets-on-the-block-1532972822
[79] https://www.cio.com/article/3248946/digital-transformation/12-reasons-why-digital-transformations-fail.html

9.3.7 Resource Scarcity and Constraints

It was proposed in hypotheses H28A1 – H28C that Resource Scarcity and Constraints negatively moderates the relationships between 'DTC – Business Model Transformation (Customer Engagements)' and DCImp, DCIpr & DCCom, and the results supported two out of four hypotheses. Zott and Amit (2015) have suggested internal constraints, such as availability, ownership and control of organizational resources are antecedents for business model innovation. Catlin, Lorenz, Sternfels and Willmot (2017) suggested that though a growing number of executives believe that implementing digital business models may have significant impacts on developing capabilities, which may be indicative of the degree of Digital Transformation in a firm, the non-availability of resources may slow down the transformation capabilities of an organization. Thus, we may infer from these discussions that resource scarcity and constraints may have a negative moderation effect on the relations of 'DTC – Business Model Transformation' and DCs which may be indicative of the degree of Digital Transformation in a firm.

Based on hypotheses H29A1 – H29C, Resource Scarcity and Constraints negatively moderates the relationships between 'DTC – Operating Model Transformation' and DCImp, DCIpr & DCCom; the results did not support that as the relationships were not significant. Though intuitively it seems that resource scarcity and constraints may negatively moderate the relationship between 'DTC – Operating Model Transformation' and DCs, which may be indicative of degree of Digital Transformation in a firm, in reality this may or may not be true. Firms going through Digital Transformation and transforming their operating models may not seek all the resources and capabilities in-house and may collaborate with partners to fulfil the resource and capability gaps[80]. Also, in a resource constraints environment, firms may come up with innovative ideas and adapt to a frugal digital innovation (Agarwal and Brandinali, 2018), hence the moderation effect may not exist.

It was proposed in hypotheses H30A1 – H30C that Resource Scarcity and Constraints negatively moderates the relationships between 'DTC – Cultural Transformation' and DCImp, DCIpr & DCCom; the results did not support that as the relationships were not significant. The possible explanation for this result may be similar to the previous section. Though intuitively it seems that resource constraints may have a negative impact on digital cultural changes within an organization, in reality it seems digitally mature organizations accept this risk and develop DCs in line with overall organization strategy while including resource scarcity as a constraint and plan it accordingly (Kane, Kiron, Palmer, Buckley and Phillips, 2016). Hence the results were not significant.

9.4 Conclusion

The current study provides some of the very first empirical evidence about the nomological network of factors involved in Digital Transformation. It is apparent from the discussions that some of the predictors drawn from existing theories and literature are functioning and some are not functioning as expected.

[80] https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/acquiring-the-capabilities-you-need-to-go-digital

9.4.1 Summary of Front-End Model

The table below summarizes the results from the front-end model.

Table 64 : Summary of the Front-end Model

Hypothesis	Description	Supported (S/N/M/P)	Remarks
H1	Digital Twin is a key input for DTC.	N	None of the 4 forms were supported.
H2	Digital Thread is a key input for DTC.	S	All 4 forms were supported.
H3	Digital Mindset is a key input for DTC.	P	1 form was supported and 3 forms were not supported.
H4 – H6	Moderating effect of Technology Turbulence	P/R	Digital Twin was refuted, Digital Thread was partially supported. Digital Mindset was supported.
H7 – H9	Moderating effect of Market Turbulence	P	Digital Twin was partially supported. Digital Thread was supported and Digital Mindset was not supported.
H10 – H12	Moderating effect of Competitive Turbulence	P/R	Digital Twin was supported. Digital Thread was not supported and Digital Mindset was not supported.
H13 – H15	Moderating effect of Path Dependency	P	Digital Twin and Digital Thread were partially supported. Digital Mindset was not supported.

S = Supported, N = Not Supported, P = Partially Supported, R = Refuted

In conclusion, we can group the hypotheses into four different categories as mentioned in Table 64.

Supported:

The study supported that Digital Thread was a key input for DTCs. As industrial businesses are generating new business models utilizing Digital Threads, they are integrating disparate business systems internally; with ecosystems partners and businesses are making data-driven decisions as managers and employees are becoming more digitally oriented. In the coming years, Digital Thread may have more impact on DTCs, which in turn influences DCs which may be indicative of the degree of DT in a company.

Partially Supported:

A number of hypotheses are in this category. The influence of Digital Mindset was partially supported and all moderation effects were partially supported.

The study supported that Digital Mindset was a key input for 'DTC – Cultural Transformation'. Digital Mindset is fostering cultural changes in industrial businesses and it is critical for developing DTCs. Cultural transformation is an important indicator of DT, and a company may like to accelerate digital culture which may have an effect on DTCs.

Similarly, Technology Turbulence had a positive moderating effect on the relationship between Digital Mindset and 'DTC – Cultural Transformation'. As Technology Turbulence is increasing, it is positively influencing the organization culture and in turn may help a company to change to a digital workplace. market turbulence positively moderated the relationship between Digitalization Profile and 'DTC – Business Model Transformation' and 'DTC – Operating Model Transformation'. During high Market Turbulence, industrial businesses are developing more Digital Twins, and Digital Threads by integrating internal and external systems and which in turn help them to develop capabilities for business model and operating model transformations. Competitive Turbulence had a positive moderation effect on the relationship between Digital Twin and DTCs. It seems, as industrial businesses are facing intense competition, that industrial businesses are utilizing Digital Twins to transform their business models and operating models and developing capabilities for such transformation. Path Dependency negatively moderated the relationship between Digital Thread and 'DTC – Operating Model Transformation'. Though industrial managers are thinking of developing new operating model capabilities during this turbulent time, due to previous experiences of managers they are still reluctant to prioritize those initiatives.

Not Supported:

Some of the hypotheses were not supported.

Digital Twin did not have any effect on DTCs. The possible reasons may be the adoption of Digital Twins in the industry. It seems viable business models for Digital Twins are still not clear, the business infrastructure is still not ready such that industrial businesses can utilize it effectively and there is a lack of critical mass of digitally skilled people who could understand the intricacies of Digital Twins and develop DTCs. The study did not support the relationship between Digital Mindset and 'DTC – Business Model Transformation' and 'DTC – Operating Model Transformation'. Though the mindset of the industrial employees is changing, the pace of change is slow and it may not have any effect, at this time, on the business models and operating models of a company.

Technology Turbulence did not have any effect on 'DTC – Business Model Transformation' and 'DTC – Operating Model Transformation'. As Technology Turbulence increases, it positively influences an industrial business to change its business models, operating processes and procedures and the culture of the organization. However, in this turbulent time, Digital Twins are still evolving and firms and alliance partners are still figuring out their operating models for a successful alliance relationship. The moderating effect of Competitive Turbulence on the relationships between Digital Mindset and 'DTC – Business Model Transformation' and 'DTC – Operating Model Transformation' was not supported. Moderating effect of Path Dependency on the relationships between Digital Twin and Digital Mindset and DTCs were not supported. It seems that Digital Twin is not yet mainstream, businesses are still developing Digital Threads internally, cooperation with external partners is slowly materializing and cultural changes are slow. So, at this time, Path Dependency may not have any significant effect, however, as Digital Transformation is progressing, Path Dependency may be more significant.

Refuted:

The positive moderation effect of Technology Turbulence between the relationship of Digital Twin and DTCs was refuted. Industrial businesses are rapidly adopting Digital Twin for NPD and improving product quality-related issues, however, the new business and operating models with partners are not evolving quickly and cultural changes are slow. Thus, the moderation effects may be negative at this time. The positive moderating effect of market turbulence between the relationship of Digital Mindset and DTCs was refuted. market turbulence is influencing the changes in the business models and operating models faster, however, the pace of cultural changes may be slower than the pace of business model transformation, operating model transformation and workplace transformation. So, due to this mismatch, at this time, market turbulence may have a negative moderation effect on the relationship between Digital Mindset and DTCs.

9.4.2 Summary of Back-End Model

The table below summarizes the results from the back-end model.

Table 65 : Summary of the Back-end Model

Hypothesis	Description	Supported (S/N/M/P)	Remarks
H16	'DTC – Business Model Transformation' positively influences DCs which may be indicative of DT (DTCBMT)	N	None of the 4 forms were supported.
H17	'DTC – Operating Model Transformation' positively influences DCs which may be indicative of DT (DTCOMT)	S	All 4 forms were supported.
H18	'DTC – Cultural Transformation' positively influences DCs which may be indicative of DT (DTCCLT)	P	1 out of 4 forms was supported and 3 forms were not supported.
H19 – H21	Moderating effect of Ecosystem Partnership	P/R	DTCBMT was refuted, DTCOMT was supported and DTCCLT was partially supported.
H22 – H24	Moderating effect of Customer and Market Demands	N	None of the 4 forms were not supported.
H25 – H27	Moderating effect of Digital Commitment	N/R	DTCBMT was not supported, DTCOMT and DTCCLT were refuted
H28 – H30	Moderating effect of Resource Scarcity and Constraints	P	DTCBMT was supported. DTCOMT and DTCCLT were not supported

S = Supported, N = Not Supported, P = Partially Supported, R = Refuted

In conclusion, we can group the hypotheses into four different categories as mentioned in Table 65.

Supported:

The study supported the positive influence of 'DTC – Operating Model Transformation' on DCs, which might be indicative of the degree of DT in a firm. Industrial businesses are transforming their operating models, developing strategic alliances and integrating internal and external business systems which are influencing DCs and this trend may continue as DT accelerates in industrial businesses.

Partially Supported:

A number of hypotheses are in this category. The hypotheses related to 'DTC - Cultural Transformation' was partially supported and some of the moderation effects were partially supported.

The influence of 'DTC - Cultural Transformation' on DCs, which might be indicative of the degree of DT, was partially supported. The cultural changes in industrial businesses are impacting DCs, however, the changes have started in recent years and compared to competitors, changes are not significant. The digital cultural changes may take some time before its effect may be more significant.

The moderation effect of ecosystem partnership and the relationship between DTCs and DCs were partially supported. In industrial businesses, business models are still evolving and a joint business model with ecosystem partners is not clear, however, industrial businesses are forming more and more strategic alliances and working jointly to develop transformative solutions; digital cultural changes have started but compared to competitors the changes are not significant.

The moderation effect of resource scarcity and constraints and the relationship between DTCs and DCs were partially supported. The non-availability of resources may have a negative effect on business models, which in turn influences the DCs. However, in a resource constraint environment, firms may have innovative operating models for DT-related projects and cultural changes may not have any impact in such an environment.

Not Supported:

Some of the hypotheses were not supported.

The study did not support the positive influence of 'DTC – Business Model Transformation' on DCs. Though industrial businesses are going through technological disruption, its impact on businesses is not still clear and they may not have clear business strategies at this point.

The moderation effect of customer and market demand and the relationship between DTCs and DCs were not supported. Due to the uncertainties in customer and market demand, executives in industrial businesses are still not clear about the strategies they should undertake for developing DCs which may be indicative of the degree of Digital Transformation in a firm.

The moderation effect of digital commitment and the relationship between DTCs and DCs were not supported. Due to the uncertainties in digital business, executives in industrial businesses are not ready to commit to high value projects for Digital Transformation and are still not committed to develop DCs which might be indicative of the degree of Digital Transformation in an organization.

Refuted:

The positive moderation effect of Ecosystem Partnership on the relationships between ‘DTC – Business Model Transformation (Customer Engagement)’ and DCs was refuted by the study. Business model transformation did not have any relationships with DCs. Also, at this digitally turbulent time, industrial managers may not have trust in their ecosystem partners to jointly develop business models for Digital Transformation initiatives. The positive moderation effect of Digital Commitment on the relationship between ‘DTC – Operating Model Transformation’ and ‘DTC - Cultural Transformation’ was refuted by this study. Due to recent failures of Digital Transformation initiatives in big industrial companies like GE, industrial managers are not ready to commit to high value Digital Transformation projects and they are reluctant to change their operating models and organizational cultures at this time. In the coming years, the situation may improve and the moderation effects may be significant.

Chapter 10: Conclusions

This chapter represents the final conclusions of this study. The chapter starts with a brief summary of the whole research. The next section describes the theoretical contribution of this research to the existing body of knowledge related to Digital Transformation and offers implications for managers. The chapter concludes with the limitations of the study and important directions for future research.

10.1 Research Summary

The current study examined Digital Transformation in industrial businesses by leveraging Industrial Internet and developed a conceptual model for such transformation. The conceptual development of the study (Chapter 5) relied on literature review (Chapter 2), industry review (Chapter 3) and exploratory studies (Chapters 4 and 5), principally because there are virtually no in-depth academic studies of Digital Transformation to date. Digital Transformation and IIoT are revolutionizing industrial businesses. However, based on the state of current knowledge, there is no systematic academic study in this area. Even if all companies are scrambling to develop their own Digital Transformation strategy, it seems there is no common conceptual framework. This study is an attempt to develop a conceptual framework for Digital Transformation based on an extensive empirical study. In turn, it represents an effort to identify and develop the nomological network of antecedents, contingencies and boundary conditions for Digital Transformation.

The study suggests that industrial businesses should develop digital transformative capabilities (DTCs) to help them in their Digital Transformation journeys. DTC is an extension of dynamic capability (DC), which identifies and coordinates digital changes in the digitalization of the core business routines. This study used Teece et al.'s (2007) DC framework of sensing, seizing and reconfiguration capabilities as its starting point to conceptualize the degree of Digital Transformation in a company. Industrial businesses are going through digital disruption and moving from technology-enabled to technology-centric businesses. Earlier businesses used technologies to augment decision-making processes and now humans and technologies are jointly taking decisions based on prior knowledge and future predictions[81]. The Industrial Internet of Things (IIoT) includes IoT-enabled applications in businesses and these applications are augmented with emerging technologies (such as IIoT, Artificial Intelligence, Machine Learning, Big Data & Analytics, Blockchain, etc.). To understand how businesses are developing DTC, the study utilized Teece et al.'s (2007) DC framework to initiate the transformation models.

The preliminary and detailed exploratory studies (Chapters 4 and 5) were conducted to obtain insights about Digital Transformation processes in situ and from the experience of companies. This was in an effort to understand better how companies are developing DTCs by leveraging IIoT. The first, preliminary exploratory study identified some of the key factors such as executive intent and focus, strategic collaboration and new product development capabilities in a high-velocity environment as key factors relevant to DTCs. The second, detailed exploratory study identified business model changes and mindset changes as key inputs for

[81] https://www.forbes.com/sites/oracle/2015/07/20/the-tech-centric-revolution-is-here/#414e3071fe71

DTCs. The detailed exploratory study also identified internal and external factors such as ecosystem partnership, Path Dependency, technology disruption, strategic focus and intent, capability modularization, internal collaboration, context dependency and organization structure, which could influence DTCs and which in turn may influence DCs for Digital Transformation.

The detailed exploratory study identified ecosystem partnership as a key influencer for DTC. All executives, during the detailed exploratory study, expressed the great importance of ecosystem partnership for Digital Transformation. Similarly, business model changes and mindset changes were identified as key inputs for DTCs. Path dependency, internal collaboration, organization structure and strategic focus were identified as key internal factors which might influence DTCs and DCs, whereas, technology disruption and external collaboration were identified as external factors effecting DTCs and DCs. Based on these exploratory studies, ecosystem partnership, strategic focus and intent, Path Dependency and collaboration were added as moderators for the conceptual model.

In the conceptualization phase (Chapter 6), the study identified two models to form the overall conceptual framework: one was focusing on the front-end model and the other was focusing on the back-end model. These models were identified based on literature survey, industry survey and exploratory studies. The front-end model identified three types of DTCs 'DTC – Business Model Transformation', 'DTC – Operating Model Transformation' and 'DTC – Cultural Transformation', which might affect DCs, and which might identify the degree of Digital Transformation in a company. The front-end model identified three key inputs (Digital Twin, Digital Thread and Digital Mindset) for DTCs. The front-end model identified Path Dependency, environmental dynamism and competitor turbulence as moderators. Digital Transformation is a recent initiative for industrial businesses, and the standard financial performance measures, such as total revenue, net income, earning-per-share (EPS), may not indicate or be relevant to the degree of Digital Transformation in a company. Instead, changes, improvements and comparison (with respect to competitors) of core DCs related to sensing, seizing and reconfiguration DCs were identified as measures of Digital Transformation in a company. Thus, in the back-end model, the influence of DTCs on DCs were considered as key constructs for Digital Transformation. Ecosystem partnerships, digital commitment, customer and market demands and recourse scarcity and constraints were considered as moderators which might influence the relationship between DTCs and DCs.

The methodology for quantitative analysis was presented in the research methodology (Chapter 7). To test the conceptual model, 300 senior executives were selected from industrial businesses and an on-line survey was used for data collection. A pilot survey was launched initially to pre-test the online questionnaire and the final survey was sent by email and through messages on Linkedin.com. The response rate was 36% which was an acceptable rate for this study.

The analysis of the result (Chapters 8 and 9) revealed important findings to answer three research questions: “How are firms developing digital transformative capabilities (DTC) for Digital Transformation?”, “What are the inputs, antecedents, contingencies and boundary conditions for DTC?” and “How can the degree of Digital Transformation in a company be measured?”, which are identified in the literature survey (Chapter 2).

The study identified three main inputs for DTCs: Digital Twin, Digital Thread and Digital Mindset. Though Digital Twin is widely touted as an important input for DTC, based on this study, it was revealed that Digital Twin may not have a significant influence for Digital Transformation at this time and industrial businesses are still adopting Digital Twins in their businesses. Digital Thread was considered an important input for DTCs and the study supported that. Digital Thread gives the visibility and control of the entire business processes of an industrial business. Though Digital Thread developments are in progress and overall integration within a company and with outside ecosystem partners may take time, initial integrations have produced good results and executives acknowledged that. Digital Mindset was considered another important input for DTC and it was partially supported. The mindset of employees is slowly changing in industrial businesses and this has a strong effect in transforming workplaces into digital workplaces, however its impact on business models and operating models is still evolving.

The study also identified four moderators which may affect DTCs: Technology Turbulence, Market Turbulence, Competitive Turbulence and Path Dependency. Some of the moderating effects were supported and some of them were refuted. The moderating effect of Technology Turbulence on the relationship between Digital Twin and DTCs was refuted, indicating that though industrial businesses are adopting Digital Twin during the digital disruption phase, the business models, operating models and organization culture changes to support that are changing slowly. Similar refutation was shown for the effect of Market Turbulence on the relationship between Digital Mindset and DTCs, indicating that cultural changes are not keeping pace with business model and operating model changes when businesses are faced with Market Turbulence.

Based on this study, a conceptual model for Digital Transformation was developed. The front-end model deals with the development of DTCs and three major inputs and moderators affecting DTCs and the back-end model identifies the importance, improvements and comparison of the dynamic capabilities with competitors, which are indicative of the degree of Digital Transformation in a company. The front-end model is described in the previous section. In the back-end model, the influence of 'DTC – Business Model Transformation' on DCs which may be indicative of Digital Transformation in a company was not supported, indicating that though industrial businesses are going through business model transformations its impact on core business capabilities is not clear at this time. However, the influence of 'DTC – Operating Model Transformation' on DCs was supported, indicating that the operating model is transforming with clear objectives and those have started impacting core capabilities for industrial businesses. The influence of 'DTC – Cultural Transformation' was partially supported. As industrial businesses are going through digital cultural transformations, the importance of core DCs is becoming more important, however, improvements and comparisons with competitors may be too early to get a clear understanding of DC changes in organizations. In the back-end model, four moderators were identified: ecosystem partnership, digital commitment, resource scarcity and constraints and customer and market demands. The moderating effects of ecosystem partnership and resource scarcity and constraints on the relationship between DTCs and DCs were partially supported and some of the moderating effects, such as the effect of ecosystem partnership on the relationship between 'DTC – Business Model Transformation' and DCs', were refuted. This indicates that during this technological turmoil, digital employees may not have enough trust with ecosystem partners for business model transformation. Similarly, the effect of Digital Commitment on the relationships between 'DTC – Operating Model Transformation' and 'DTC – Cultural Transformation' were refuted, indicating that the industrial managers were still not committed to high value Digital Transformation projects at this time. Figure 17 presents the conceptual framework of Digital Transformation (front-end) model with the hypotheses partially supported, totally supported, not supported and refuted.

Figure 17: Conceptual Framework for Digital Transformation (Front-end Model)

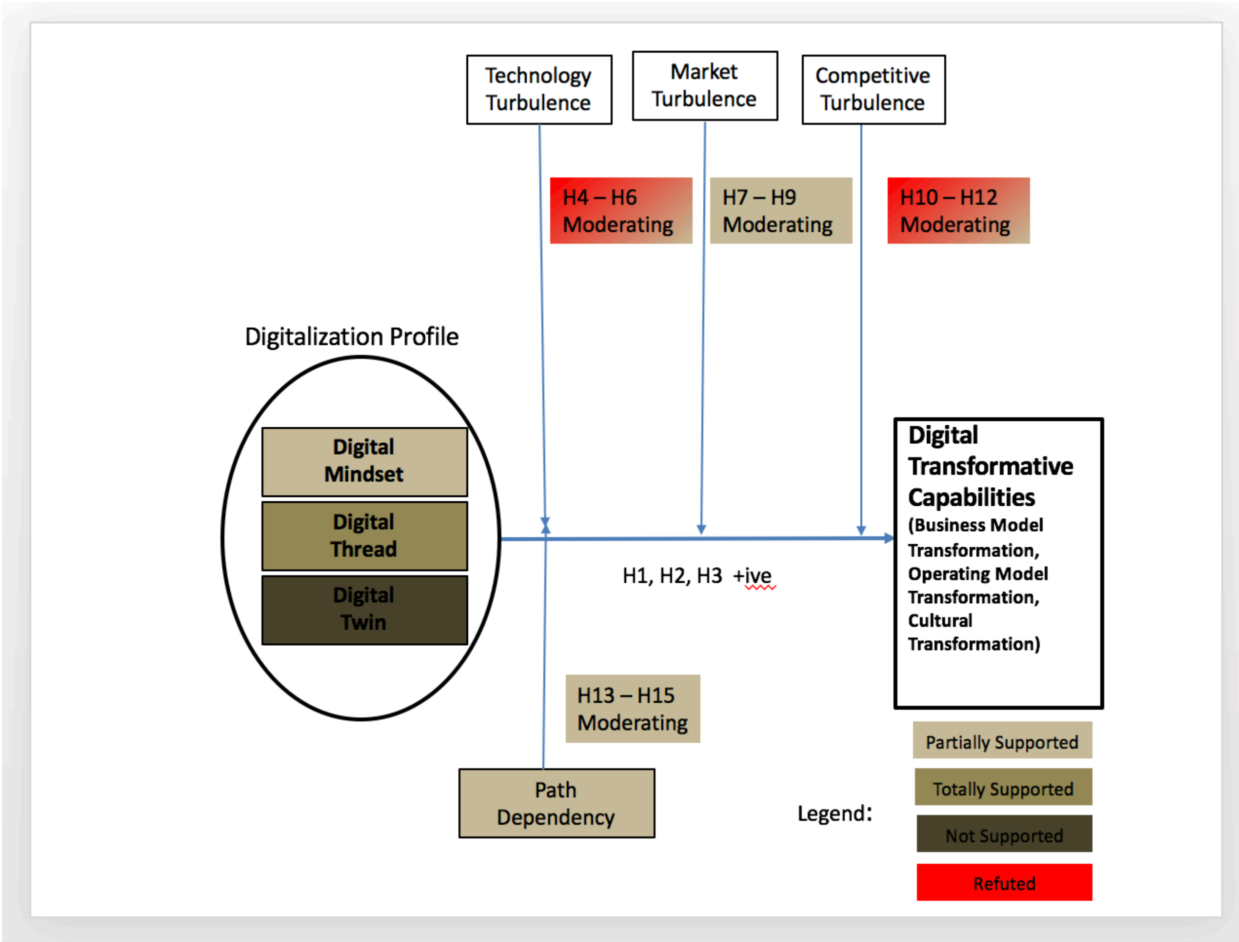
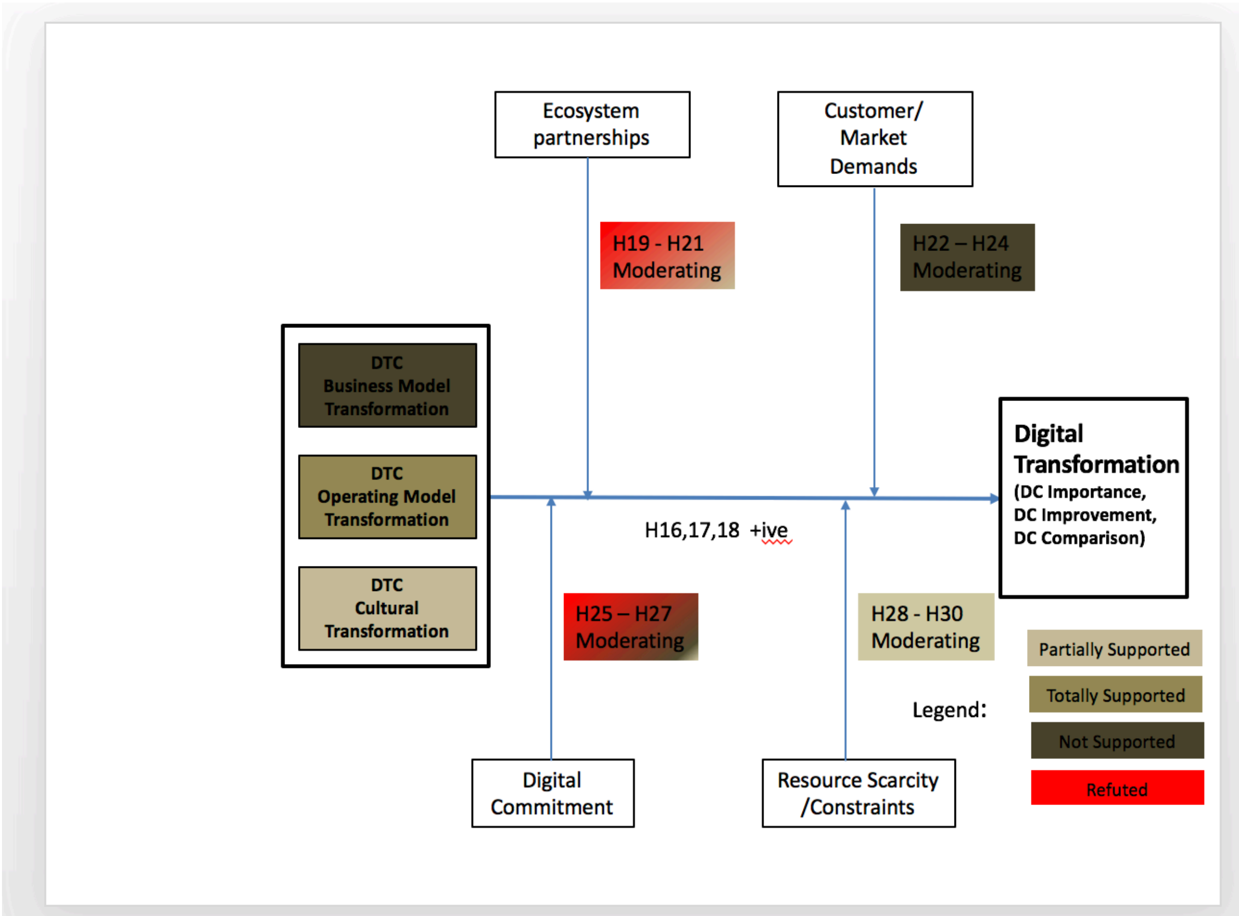


Figure 18 presents the conceptual framework of Digital Transformation (back-end) model with the hypotheses partially supported, totally supported, not supported and refuted.

Figure 18: Conceptual Framework for Digital Transformation (Back-end Model)



10.2 Theoretical Contributions

To the best of the author's knowledge, the study is the first academic study to illustrate and unpack the nomological network of Digital Transformation of industrial businesses at a time of considerable trauma for firms when little or no research in this field exists. Thus, this study makes a significant contribution to the body of knowledge about dynamic capability theory, Digital Transformation and its profound impact on industrial businesses.

The recent business literature emphasizes the importance of Digital Transformation and its impact on the fourth industrial revolution[82]; however, this literature does not explain different inputs and constructs for Digital Transformation. This study is the first of a kind which examines Digital Transformation from the capability point of view and evidences that firms should develop DTCs for Digital Transformation and which DTCs to prioritize. This study advances the knowledge of DCs and their applicability for Digital Transformation and has identified three DTCs: business model transformation, operating model transformation and cultural transformation, which may help a firm in their Digital Transformation journey (Sections 6.2.1, 6.2.2 and 6.2.3). The conceptualization of DTCs and identifying key elements and inputs for DTCs are a significant contribution to the body of knowledge of strategic management theory related to DT. DTCs are an extension of DCs which help a firm in developing competitive advantages in a high-velocity environment (Teece et al., 1997, 2007). In turn, then, the model extends the boundary conditions of DC as well by revealing its usefulness as a framing device to conceptualize and support Digital Transformation.

The digitalization profile of a company is another contribution to the body of knowledge for DTCs. A digitalization profile consists of Digital Twin, Digital Thread and Digital Mindset and these three elements are key inputs for DTCs (Sections 6.2.4.1, 6.2.4.2 and 6.2.4.3). Though the current study did not support the influence of Digital Twin on DTCs, as discussed in Section 6.2.4.1, there are significant interests of Digital Twins among industrial businesses. Based on these discussions, it is clear that the business potential of Digital Twin is still unclear but industrial managers believe Digital Twin to be a key input for DTCs. The positive effects of

[82] https://www.forbes.com/sites/danielnewman/2018/06/12/four-digital-transformation-trends-driving-industry-4-0/#62d062dc604a

Digital Thread and DTCs are well supported and, as discussed in Section 6.2.4.2, industrial managers believe Digital Thread across their businesses and Digital Threads with partners are critical for DTCs. Similar to Digital Thread, Digital Mindset is another key input for DTCs. The study partially supported this hypothesis, however, based on the discussions in Section 6.2.4.3, industrial managers suggest that Digital Mindset is a key input for DTCs and that it will have a lasting effect on Digital Transformation journeys. In turn, these findings contribute to setting out the usefulness of these elements of a firm's digitalization profile and serve as a cautionary device. Despite profound managerial interest among companies, the results suggest that the value of Digital Twins, threads and mindset need different prioritization in a wider system of investments to achieve Digital Transformation, Digital Thread and Mindset being of direct importance.

A final contribution is related to the development of a measurement framework to understand the degree of Digital Transformation in a company based on dynamic capabilities. This is a modest methodological contribution. Since it is difficult to measure the degree of Digital Transformation in a company, the study has identified key dynamic capabilities which may help a firm in Digital Transformation. Thus, the study advances the body of knowledge of DC theory and its applicability for Digital Transformation. Similar approaches may be applied for other academic studies where direct measurements are not available.

10.3 Implications for Managers

The study makes significant managerial contributions. Industrial managers can use the conceptual framework and build necessary capabilities and contingencies to manage their Digital Transformation initiatives. Without any conceptual framework, managers are engaged in Digital Transformation projects more as proof-of-concept projects because they are not clear about the capabilities and resources needed for Digital Transformation initiatives, and they are not aware of any internal or external contingencies which would affect the outcomes. Based on this study, I wish to provide the following guidance to industrial managers who have started or are planning to start Digital Transformation initiatives.

Industrial managers should carefully review their Digital Twin initiatives. Though there are a lot of discussions about the impact of Digital Twins for Digital Transformation, in reality, developing a true Digital Twin to mimic the actual physical machine is difficult and resource intensive. Instead of developing the entire Digital Twin, the managers should focus on key attributes in a physical system or processes and develop Digital Twins for those systems or processes. A generic Digital Twin workbench is still in the conceptual phase and no company has any good framework to support that.

Industrial managers should focus on Digital Thread initiatives in their companies as integrated Digital Threads with applicable emerging technologies like AI/ML, Big Data and analytics, and Blockchain would help them tremendously in their Digital Transformation projects. Instead of a siloed approach, managers should consider these as enterprise-wide projects with multiple phases and should look for early gains such that they can develop confidence for top management executives. Digital Transformation projects are multi-year projects and need active participation from ecosystem partners so these projects should be time-based with clear outcomes at the end of each phase. There are IT-based enterprise systems and there are OT-based machine-to-machine communication solutions. Industrial managers should look into IT and OT integration projects starting from one factory at a time and then gradually integrate other factories of the company. Managers should also select a proper IIoT software platform to integrate these systems. Chapter 3 (industry study) has guidelines regarding IIoT platforms from different solution providers.

Managers in industrial businesses should pay special attention to the cultural aspects of Digital Transformation as any Digital Transformation initiatives cannot be successful unless employees are properly trained in digital technologies and they have fundamental knowledge about data science, statistical methods, commonly used analytical technologies, social networking skills and above all, analytical mindset. The cultural changes will take time; however, managers need to have proper plans in place to achieve that. Managers should also organize training and development programmes for existing employees to train them in data-driven decision making technologies and processes. The company which can change the mindset quickly will have a competitive advantage against others in the industry.

Though Business Model Transformation was not supported in this study, as the pace of the transformation is slower and the actual outcomes are not clear, business model changes are a critical success factor for Digital Transformation (Chapter 5, Detailed Exploratory Study). As discussed in Section 6.2.1, industrial customers are looking for product-as-a-service business models and they are slowly moving towards pay-per-use based models for Business-to-Business

(B2B) transactions similar to Business-to-Customers (B2C) business transactions. Though the initial transformation is slow, industrial managers should gradually develop new product-as-a-service models and they should seek and identify early wins to obtain momentum for change.

Another focus area for managers is related to Operating Model Transformation. A business model transformation cannot be successful unless operating models are also changed to support the business models. Managers should develop operating model transformation capabilities such that they can integrate business systems within the organization and with outside partners and so they can offer Industrial Internet-based solutions to their existing and new customers. The customer definitions are changing and industry boundaries are becoming blurred. So, companies should develop appropriate operating models with their ecosystem partners such that they can provide end-to-end digital solutions for Digital Transformation. Though this may not be a simple task, managers should start working on this immediately.

Digital Transformation initiatives cannot be successful unless industrial managers transform their organizational cultures. Managers should develop cultural capabilities to transform their workplaces into digital workplaces and develop both internal and external customer engagement solutions leveraging digitally connected ecosystems. Industrial managers must develop proper education and training programmes to retrain their existing workforce and hire a new digital workforce for Digital Transformation initiatives. This should be a gradual process and managers should develop a proper implementation plan to achieve this.

Managers in industrial businesses should pay attention to the moderating effect of environmental dynamism and how it influences the relationship between Digital Twin, Digital Thread, Digital Mindset and DTCs. Technology Turbulence, Market Turbulence and Competitive Turbulence have limited moderation effects based on this study. However, it is anticipated that as Digital Transformation matures, environmental dynamism will have a significant effect on the relationship. So, managers should pay attention to such turbulence and develop appropriate business model and operating model strategies for Digital Transformation. Though Path Dependency was partially supported by this study, Path Dependency will have a strong negative effect on DTC and managers should be aware of this and new leadership, new technologies and new ways of looking at the businesses will be more important for sustained competitive advantage.

Lastly, the study has identified core DCs for sensing, seizing and reconfiguration capabilities which can be conceptualized as the degree of Digital Transformation in a company. Industrial managers should develop these dynamic capabilities either from scratch or reconfigure existing capabilities to make them into DCs. Managers should pay special attention to key sensing capabilities related to R&D, NPD and NPI processes as Digital Twin and Digital Threads will have significant impacts on them. The seizing capabilities related to organizational flexibility, market responsiveness and knowledge management during this disruption will help a company to develop new products and services utilizing Digital Transformation initiatives. Also, managers should reconfigure or develop capabilities related to alliance management, integration and coordination within the organization and with ecosystem partners such that they can provide end-to-end digital solutions for their customers.

10.4 Research and Study Limitations

The current study has several limitations and implications and contributions are conditioned or constrained by these limitations, warranting a degree of caution in interpreting its conclusions.

The first limitation is that the study has applied a cross-sectional research design and a cause–effect relationship (causality) cannot be specified from the results (Covin et al., 1989, Menon et al., 1999, Morgan et al., 2006) beyond causal inferences. A longitudinal research design is preferable in any future research such that the Digital Transformation initiatives can be studied in companies for a longer period of time and, potentially, with specific transformation initiatives being tracked over time. The longitudinal research has some further advantages such as evidence of the time order of occurrence and reduction of common method variances (Filipescu et al., 2013). Since DT initiatives are gradually gaining momentum, longitudinal studies could augment this study and clarify certain hypotheses, for example, which were not supported or were refuted.

The study was designed to understand how industrial businesses are developing DTCs by leveraging IIoT for DT. Thus, the study was not for a specific industry segment but more of a general empirical study of industrial businesses. There may be segment specific features and relationships that are not accounted for. To understand whether there are specific transformation capabilities for a specific segment, such as an automotive or industrial machinery segment, a separate study deploying more finely-grained homogenous samples should be conducted.

Since Digital Transformation initiatives are not homogeneous within industrial businesses, the pace of Digital Transformation is not the same across those businesses. Some companies surveyed for this study, such as GE or Cisco, have been running their Digital Transformation initiatives for a couple of years and have developed certain maturity in their capabilities to address the Digital Transformation challenges, while other companies surveyed, such as Hitachi, started their Digital Transformation initiatives later. Therefore, the survey results may have shown some variations for this study based on the relative degree of maturity or stage of transformation. This could be considered as a limitation, however, as with any other survey, the samples are not always homogeneous and this study has taken precautions, such as factor analysis, collinearity analysis, ANOVA etc., to minimize such variations.

This study has developed a measurement framework based on importance, improvements and comparison of DCs with competitors as a conceptual measurement framework to understand the degree of Digital Transformation in a company. Though it is not a strict limitation, in future the measurement can be enhanced by adding financial measures, such as growth in revenue, profitability, market share, earnings per share (EPS) etc., to obtain a clear understanding of Digital Transformation in industrial companies. Since Digital Transformation only started three to four years ago, financial data are not available now but could be available in the coming years.

A larger sample could have been more beneficial, however, the time and financial constraints did not allow to increase the sample size. For this study, more than 300 industrial executives were contacted for the survey and around 100 executives responded to the survey. It was difficult to obtain greater participation from senior executives and since Digital Transformation is a strategic decision, the study only contacted executives who were directors and more senior in the companies, thus limiting the number of respondents.

10.5 Directions for Future Research

This study definitely sets the pace for future research related to Digital Transformation as all industrial businesses are hoping that Digital Transformation could bring about the fourth industrial revolution[83]. Though Digital Transformation is a priority among industrial managers, lack of any comprehensive academic research is slowing down its progress. With recent negative news of these initiatives, such as at GE[84], industrial managers are reluctant to commit to high value digital projects. During this digital disruption phase, more and more academic studies could highlight different aspects of Digital Transformation and how managers could face the challenges and mitigate risks associated with that.

As mentioned in the previous section, a longitudinal study with several companies could augment this study further. Digital Transformation initiatives are slowly progressing in industrial businesses and companies have started developing DTCs in the last couple of years. They have started Digital Twin and Digital Thread projects and are slowly changing the culture of the organizations. Business performance could be measured more accurately in a longitudinal study. As suggested by Rindfleisch et al. (2008), to maximize the validity of the research, a combination of cross-sectional and longitudinal studies could provide better results.

The right informants are critical for any quantitative study. Since this study has used a company as the unit of analysis, at least two to three respondents were selected for quantitative analysis. However, it may be possible that these respondents may not have total knowledge about the

[83] https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab
[84] https://www.wsj.com/articles/ge-puts-digital-assets-on-the-block-1532972822

Digital Transformation initiatives within their organizations. So, in a future study, a diverse group of respondents from different departments of an organization could be chosen to get a holistic view of Digital Transformation initiatives in the company. The sample should include managers from different functional areas who are responsible for Digital Transformation projects.

As raised in Chapter 5 and Section 6.2.4.3, Digital Mindset was considered a key input for DTC and the result of this study partially supported that. The researchers and practitioners both have suggested that mindset changes of the digital managers are very important for developing DTCs. The current study considered Digital Mindset as a key input for DTC and did not consider Digital Mindset as a mediator between the relationship of Digital Twin, Digital Thread and DTCs. Researchers should look into this relationship in a separate study. Similarly, Technology Turbulence, Market Turbulence and Competitive Turbulence were considered moderators for DTCs, and a separate study should look into the mediation effects of these external and internal factors.

Lastly, the study recommends an empirical study to develop a maturity model for Digital Transformation readiness for industrial businesses. Schumacher et al. (2016) have done some initial research for a maturity model for Industry 4.0 readiness of manufacturing enterprises. The conceptual framework of the current study could be extended and maturity factors of DCs, which are conceptualized as a degree of Digital Transformation in a company, can be identified for three key dimensions (sensing, seizing and reconfiguration) through a survey and the maturity of each dimension can be calculated by the weighted average basis for all maturity items for that dimension. Then the maturity of Digital Transformation can be calculated by the weighted average of the three key dimensions for that company.

10.6 Concluding Remarks

This chapter concludes the whole thesis by revisiting all previous chapters and summarizing the key elements of each chapter. This includes research objectives, research questions, exploratory and detailed qualitative study, conceptualization, research design, analysis and hypotheses results. The chapter also summarized the academic contribution and managerial contribution of the study. At the end, the limitations of the research and the direction for future research were presented.

Digital transformation is revolutionizing industrial businesses. Industrial Internet and Industry 4.0 initiatives are in the minds of all industrial managers. Digitally connected ecosystems are being considered as the fourth industrial revolution and have the potential to transform businesses as well as humanity.

To conclude, this study presents the first academic study related to Digital Transformation networks and in future more academic studies and research will be conducted to understand Digital Transformation holistically.

Appendices

A-1 Preliminary Exploratory Study - Questions

1. How are your IIoT business different from other core businesses in your organization?

2. Do you think the definition of the customer has changed for the IIoT business?

3. What new challenges are facing in the IIoT business? How you are overcoming these challenges?

4. Do you think IIoT managers need different capabilities/skill sets than managers in other businesses?

5. How do you sense/figure out business opportunities in the IIoT business? Are they similar to your traditional business?

6. How are your New Product Development (NPD) capabilities changing for IIoT business?

7. How are your strategic alliance capabilities changing for the IIoT business?

8. Is there a change in the organization structure for the IIoT business? Is it centralized or de-centralized?

9. How are you accelerating innovations in your IIoT business? Do you need new capabilities for IIoT innovations?

10. How are you fostering entrepreneurship within your organization for your IIoT business?

11. How are your IIoT business models different from other business models?

12. Do you compete and collaborate with your strategic partners? If so, how do you manage that?

13. Since future customer demand is not well known, companies are forming strategic alliances/partnership with a large number of companies. Do you see the same trend in your organization?

14. According to you, what are the key success factors for the IIoT business? Do you have capabilities to meet those success factors?

A-2 Detailed Exploratory Study – Questions

1. IoT Business Overview

- How does your IoT business differ from your other businesses and what are the main challenges you are facing now?
- What new products and or services are you developing for IoT?
- Are you developing your own IoT platform or do you plan to use IoT platform(s) from others?
- Do you have a separate business group (with profit and loss, P&L responsibility) for IoT? If so, why?
- Do you have a separate sales/business development organization for product/service sales?
- In the IoT business who are your potential customers?
- Who are your current competitors? Who are the direct competitors and indirect competitors?

2. Collaboration with Internal Partners (Intra-firm collaboration)

- In terms of collaboration/partnership (both internal/external), do you observe any significant differences between the IoT business and other businesses in your organization?
- Do you think business models are changing for IoT (from a product-centric to outcome centric)? If so, how that is impacting your relationship with your partners?
- Why do you collaborate within the organization for your IoT business?
- Do you have a formal process for collaboration? (For example, you may like to create a task force or working group from different businesses to work on a specific IoT programme for a period of time)
- Could you list some of the significant intra-firm collaboration initiatives for IoT?

3. Collaboration with external partners (inter-firm collaboration)

- Do you think collaboration among eco-system partners is a key success factor for IoT?
    - If yes, please explain your answers.
- How do you decide on your collaboration partners? (For example, when you are collaborating in developing a IOT platform, or developing a new product/service or

selling your products through Independent Software Vendors (ISVs) or System Integrators.

- In IoT partnership, you may compete and collaborate with the same firm.
    - How do you decide to work with a partner who might have competitive offerings?
    - How do you protect your intellectual property?
- Do you have a process in place to select partners for IoT? If so, what is that selection process?
- What types of collaborations do you have? (short, medium or long term).
    - In terms of %, what is the break-up of short-, medium- and long-term partnerships?
- Do you think inter-firm collaboration is helping you to create a specific intellectual property (for example, a reference architecture for IoT, or an IoT development platform), which you could leverage in future?
- What are some of the impediments of inter-firm collaboration?

4. Capability development

- What types of capabilities are required for successful collaboration with partners? (For example, you might have a well-defined partner selection process, partner management, partner governance process etc.)
- Since you have formed partnerships in your other businesses, do you think IoT & Cloud businesses need different capabilities than your core business?
- If you need different capabilities, how do you develop these capabilities within your organization?
- In strategic management, there are two types of capabilities, Operational and Dynamic. Operational capabilities are required for day-to-day functioning of the firm, whereas, dynamic capabilities create competitive advantage and it normally reconfigure Operation capability.
- What are your operational and dynamic capabilities?
- Have your capabilities degraded or enhanced over time? What are the reasons for that?
- Does collaboration play any role in capability degradation or enhancement?
- Do you form partnerships for joint product development and R&D work? If so, how do you manage that?
- Do you form partnership for marketing/sales and utilize the relationship for your channel sales?

5. Performance measurement

- How do you measure the performance of your ecosystem partners?
- Do you have specific revenue or adoption targets on a periodic basis?
- Do you think through IoT partnership you have gained access to new market segments, new geographies etc.?
- What percentage of your partnership is in the USA and what is outside? Do you envision any change in the mix?
- How do you maintain your brand when you are partnering your products/solutions with others? Do you prefer co-branded relationships?

6. Collaboration categories

There are four types of collaboration categories and a firm might have one or more categories for developing strategic partnership with another firm. What types of partnerships are in place for your IoT business?

Organization (Learning/Competence building)

- Learning technologies, processes or combination of both
- Collective and embedded skills
- Acquiring means distribution
- Complementary goods and services to the market
- Improving performance

Economic (Market-, Cost & Risk-related)

- Cost sharing and pooling of resources
- Risk reduction and risk diversification
- Obtaining economies of scale
- Co-specialization

Strategic (Competitive focus-, Product- and Technology-related)

- Achieving vertical integration
- Developing competitive advantages
- Diversifying into new markets, geographies
- Gaining access to new technology

- Developing new products and technologies
- Co-operating with potential rivals

Market development

- Develop industry standards for the industry groups
- Overcome regulatory compliances

A-3 Email for Exploratory Study

Date, 23rd August, 2016

To:
Julian Loren
Global Markets Competitive Intelligence & Strategy Director
GE Digital, San Ramon, CA, 94583

Dear Julian

I am a doctoral research student at Durham Business School, Durham University, UK, and I am conducting a case study research focusing on transformation capabilities of industrial businesses by leveraging Industrial Internet of Things (IIoT) for sustained growth. The overall objective of this research is to expand the body of knowledge in strategic management and specifically how firms develop competitive advantages in uncertain environments like IIoT. I am attaching the questionnaire for your review.

For this research my supervisors are, Dr. Mathew Hughes, (mat.hughes@durham.ac.uk), Reader in Entrepreneurial management and Dr. Paul Hughes, paul.hughes@durham.ac.uk) , Sr. Lecturer in Strategy, Durham Business School, Durham University, U.K. You may like to contact them at any time for any questions or clarifications.

I want to let you know that the information you will provide during this interview will be for academic purposes only and will be treated as strictly confidential. Your name and your company's name will not be revealed to anyone without your written permission. The data from various interviews will be aggregated for analysis. The final report will be available to you. I want to ask your consent to record this interview for the purpose of facilitating data analysis. Durham university has strict guidelines for conducting interviews for the purpose of research and I will follow their ethics guidelines.

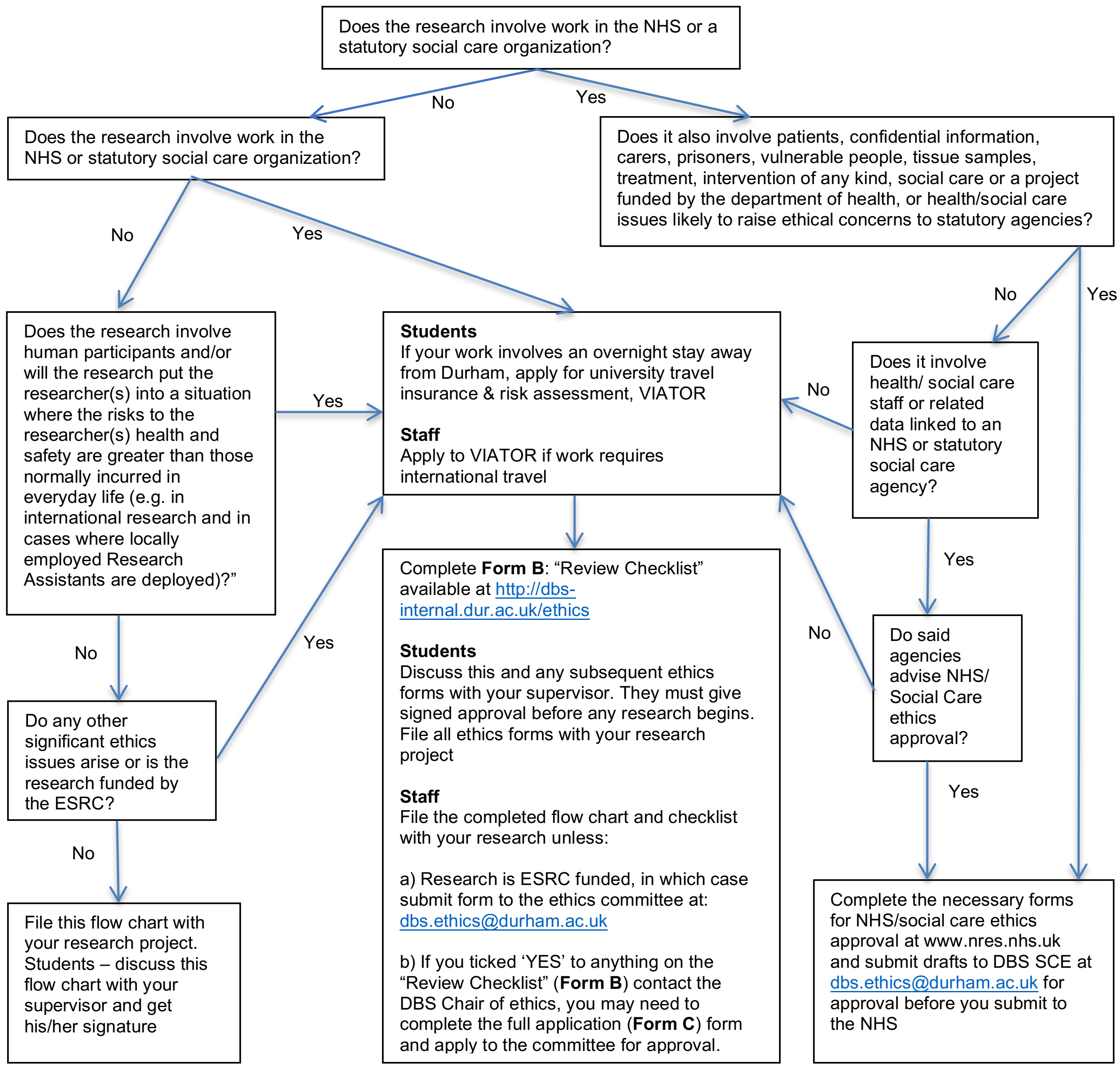
I wish you will enjoy our conversation and I look forward to talk to you soon.

Kind Regards,
Swapan K Ghosh
Research Fellow
Durham Business School, Durham University, U.K.
s.k.ghosh@durham.ac.uk

A-4 Ethics Form

Title of Project: Developing transformative capabilities of industrial businesses by leveraging industrial Internet

Name of Principal Researcher or Student: Swapan K Ghosh



☐ ☐ X ☐

Tick one box only

Signature of Principal Researcher or Supervisor:

Signed: Swapan K Ghosh

Date: 10th July 2015

A-5 Email for Survey Questionnaire

(from Loughborough email account)

Dear <Respondent-name>

I am a PhD student at Loughborough University in UK and I also work for GE Digital in technical product management. I am conducting a survey for my PhD research work. My PhD research topic is ***'Developing Digital Transformative Capabilities of Industrial Businesses by leveraging Industrial Internet of Things (IIoT) - A study of Industrial Internet Companies'.***

I request you to fill up the survey at your convenience. The content of this survey will be strictly used for the academic purposes and the results will be summarized. Each survey answers will be kept strictly confidential.

The details of the survey are as follows:

- The URL for the survey is https://lboro.onlinesurveys.ac.uk/digital-transformative-capability-survey-pilot-1.
- The survey will take you approximate 40 minutes to complete. You can save the survey and come back to the survey again.
- In some questions, you can click on 'more info' tab to get more information about a particular question.
- Some questions may not be directly related to your current work; however, you please answer those questions based on your previous experience and/or your experience about that subject.
- Please respond to this survey in a week or so. I sincerely appreciate your help in answering this survey. This will help me tremendously to complete my research work. For any questions or comments, please contact me by email.

Regards,
Swapan
======
Swapan Ghosh
Research Scholar
Loughborough University, UK, s.ghosh@lboro.ac.uk

A-6 Message from linkedin.com for Survey Questionnaire

Dear <Respondent-name>

I sent you an email earlier from my University account (s.ghosh@lboro.ac.uk).

I am reaching out to you as I am requesting your help for my academic work. My PhD topic is 'Developing Digital Transformative Capabilities of Industrial businesses by leveraging Industrial IoT'.

I am conducting a comprehensive survey about Digital Transformation and the link for the survey is: https://lboro.onlinesurveys.ac.uk/digital-transformative-capability-survey-1 .

This survey will take around 40 minutes to complete and you can save the survey and come back to it. The content of the survey will be kept strictly confidential and your name or your company name will not be disclosed.

I will aggregate the findings of the survey and send you a summary report.

Thank you,

Swapan
408-368-2450

A-7 List of companies for the survey

Serial No.	Company Name	Type of Industry	Revenue	Number of Employee	Type
1	3M Company (MMM)	Industrial Goods	$30B	91,854	Public
2	ABB Ltd. (ABB)	Industrial Goods	$33B	132,000	Public
3	Accenture	Information Technology Services	$32B	411,000	Public
4	Analog Devices Inc.	Semiconductor-IC	$3.4B	10,000	Public
5	Azabil Corporation (Japan)	Industrial Automation	$2.2B	9,290	Public
6	B&R Industrial Automation	Automation Tech	585M Euros	3,000	Public
7	Belden Inc	Network, connectivity, cable	$2.3B	8,100	Public
8	The Boeing Company	Aviation	$94.5B	150,500	Public
9	Bosch	Engineering & Electronics	73.3B Euro	390,000	Public
10	BP	Oil & Gas	$183B	74,500	Public
11	China Telecom	Telecom - Govt owned	$53B	287,000	Public
12	Cisco Systems	Network Equipments mfg.	$49.24B	73,700	Public
13	Dell Technologies	Information Tech H/W & S/W	$61B	138,000	Public
14	Deloitte LLP	Multi national prof. service (UK)	$36.8B	244,000	Public
15	Dun & Bradstreet	American Business Service	$1.7B	4800	Public
16	Equinix	Data Center	$3.61B	6200	Public
17	Ericsson	Telecom	$24B	109,127	Public
18	Evonik Industries AG	Industrial	12.92B Euro	33,412	Public
19	Fluke Corporation	Subsidiary of Fortive	$1B	2525	Public
20	Fuji Electric Co. Ltd.	Power plants, energy mgmt.	$7.37B	25,524	Public
21	Fujifilm Corporation	Photography and Imaging	$22.6B	79,235	Public
22	General Electric	Industrial	$124B	295,000	Public
23	Genpact	BPM and Services	$1B	77,000	Public
24	Haier Group	Chinese Consumer Electronics	$29.2B	78,000	Public
25	HP	Information Tech H/W & S/W	$50.1B	195,000	Public
26	Hitachi Ltd.	Industrial conglomerate	$82.5B	355,000	Public
27	Honeywell	Industrial conglomerate	$39.3B	131,000	Public
28	IBM	Technology - software, services	$80B	380,300	Public
29	Infineon Technolgies	Semiconductor Manufacturer	6.43B Euro	36,299	Public
30	Infosys Limited	Software Services	$10.2B	200,364	Public

A-7 List of companies for the survey (continued)

Serial No.	Company Name	Type of Industry	Revenue	Number of Employee	Type
31	Intel	Technology - H/W S/W	$59.38B	106,000	Public
32	Itron Inc.	Energy & water resource Mgmt.	$2B	6,200	Public
33	JTEKT Corporation	Manufacturing (Japan)	$14,75B	40,756	Public
34	Keysight Technologies Inc.	Manufacturing	$2.91B	10,250	Public
35	Konica Minolta	Technology - H/W S/W	$86B	43,300	Public
36	Kuka AG	Industrial Robot	2.095 Euro	12,102	Public
37	Larsen & Tubro Infotect Ltd.	Information Technology Services	$970M	22321	Public
38	Michelin	Tire Manufacturer	20.907B Euro	112,800	Public
39	Micron Technology	Semiconductor Manufacturer	$12.4B	31,400	Public
40	Microsoft Corporation	Business Software	$89B	124,000	Public
41	Mitsubishi Electric Corporation	Japan Trading company	$17.8B	60,000	Public
42	Mitsubishi Heavy Industries Ltd.	Industrial conglomerate	$39.1B	82,728	Public
43	National Instruments	System & Software	$1.2B	7552	Public
44	NEC Corporation	Industrial conglomerate	$28B	102,375	Public
45	Olympus Corporation	Optical Instrument manufacturer	$7.8B	39,727	Public
46	Oracle	Software, Hardware solutions	$37B	138,000	Public
47	Parker Hannifin	Industrial Control systems	$13.2B	56,690	Public
48	Pegasystems	Software	$750M	3,500	Public
49	PWC	Software Services	$35.9B	223,468	Public
50	PSJC Rostelcom	Russian Telecom	$1B	170,000	Public
51	PTC Inc.	Software	$1.1B	5,982	Public
52	Qualcomm Technologies Inc.	Semiconductor Manufacturer	$23.5B	30,500	Public
53	Red Hat	Software	$2.4B	10,500	Public
54	Renesas Electronics Corporation	Semiconductor Manufacturer	$1.78B	18,900	Public
55	Ricoh Company Ltd.	Imaging & Electronics	$20.6B	109,361	Public
56	Rockwell Automation	Industrial Goods	$5.87B	22,000	Public
57	Rostelecom	Russian Telecom	$4.46B	170,000	Public
58	Samsung Electronics	Industrial conglomerate	$174B	319,000	Public
59	SAP SE	Software	$22B	87,114	Public
60	Schindler Digital Business Ltd. (Schindler)	Industrial Equipment	$10.2B	58,271	Public

A-7 List of companies for the survey (continued)

Serial No.	Company Name	Type of Industry	Revenue	Number of Employee	Type
61	Schlumberger	Industrial Equipment	$27.8B	100,000	Public
62	SICK AG	Industrial Equipment	1.1B Euro	6,957	Public
63	Siemens	Industrial conglomerate	79.64B Euro	360,000	Public
64	Tata Consultancy Services	Software	$17.57B	371,519	Public
65	TE Connectivity	Technology - H/W S/W	$12B	75,000	Public
66	Tech Mahindra Limited	Software Services	$4.35B	115,980	Public
67	Texas Instruments	Technology - H/W S/W	$13,3B	29,885	Public
68	Toshiba	Industrial conglomerate	$52.56B	187,809	Public
69	Verisign Inc.	Technology - software, services	$1.1B	990	Public
70	Wipro Limited	Technology - software, services	$8.48B	166,790	Public
71	Xilinx Inc.	Semiconductor Manufacturer	$2.382B	3,831	Public
72	ZTE Corporation	Telecom - China	$15.4B	69,093	Public
73	AT&T	Telecom	$160.5B		Public
74	Google	Software	$110B		Public
75	AWS	Infrastructure, B2C	$177.9B		Public
76	Broadcom	Telecom	$17.64B		Public
77	Johnson Control	Control systems for Energy	$30.17B		Public
78	Blackberry	Wireless, Handheld device	$1.30B		Public
79	VmWare	Cloud software	$7.92B		Public
80	Advantech	Automation product	$12.98B		Public
81	Deutsche Telekom	Telecom	$73.09 Euro		Public
82	Sierra Wireless	Telecom	$.615B		Public
83	Software AG	Cloud software	$879B Euro		Public
84	BAE Systems	Defense / Cyber Crime software	$18.32B GBP		Public
85	Orange	Technology - H/W S/W	$40.92B Euro		Public
86	CSC	Software Services	Merged with HP		Public
87	Splunk	Software	$1.27B		Public

A-8 Survey Questionnaire

Digital-Transformative-Capability-Survey-1

Page 1: Survey Questions

Developing transformative capabilities of industrial businesses by leveraging industrial internet of things (IIOT)

A study of Industrial Internet Companies

Researchers:

Swapan Ghosh, Technical Product Management, GE Digital & PhD student, Loughborough University, UK, s.ghosh@lboro.ac.uk

Prof. Mat Hughes, Loughborough University, UK, m.hughes2@lboro.ac.uk

Prof. Ian Hodgkinson, Loughborough University, UK, i.r.hodgkinson@lboro.ac.uk

Prof. Paul Hughes, De Montfort University, UK, paul.hughes@dmu.ac.uk

Note: The content of this survey is strictly confidential and will be used only for academic purposes. For any question(s) or concern(s), please contact anyone of us.

The survey may take 20 minutes to complete so, you may like to save the survey and come back to it later.

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Page 2: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT

Note: Please click on '**More Info**' to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

The first two questions, Digital Twin and Digital Thread are not only related to manufacturing industry, it is applicable for all other industries. These are two digtalization processes for digital transformation.

Digital Twin is the digital representation of a physical system and Digital Thread is a process of collecting digital information from the design of any system to the implementation of that system.

1. **Digitalization Process - Digital Twin:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Using digital twin we build a bridge between the physical and digital world.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we simulate actual production environments.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we detect product shortcomings in advance.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we design new products with complex requirements.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we build new products.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we build better quality products.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we run/operate new products with greater efficiency.	☐	☐	☐	☐	☐	☐	☐

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Using digital twin we receive early warning of system failures.	☐	☐	☐	☐	☐	☐	☐
Using digital twin we foresee the business outcomes of our decisions.	☐	☐	☐	☐	☐	☐	☐

2. **Digitalization Process - Digital Thread:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We are using more digital technologies in our manufacturing processes.	☐	☐	☐	☐	☐	☐	☐
We integrate our Information technology (IT) data with Operational Technology (OT) data to accelerate digital transformation.	☐	☐	☐	☐	☐	☐	☐
We maintain manufacturing health records (from design, sourcing, and production to distribution, point of sale and use) to optimize digital transformation.	☐	☐	☐	☐	☐	☐	☐
By mining data, our engineers are gaining new insights into our assets.	☐	☐	☐	☐	☐	☐	☐
By mining data, our engineers are improving the reliability of our assets.	☐	☐	☐	☐	☐	☐	☐

By using digital technologies, we are improving distribution of our products to our customers.	☐	☐	☐	☐	☐	☐	☐
By using digital technologies, we are integrating our supply chain networks with our customers and partners.	☐	☐	☐	☐	☐	☐	☐

3. **Digital Mindset:** Regarding your **digital business**, *using the scales below, please indicate your level of disagreement/agreement, by selecting the numbers of your choice in the boxes provided.* * Required

More info

	1	2	3	4	5	6	7	
The managers in our firm do not have a clear vision for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm have a clear vision for digital transformation.
The managers in our firm do not empower employees to implement digital strategies.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm empower employees to implement digital strategies.
The managers in our firm do not encourage employees to make decisions for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm encourage employees to make decisions for digital transformation.
The managers in our firm do not make decisions based on information for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm make decisions based on information for digital transformation.

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The managers in our firm do not make decisions based on intuition for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm make all decisions based on intuition for digital transformation.
The managers in our firm do not make decisions based on experience for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm make decisions based on experience for digital transformation.
The managers in our firm do not try out different technological and process options before deciding on particular options for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm try out different technological and process options before deciding on particular options for digital transformation.
The managers in our firm do not encourage experimentation by our employees for digital transformation.	☐	☐	☐	☐	☐	☐	☐	The managers in our firm encourage experimentation by our employees for digital transformation.

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Page 3: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT - Continued

Note: Please click on **'More Info'** to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

4. **Business Model Transformation - Marketing & Sales:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. ✱ *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We are changing our marketing activities from transactional to relational marketing.	☐	☐	☐	☐	☐	☐	☐
We are changing our sales activities from selling multi-million dollar products to selling services capabilities.	☐	☐	☐	☐	☐	☐	☐
We are educating our customers from owning products to seeking service.	☐	☐	☐	☐	☐	☐	☐

4.a. **Business Model Transformation - Customer Engagement:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. ✱ *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

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We are extending the timescale of our customer engagements by managing and delivering multi-year partnerships.	☐	☐	☐	☐	☐	☐	☐
We are extending the timescale of our customer engagements by managing and controlling long term risk and exposure.	☐	☐	☐	☐	☐	☐	☐
We are extending timescale of our customer engagement by modeling and understanding of cost and profit implications of long term partnerships.	☐	☐	☐	☐	☐	☐	☐

4.a.i. **Business Model Transformation - Customer Offerings:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We are changing our customer offerings by understanding what value means to them.	☐	☐	☐	☐	☐	☐	☐
We are changing our customer offerings by delivering services rather than products.	☐	☐	☐	☐	☐	☐	☐
We are promoting an organizational culture such that our employees have high concern for servicing customers.	☐	☐	☐	☐	☐	☐	☐

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Page 4: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT - Continued

Note: Please click on **'More Info'** to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

5. **Operating Model Transformation:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We are looking for business opportunities beyond our industry that are possible by digital transformation.	☐	☐	☐	☐	☐	☐	☐
We are experimenting with our ideas and launching them faster for transforming our business.	☐	☐	☐	☐	☐	☐	☐
We are developing strategic relationships with our partners to augment our capabilities for digital transformation.	☐	☐	☐	☐	☐	☐	☐
We are gaining full support from our top executives for digital transformation.	☐	☐	☐	☐	☐	☐	☐

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We are implementing digital traction metrics (such as, number of unique users/active users, customer retention rate, abandon rate) to measure the performance of our digital business.	☐	☐	☐	☐	☐	☐	☐

6. **Digital Employees and Workplace:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Our employees bring high level of digital fluency to the workforce.	☐	☐	☐	☐	☐	☐	☐
Our employees can be utilized in many kinds of jobs since they have multiple skills.	☐	☐	☐	☐	☐	☐	☐
We are creating an open collaborative environments powered by digital collaboration tools such that employees can participate in decision making processes.	☐	☐	☐	☐	☐	☐	☐
Our employees are flexible and willing to change their working habits in response to external influences.	☐	☐	☐	☐	☐	☐	☐
We have created a digital workplace such that our employees can collaborate, communicate and connect with each other.	☐	☐	☐	☐	☐	☐	☐

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Page 5: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT - Continued

Note: Please click on '**More Info**' to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

7. **Market Turbulance:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
The market activities of our competitors are not predictable.	☐	☐	☐	☐	☐	☐	☐
The rate of innovations of new operating processes in our industry has increased drastically.	☐	☐	☐	☐	☐	☐	☐
The rate of innovations of new products and services in our industry has increased drastically.	☐	☐	☐	☐	☐	☐	☐
The market activities of our key competitors now affect us in more ways than before.	☐	☐	☐	☐	☐	☐	☐
We are witnessing demand from totally new group of customers who earlier never bought our products/services.	☐	☐	☐	☐	☐	☐	☐
New customers have product related needs that are very different from our existing customers.	☐	☐	☐	☐	☐	☐	☐

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Environmental demands on us are constantly changing.	☐	☐	☐	☐	☐	☐	☐
Environmental changes in our industry are unpredictable.	☐	☐	☐	☐	☐	☐	☐

8. **Technology Turbulance:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Technology in our digital business is changing rapidly.	☐	☐	☐	☐	☐	☐	☐
Technology breakthroughs provide substantial opportunities in our digital business.	☐	☐	☐	☐	☐	☐	☐
A large number of new product ideas have been made possible through technological breakthroughs in our digital business.	☐	☐	☐	☐	☐	☐	☐
The rate of product/service obsolescence in the digital business is very high.	☐	☐	☐	☐	☐	☐	☐
In digital business, our production and service technologies change often and in major ways.	☐	☐	☐	☐	☐	☐	☐

9. **Competitor Turbulance:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

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More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We encounter new competitors all the time.	☐	☐	☐	☐	☐	☐	☐
Competitors change their strategy constantly.	☐	☐	☐	☐	☐	☐	☐
Our competitors are not the same from previous years.	☐	☐	☐	☐	☐	☐	☐
Our customers have competing assets and capabilities.	☐	☐	☐	☐	☐	☐	☐
Our partners have competing assets and capabilities.	☐	☐	☐	☐	☐	☐	☐

Page 6: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT - Continued

Note: Please click on '**More Info**' to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

10. **Ecosystem Partnership:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Our activities with alliance partners are well coordinated.	☐	☐	☐	☐	☐	☐	☐
There is a great deal of interactions with our alliance partners in most decisions.	☐	☐	☐	☐	☐	☐	☐
We ensure an appropriate coordination among the activities of our different alliances.	☐	☐	☐	☐	☐	☐	☐
We determine the area of synergy in our alliance portfolio.	☐	☐	☐	☐	☐	☐	☐
We ensure that interdependencies between our alliances are identified.	☐	☐	☐	☐	☐	☐	☐
We have the managerial competence to absorb knowledge from our alliance partners.	☐	☐	☐	☐	☐	☐	☐

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We can successfully integrate our existing knowledge with new information acquired from our alliance partners.	◻	◻	◻	◻	◻	◻	◻
Collaboration among ecosystem partners is a key success factor for Industrial IoT.	◻	◻	◻	◻	◻	◻	◻
Inter-firm collaboration is helping us to create specific intellectual property.	◻	◻	◻	◻	◻	◻	◻

11. **Customer/Market Demands:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We have significant demands from our customers for Industrial IoT solutions.	◻	◻	◻	◻	◻	◻	◻
We are delivering significant number of industrial IoT based products and services in the next year.	◻	◻	◻	◻	◻	◻	◻
Our competitors are delivering significant number of Industrial IoT based products and service in this year.	◻	◻	◻	◻	◻	◻	◻
Some of our customers have implemented industrial IoT solutions.	◻	◻	◻	◻	◻	◻	◻
Some of our customers have plans to use industrial IoT solution in the next year.	◻	◻	◻	◻	◻	◻	◻

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12. **Organizational Process:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * Required

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We hold on to our current businesses which are profitable in the past.	☐	☐	☐	☐	☐	☐	☐
We seldom give discounts to our customers to move from our old products and services to new products and services.	☐	☐	☐	☐	☐	☐	☐
Our biggest challenge is to move from our existing systems to the new and improved systems.	☐	☐	☐	☐	☐	☐	☐
We seldom help our customers to move them from old business model (e.g. licensing) to new business model (e.g. cloud).	☐	☐	☐	☐	☐	☐	☐
We like to maintain strong relationship with our current partners and occasionally look for new partners.	☐	☐	☐	☐	☐	☐	☐

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Page 7: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT - Continued

Note: Please click on **'More Info'** to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

13. **Digital Commitment:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. * *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
Most of our business processes (generating leads, sales information, manufacturing information etc.) are digitized.	☐	☐	☐	☐	☐	☐	☐
Most of our business routines (new product development, after sales support, manufacturing execution system etc.) are digitized.	☐	☐	☐	☐	☐	☐	☐
Our senior executives are committed for digital transformation.	☐	☐	☐	☐	☐	☐	☐
We have developed digital strategies for next 3 years.	☐	☐	☐	☐	☐	☐	☐
We are implementing digital strategies for our groups/businesses.	☐	☐	☐	☐	☐	☐	☐
We have formed strategic partnerships for digital transformation.	☐	☐	☐	☐	☐	☐	☐

14. **Resource Scarcity and Constraints:** Regarding your **digital business**, using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting your choice in the boxes provided. ✱ *Required*

More info

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
We face a shortage of skill personnel (proper software and domain knowledge) for implementing digital strategies in our organization.	☐	☐	☐	☐	☐	☐	☐
We face a shortage of financial resources for implementing digital strategies in our organization.	☐	☐	☐	☐	☐	☐	☐
We face a shortage of managerial capacity for implementing digital strategies in our organization.	☐	☐	☐	☐	☐	☐	☐
The shortage of resources are delaying our digital projects.	☐	☐	☐	☐	☐	☐	☐
We understand the digital transformation projects are resource intensive and multi-years projects.	☐	☐	☐	☐	☐	☐	☐

Page 8: SECTION 1: DIGITAL TRANSFORMATION IN YOUR COMPANY / YOUR COMPANY AS A SOLUTION PROVIDER TO IIOT - Continued

Note: Please click on '**More Info**' to get more information about a particular question.

Please answer these questions by keeping in mind your role as a solution provider to industrial/digital businesses.

15. ***Importance of Capabilities:*** *Regarding your* ***digital business****, using the scale below, please indicate the* ***importance of the following capabilities*** *in your organization, by selecting numbers of your choice in the boxes provided.* *✱ Required*

More info

	Not at all important	Not important	Slightly not important	Neutral	Slightly important	Important	Very important
New product development.	☐	☐	☐	☐	☐	☐	☐
Product innovation.	☐	☐	☐	☐	☐	☐	☐
Services innovation.	☐	☐	☐	☐	☐	☐	☐
Sensing about opportunities/ market/competitors.	☐	☐	☐	☐	☐	☐	☐
Learning & knowledge management.	☐	☐	☐	☐	☐	☐	☐
Integration.	☐	☐	☐	☐	☐	☐	☐
Coordination.	☐	☐	☐	☐	☐	☐	☐
Exploration (for new products/services).	☐	☐	☐	☐	☐	☐	☐
Exploitation (of existing products and services).	☐	☐	☐	☐	☐	☐	☐
Strategic flexibility.	☐	☐	☐	☐	☐	☐	☐
Market responsiveness.	☐	☐	☐	☐	☐	☐	☐
Alliance management.	☐	☐	☐	☐	☐	☐	☐
Research & Development (R&D).	☐	☐	☐	☐	☐	☐	☐

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16. ***Improvement in Capabilities:*** *In last three years, regarding your* ***digital business****, please rate whether a* ***particular capability improved or not (1 = No Improvement, 7 = Substantial Improvement)*** *in your organization, by selecting the numbers of your choice in the boxes provided.* ✱ Required

More info

	1	2	3	4	5	6	7
New product development.	☐	☐	☐	☐	☐	☐	☐
Product innovation.	☐	☐	☐	☐	☐	☐	☐
Services innovation.	☐	☐	☐	☐	☐	☐	☐
Sensing about opportunities/ market/competitors.	☐	☐	☐	☐	☐	☐	☐
Learning & knowledge management.	☐	☐	☐	☐	☐	☐	☐
Integration.	☐	☐	☐	☐	☐	☐	☐
Coordination.	☐	☐	☐	☐	☐	☐	☐
Exploration (for new products/services).	☐	☐	☐	☐	☐	☐	☐
Exploitation (of existing products and services).	☐	☐	☐	☐	☐	☐	☐
Strategic flexibility.	☐	☐	☐	☐	☐	☐	☐
Market responsiveness.	☐	☐	☐	☐	☐	☐	☐
Alliance management.	☐	☐	☐	☐	☐	☐	☐
Research & Development (R&D).	☐	☐	☐	☐	☐	☐	☐

17. ***Comparison of Capabilities:*** *Relative to competitors in last three years, regarding your* ***digital business****, please rate the following* ***capabilities in term of their standards in comparison to your main competitors****, by selecting the numbers of your choice in the boxes provided.* ✱ Required

More info

	Much worse	Worse	Slightly worse	Parity	Slightly better	Better	Much Better
New product development.	☐	☐	☐	☐	☐	☐	☐
Product innovation.	☐	☐	☐	☐	☐	☐	☐
Services innovation.	☐	☐	☐	☐	☐	☐	☐

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Sensing about opportunities/ market/competitors.	☐	☐	☐	☐	☐	☐	☐
Learning & knowledge management.	☐	☐	☐	☐	☐	☐	☐
Integration.	☐	☐	☐	☐	☐	☐	☐
Coordination.	☐	☐	☐	☐	☐	☐	☐
Exploration (for new products/services).	☐	☐	☐	☐	☐	☐	☐
Exploitation (of existing products and services).	☐	☐	☐	☐	☐	☐	☐
Strategic flexibility.	☐	☐	☐	☐	☐	☐	☐
Market responsiveness.	☐	☐	☐	☐	☐	☐	☐
Alliance management.	☐	☐	☐	☐	☐	☐	☐
Research & Development (R&D).	☐	☐	☐	☐	☐	☐	☐

Page 9: SECTION 2: ABOUT YOUR COMPANY

18. Which industry does your company operate in?

19. How old is your company?

20. Do you have a separate Industrial IoT division or department or both?

Page 10: SECTION III: YOURSELF

21. What is your job title?

22. How long you are with the company?

23. *Using the scale below, please indicate the extent to which you disagree or agree with the following statements, by selecting the numbers of your choice.*

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
I have adequate knowledge answering the questions in this survey.	☐	☐	☐	☐	☐	☐	☐
The questions in this survey are relevant to my organization.	☐	☐	☐	☐	☐	☐	☐

24. What is your email id?

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Page 11: Final Page

Key for selection options

20 - Do you have a separate Industrial IoT division or department or both?

Yes
No

A-9 Harman's Single Factor Test for CMV (Front-End Model)

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.318	26.938	26.938	18.318	26.938	26.938
2	5.738	8.439	35.377			
3	4.772	7.018	42.395			
4	3.825	5.625	48.020			
5	2.797	4.113	52.133			
6	2.366	3.480	55.613			
7	2.147	3.157	58.770			
8	1.995	2.933	61.703			
9	1.855	2.728	64.432			
10	1.703	2.504	66.935			
11	1.561	2.296	69.232			
12	1.488	2.189	71.420			
13	1.248	1.836	73.256			
14	1.179	1.734	74.990			
15	1.080	1.588	76.579			
16	.996	1.465	78.044			
17	.919	1.351	79.395			
18	.908	1.335	80.730			
19	.813	1.195	81.925			
20	.746	1.097	83.023			
21	.687	1.011	84.034			
22	.676	.995	85.028			
23	.642	.945	85.973			
24	.619	.910	86.883			
25	.556	.817	87.700			
26	.543	.799	88.499			
27	.534	.785	89.284			
28	.488	.717	90.001			
29	.477	.701	90.702			
30	.454	.667	91.369			
31	.405	.596	91.965			
32	.381	.561	92.526			
33	.374	.550	93.076			
34	.353	.519	93.594			
35	.341	.502	94.096			
36	.293	.431	94.527			

37	.284	.417	94.944			
38	.272	.399	95.344			
39	.261	.384	95.728			
40	.255	.375	96.103			
41	.243	.358	96.461			
42	.210	.308	96.769			
43	.195	.287	97.056			
44	.190	.280	97.336			
45	.171	.251	97.587			
46	.148	.217	97.804			
47	.144	.212	98.016			
48	.139	.204	98.220			
49	.128	.189	98.409			
50	.123	.181	98.590			
51	.106	.156	98.746			
52	.100	.147	98.893			
53	.093	.137	99.030			
54	.085	.125	99.155			
55	.081	.120	99.275			
56	.078	.114	99.389			
57	.064	.094	99.483			
58	.055	.080	99.564			
59	.051	.075	99.639			
60	.046	.068	99.707			
61	.041	.060	99.766			
62	.036	.053	99.819			
63	.030	.044	99.863			
64	.027	.040	99.903			
65	.023	.033	99.936			
66	.020	.029	99.965			
67	.016	.023	99.988			
68	.008	.012	100.000			

Extraction Method: Principal Component Analysis.

A-10 Harman's Single Factor Test for CMV (Back-End Model)

Total Variance Explained

Component	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %
1	27.905	32.829	32.829	27.905	32.829	32.829
2	6.891	8.107	40.936			
3	5.179	6.093	47.029			
4	3.825	4.500	51.529			
5	3.692	4.344	55.873			
6	3.038	3.574	59.448			
7	2.540	2.988	62.436			
8	2.285	2.688	65.124			
9	2.026	2.384	67.507			
10	1.900	2.236	69.743			
11	1.822	2.143	71.887			
12	1.608	1.891	73.778			
13	1.493	1.756	75.534			
14	1.416	1.666	77.200			
15	1.266	1.489	78.690			
16	1.172	1.379	80.069			
17	1.095	1.288	81.357			
18	.943	1.109	82.466			
19	.889	1.045	83.512			
20	.809	.952	84.463			
21	.792	.932	85.395			
22	.741	.872	86.267			
23	.728	.857	87.123			
24	.629	.740	87.863			
25	.610	.718	88.581			
26	.595	.699	89.280			
27	.563	.662	89.942			
28	.488	.574	90.517			
29	.474	.558	91.075			
30	.447	.526	91.601			
31	.421	.496	92.096			
32	.396	.466	92.562			
33	.368	.433	92.995			

34	.358	.422	93.417			
35	.349	.411	93.828			
36	.326	.383	94.211			
37	.323	.380	94.590			
38	.310	.365	94.956			
39	.292	.343	95.299			
40	.264	.310	95.609			
41	.259	.305	95.914			
42	.243	.285	96.199			
43	.220	.259	96.459			
44	.210	.247	96.705			
45	.189	.222	96.927			
46	.183	.215	97.142			
47	.173	.203	97.346			
48	.164	.193	97.539			
49	.156	.184	97.722			
50	.147	.173	97.895			
51	.138	.162	98.057			
52	.134	.158	98.215			
53	.131	.154	98.369			
54	.122	.144	98.512			
55	.115	.136	98.648			
56	.106	.125	98.773			
57	.088	.104	98.877			
58	.088	.103	98.980			
59	.081	.095	99.075			
60	.075	.088	99.164			
61	.074	.087	99.250			
62	.065	.077	99.327			
63	.059	.069	99.396			
64	.055	.065	99.461			
65	.050	.059	99.521			
66	.048	.056	99.577			
67	.045	.052	99.629			
68	.039	.046	99.675			
69	.036	.042	99.717			
70	.033	.039	99.756			
71	.032	.038	99.794			

72	.029	.034	99.828			
73	.023	.027	99.856			
74	.022	.026	99.881			
75	.021	.024	99.906			
76	.017	.020	99.926			
77	.015	.017	99.943			
78	.013	.016	99.959			
79	.010	.012	99.971			
80	.007	.008	99.979			
81	.006	.007	99.985			
82	.005	.006	99.991			
83	.004	.005	99.996			
84	.003	.003	99.999			
85	.001	.001	100.000			

Extraction Method: Principal Component Analysis.

A-11 Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
DTWIN1	1	7	5.32	1.400
DTWIN2	1	7	5.59	1.223
DTHREAD	2	7	5.76	1.090
DMINDSET	1	7	4.34	1.449
DTCBMT_MS	2	7	5.45	1.200
DTCBMT_CE	2	7	5.49	1.177
DTCOMT	2	7	5.45	1.185
DTCDEW	1	7	5.15	1.201
MKTTUR_P	3	7	5.58	.953
MKTTUR_C	2	7	5.28	1.116
TECHTUR	3	7	5.96	.790
COMPTUR	3	7	5.45	.959
PATHDEP	3	7	4.82	1.096
ECOPART	2	7	5.1505	1.09254
CUSTMKT	2	7	5.4019	1.14874
DIGCOM	1.33	7	5.3851	1.12750
RESCON	2.25	7	5.2549	1.19793
DTIMP_NPD	1	7	6.1893	1.13784
DTIMP_RECON	1.63	7	6.0291	.84457
DTIPR	1	7	5.1090	1.41218
DTCOM	2	7	4.8745	1.18373

A-12 Correlation Matrix for Front-End Model

		DTWIN1	DTWIN2	DTHREAD	DMINDSET	DTCBMT_MS	DTCBMT_CE	DTCOMT	DTCCLT
DTWIN1	PC	1	.737**	.682**	.280**	.323**	.414**	.435**	.439**
	Sig.		.000	.000	.002	.000	.000	.000	.000
DTWIN2	PC	.737**	1	.683**	.342**	.278**	.315**	.446**	.358**
	Sig.	.000		.000	.000	.002	.001	.000	.000
DTHREAD	PC	.682**	.683**	1	.273**	.390**	.406**	.482**	.556**
	Sig.	.000	.000		.003	.000	.000	.000	.000
DMINDSET	PC	.280**	.342**	.273**	1	.037	.122	.176*	.304**
	Sig.	.002	.000	.003		.356	.110	.038	.001
DTCBMT_MS	PC	.323**	.278**	.390**	.037	1	.480**	.307**	.382**
	Sig.	.000	.002	.000	.356		.000	.001	.000
DTCBMT_CE	PC	.414**	.315**	.406**	.122	.480**	1	.548**	.558**
	Sig.	.000	.001	.000	.110	.000		.000	.000
DTCOMT	PC	.435**	.446**	.482**	.176*	.307**	.548**	1	.605**
	Sig.	.000	.000	.000	.038	.001	.000		.000
DTCCLT	PC	.439**	.358**	.556**	.304**	.382**	.558**	.605**	1
	Sig.	.000	.000	.000	.001	.000	.000	.000	
MKTTUR_P	PC	.410**	.307**	.384**	.154	.281**	.226*	.257**	.296**
	Sig.	.000	.001	.000	.060	.002	.011	.004	.001
MKTTUR_C	PC	.437**	.300**	.317**	.124	.213*	.397**	.269**	.224*
	Sig.	.000	.001	.001	.106	.015	.000	.003	.012
TECTUR	PC	.519**	.579**	.553**	.161	.357**	.344**	.410**	.398**
	Sig.	.000	.000	.000	.052	.000	.000	.000	.000
COMPTUR	PC	.367**	.269**	.353**	.145	.418**	.154	.152	.240**
	Sig.	.000	.003	.000	.072	.000	.060	.062	.007
PATHDEP	PC	.126	.040	.075	.137	.078	.080	.022	.091
	Sig.	.103	.342	.225	.083	.216	.212	.413	.182

PC – Pearson Correlation, Sig. (1-tailed), ** - Significant at 0.01 level, * - Significant at 0.05 level

A-12 Correlation Matrix for Front-End Model (Continued)

		MKTTUR_P	MKTTUR_C	TECHTUR	COMPTUR	PATHDEP
	Sig.	.001	.012	.000	.007	.182
MKTTUR_P	PC	1	.486**	.547**	.526**	.088
	Sig.		.000	.000	.000	.187
MKTTUR_C	PC	.486**	1	.455**	.508**	.326**
	Sig.	.000		.000	.000	.000
TECHTUR	PC	.547**	.455**	1	.442**	.046
	Sig.	.000	.000		.000	.321
COMPTUR	PC	.526**	.508**	.442**	1	.213*
	Sig.	.000	.000	.000		.016
PATHDEP	PC	.088	.326**	.046	.213*	1
	Sig.	.187	.000	.321	.016	

PC – Pearson Correlation, Sig. (1-tailed), ** - Significant at 0.01 level, * - Significant at 0.05 level

A-13 Correlation Matrix for Back-End Model

		DTCBMT_ MS	DTCBMT_ CE	DTCOMT	DTCCLT	ECOPART	CUSTMKT	DIGCOM	RESCON
DTCBMT_MS	PC	1	.480**	.307**	.382**	.274**	.462**	.359**	.069
	Sig.		.000	.001	.000	.003	.000	.000	.244
DTCBMT_CE	PC	.480**	1	.548**	.558**	.418**	.315**	.568**	.020
	Sig.	.000		.000	.000	.000	.001	.000	.422
DTCOMT	PC	.307**	.548**	1	.605**	.387**	.288**	.540**	.054
	Sig.	.001	.000		.000	.000	.002	.000	.295
DTCCLT	PC	.382**	.558**	.605**	1	.541**	.325**	.592**	-.069
	Sig.	.000	.000	.000		.000	.000	.000	.245
ECOPART	PC	.274**	.418**	.387**	.541**	1	.265**	.535**	-.088
	Sig.	.003	.000	.000	.000		.003	.000	.188
CUSTMKT	PC	.462**	.315**	.288**	.325**	.265**	1	.356**	.218*
	Sig.	.000	.001	.002	.000	.003		.000	.013
DIGCOM	PC	.359**	.568**	.540**	.592**	.535**	.356**	1	.010
	Sig.	.000	.000	.000	.000	.000	.000		.460
RESCON	PC	.069	.020	.054	-.069	-.088	.218*	.010	1
	Sig.	.244	.422	.295	.245	.188	.013	.460	
DTIMP_NPD	PC	.211*	.278**	.419**	.326**	.204*	.276**	.358**	.187*
	Sig.	.016	.002	.000	.000	.020	.002	.000	.029
DTIMP_RECON	PC	.172*	.341**	.332**	.429**	.373**	.296**	.219*	.056
	Sig.	.042	.000	.000	.000	.000	.001	.013	.285
DTIPR	PC	.358**	.414**	.523**	.434**	.522**	.246**	.516**	-.145
	Sig.	.000	.000	.000	.000	.000	.006	.000	.072
DTCOM	PC	.260**	.482**	.615**	.456**	.493**	.158	.543**	-.213*
	Sig.	.004	.000	.000	.000	.000	.056	.000	.015

PC – Pearson Correlation, Sig. (1-tailed), ** - Significant at 0.01 level, * - Significant at 0.05 level

A-14 Themes (from Qualitative Study) and Conceptual Framework Mapping

	Theme	Conceptual Framework Mapping
1	Ecosystem Partnership	Positive influence on DTCs & DT
2	Path Dependency	Negative influence on DTCs & DT
3	Mind-set Change	DTC- Cultural Transformation
4	Business Model Change	DTC – Business Model Transformation
5	Capability Modularization	Digitalization Profile (Digital Twin, Digital Thread and Digital Mindset)
6	Technology Disruption	Positive influence on DTCs & DT
7	Strategic Focus and Intent	Positive influence on DTCs & DT
8	Internal Collaboration	DTC – Operating Model Transformation
9	Context Dependency	Digitalization Profile (Digital Twin, Digital Thread and Digital Mindset)
10	Organization Structure	DTC – Operating Model Transformation

References

Aaker, D.A., Day, G.S. (1990), *Marketing Research* (4th Edition), Toronto, John Wiley and Sons.

Aaker, D. A., Kumar, V., Day, G. S., & Lawley, M. A. (2007). Marketing research: The second Pacific rim edition. *Marketing Research: The Second Pacific Rim Edition*.

Acur, N., Kandemir, D., De Weerd-Nederhof, P. C., & Song, M. (2010). Exploring the impact of technological competence development on speed and NPD program performance. *Journal of Product Innovation Management*, *27*(6), 915-929.

Afuah, A. (2002). *Internet business models and strategies: Text and cases*. McGraw-Hill, Inc.

Agarwal, R., & Selen, W. (2009). Dynamic capability building in service value networks for achieving service innovation. *Decision sciences*, *40*(3), 431-475.

Agrawal, A., Brandinali, S. (2018). Resource Constraints can spark frugal digital innovation. Information Management, From URL https://www.information-management.com/opinion/resource-constraints-can-spark-frugal-digital-innovation.

Aiken, C. B., & Keller, S. P. (2007). The CEO's role in leading transformation. *Management Quarterly*, *48*(2), 30.

Aliaga, M., & Gunderson, B. (2000). Introduction to Quantitative Research.

Alsever, J. (2015). *Startups Inside Giant Companies*.

Alvarez, S. A., & Barney, J. B. (2001). How entrepreneurial firms can benefit from alliances with large partners. *The Academy of Management Executive*, *15*(1), 139-148.

Ambrosini, V., & Bowman, C. (2001). Tacit Knowledge: Some Suggestions for Operationalization. *Journal of Management Studies* 38 (6), 811-829.

Ambrosini, V., & Bowman, C. (2009). What are dynamic capabilities and are they a useful construct in strategic management? *International Journal of Management Reviews*, *11*(1), 29-49.

Ambrosini, V., Bowman, C. & Collier, N. (2009). Dynamic capabilities: An exploration of how firms renew their resource base, *British Journal of Management*, vol. 20, no. S1, pp. S9-S24.

Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic Management Journal*, *22*(6-7), 493-520.

Amit, R., & Zott, C. (2012). Creating value through business model innovation. *MIT Sloan Management Review*, *53*(3), 41-49.

Anand, B. N., & Khanna, T. (2000). Do firms learn to create value? The case of alliances. *Strategic Management Journal*, *21*(3), 295-315.
Anand, J., Singh, H. (1997). Asset redeployment, acquisitions and corporate strategy in declining

industries. *Strategic Management Journal*, 18 (S1): 99–118.
Anand, J., Oriani, R., & Vassolo, R.S. (2007). Managing a portfolio of strategic real options. *Advances in Strategic Management*, 24.

Anand, J., Oriani, R., & Vassalo, R.S. (2010). Alliance activity as a dynamic capability in the face of a discontinuous technological change. *Organization Science*, 1213-1232.

Andrevski, G., Richard, O. C., Shaw, J. D., & Ferrier, W. J. (2014). Racial diversity and firm performance: The mediating role of competitive intensity. *Journal of Management*, *40*(3), 820-844.

Andrews, D., Nonnecke, B., & Preece, J. (2003). Electronic survey methodology: A case study in reaching hard-to-involve Internet users. *International Journal of Human-Computer Interaction*, *16*(2), 185-210.

Andriole, S. (2017). Is Digital Privacy A Right Or A Privilege? *MIT Sloan Management Review*, Spring 2017 issue.

Andriopoulos, C., Lewis, M. (2009). Exploitation-Exploration Tensions and Organizational Ambidexterity: Managing Paradoxes of Innovation. *Organ. Sci.* 20(4) 696–717.

Ang, S. H. (2008). Competitive intensity and collaboration: Impact on firm growth across technological environments. *Strategic Management Journal*, *29*(10), 1057-1075.

Arend, RJ. (2003). Revisiting the Logical and Research Considerations of Competitive Advantage, Strategic Management Journal: 24(3): 279-284.

Arend, RJ., Bromiley P. (2009). Assessing the dynamic capability view: Spare change, everyone? *Strategic Organization*, 7:75.

Augier, M., and Teece, D.J. (2009). Dynamic Capabilities and the Role of Managers in Business Strategy and Economic Performance, *Organization Science*, vol. 20, no. 2.

Auh, S., & Menguc, B. (2005). Balancing exploration and exploitation: The moderating role of competitive intensity. *Journal of Business Research*, *58*(12), 1652-1661.

Bachmann, D., Elfrink, J., & Vazzana, G. (1996). Tracking the progress of e-mail vs. snail-mail. *Marketing Research*, *8*(2), 30.

Baker, L., Wagner, T. H., Singer, S., & Bundorf, M. K. (2003). Use of the Internet and e-mail for health care information: results from a national survey. *Jama*, *289*(18), 2400-2406.

Balnaves, M., & Caputi, P. (2001). *Introduction to quantitative research methods: An investigative approach*. Sage Publication.

Baines, T., & Lightfoot, H. W. (2014). Servitization of the manufacturing firm: exploring the operations practices and technologies that deliver advanced services. *International Journal of Operations and Production Management*, *34*(1), 2-35.

Baines, T. S., Lightfoot, H. W., Benedettini, O., & Kay, J. M. (2009). The servitization of manufacturing: A review of literature and reflection on future challenges. *Journal of manufacturing technology management*, *20*(5), 547-567.

Bamberger, K. A. (2009). Technologies of compliance: Risk and regulation in a digital age. *Tex. L. Rev.*, *88*, 669.

Barreto, I. (2010). Dynamic capabilities: A review of past research and agenda for the future, *Journal of Management*, January 2010 36:256-280.

Barney, J.B. (1991). Firm resources and sustained competitive advantage, *Journal of Management*, 17: 99-120.

Barney, J. (1995). Looking inside for Competitive Advantage. *The Academy of Management Executive (*1993-2005), 9(4), 49-61.

Barnes, W., Gartland, M., & Stack, M. (2004). Old habits die hard: Path Dependency and behavioral lock-in. *Journal of Economic Issues*, *38*(2), 371-377.

Barnett, J., Evans, L. S., Gross, C., Kiem, A. S., Kingsford, R. T., Palutikof, J. P., ... & Smithers, S. G. (2015). From barriers to limits to climate change adaptation: path dependency and the speed of change. Ecology and Society 20(3):5.

Bassey, M. (1995). Case Study Research in Educational Settings. McGraw-Hill Education (UK).

Bendor-Samuel, P. (2017). How to eliminate enterprise shadow IT. *CIO.*

Bertrand, M., & Schoar, A. (2003). Managing with style: The effect of managers on firm policies. *The Quarterly Journal of Economics*, *118*(4), 1169-1208.

Bhattacharya, M., Gibson, D. E., & Doty, D. H. (2005). The effects of flexibility in employee skills, employee behaviors, and human resource practices on firm performance. *Journal of Management*, *31*(4), 622-640.

Bharadwaj, A., El Sawy, O., Pavlou, P., & Venkatraman, N. (2013). Digital business strategy: toward a next generation of insights.

Bollard, A., Larrea, E., Singla, A., & Sood, R. (2017). The next-generation operating model for the digital world. *Digital McKinsey", March*.

Bonomi, F., Milito, R. (2012). Fog Computing and its Role in the Internet of Things, Proceedings of the MCC workshop on Mobile Cloud Computing. 10.1145/2342509.2342513.

Bourgeois, L. J., & Eisenhardt, K. (1988). Strategic decision processes in high-velocity environments: Four cases in the microcomputer industry. *Management Science*, 34: 816-835.
Boulton, C. (2017). The digital workplace: 8 steps to greater agility, productivity, CIO.com, From URL https://www.cio.com/article/3229104/digital-transformation/the-digital-workplace-8-steps-to-greater-agility-productivity.html

Boschert, S., and Rosen, R. (2016). Digital Twin - The Simulation Aspect. Mechatronic Futures, Hehenberger, P., and Bradley, D. (eds.), Springer, Berlin/Heidelberg.

Bowen, D.E., Siehel, C., & Schneider, B. (1989). A framework for analyzing customer service orientations in manufacturing. *Academy of Management Review*, 14(1), 75-95.

Bowen, D. E., & Schneider, B. (1995). Winning the service game. *Harvard Business School Press, Boston, MA*.

Bowman, C., & Ambrosini, V. (2003). How the resource‐based and the dynamic capability views of the firm inform corporate‐level strategy. *British journal of management*, *14*(4), 289-303.

Bowman, EH., Singh H. (1993). Corporate restructuring: Reconfiguring the firm. *Strategic Management Journal* 14(S1): 5–14.

Bradley, J., Loucks, J., Macaulay, J., Noronha, A., & Wade, M. (2015). Digital vortex: How digital disruption is redefining industries. *Global Center for Digital Business Transformation: An IMD and Cisco initiative.*

Brenner, B., & Hummel, V. (2017). Digital twin as enabler for an innovative digital shopfloor management system in the ESB Logistics Learning Factory at Reutlingen-University. *Procedia Manufacturing*, *9*, 198-205.

Brenner, S., and Kreiss, D., (2014). Digitalization and digitization. *Culture digitally*. From URL: http://culturedigitally.org/2014/09/digitalization-and-digitization/, 1 May 2016.

Brown, T. E., & Ulijn, J. M. (Eds.). (2004). *Innovation, entrepreneurship and culture: the interaction between technology, progress and economic growth*. Edward Elgar Publishing.

Brown, S. L., & Eisenhardt, K. M. (1995). Product development: Past research, present findings, and future directions. *Academy of Management Review*, *20*(2), 343-378.

Bryman, A. (2001). Social Research Methods. Oxford, UK: Oxford University Press.

Bryman, A. (2004). Qualitative research on leadership: A critical but appreciative review. *The leadership quarterly*, *15*(6), 729-769.

Bryman, A. (2008). Why do researchers integrate/combine/mesh/blend/mix/merge/fuse quantitative and qualitative research. *Advances in mixed methods research*, 87-100.

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic perspectives*, *14*(4), 23-48.

Burrus, D. (2018). Daniel Burrus' Top 20 Technology-Driven Hard Trends. Burrus Research, January, 2018. From URL https://www.burrus.com/2018/01/daniel-burrus-top-20-technology-driven-hard-trends-shaping-2018-beyond//

Bygstad, B., Hanseth, O., Siebenherz, A., and Øvrelid, E. (2017). Process Innovation Meets Digital Infrastructure in a High-Tech Hospital. In Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 801-814).

Cadogan, J. W. (2012). International marketing, strategic orientations and business success: Reflections on the path ahead. *International Marketing Review*, *29*(4), 340-348.

Calabrese, T., Baum, J. A., & Silverman, B. S. (2000). Canadian biotechnology start-ups, 1991–1997: the role of incumbents' patents and strategic alliances in controlling competition. *Social Science Research*, *29*(4), 503-534.

Cai, J., & Tylecote, A. (2008). Corporate governance and technological dynamism of Chinese firms in mobile telecommunications: A quantitative study. *Research Policy*, *37*(10), 1790-1811.

Capron, L. (1999). The long-term performance of horizontal acquisitions. *Strategic Management Journal,* 20(11): 987-1018.

Capron, L., & Mitchell W. (2012). Build, borrow or buy: Solving the growth dilemma. HBR Press, Cambridge, MA.

Capron, L., Dussauge, P., and Mitchell, W. (1998). Resource redeployment following horizontal acquisitions in Europe and North America, 1988–1992. *Strategic Management Journal* 19(7): 631–661.

Casadesus-Masanell, R., & Zhu, F. (2013). Business model innovation and competitive imitation: The case of sponsor-based business models. *Strategic Management Journal*, *34*(4), 464-482.

Castrogiovanni, G. J. (1991). Environmental munihcence; a theoretical assessment. *Academy of Management Review*, *16*(3), 542-565.

Catlin, T., Lorenz, J-T., Sternfels, B. and Willmott, P. (2017). A Roadmap for a Digital Transformation. McKinsey & Company, From URL https://www.mckinsey.com/nl/sitecore/content/mckinsey/clientlink/a-roadmap-for-a-digital-transformationn

Cattell, R. B. (1966). The Scree test for the number of factors. *Multivariate behavioral research*, *1*(2), 245-276.

Cavana, R. Y., Delahaye, B. L., & Sekaran, U. (2001). *Applied business research: Qualitative and quantitative methods*. John Wiley & Sons Australia.

Chakrabarti, A., Vidal, E., and Mitchell, W. (2011). Business transformation in heterogeneous environments: The impact of market development and firm strength on retrenchment and growth reconfiguration. *Global Strategy Journal* 1(1-2):6-26.

Chang, S. J. (1996). An evolutionary perspective on diversification and corporate restructuring: entry, exit, and economic performance during 1981–89. *Strategic Management Journal* 17(8):587–611.

Chang, S. J. (2004). Venture capital financing, strategic alliances, and the initial public offerings of Internet startups. *Journal of Business Venturing*, *19*(5), 721-741.

Chang, J., Bai, X., & Li, J. J. (2015). The influence of leadership on product and process innovations in China: The contingent role of knowledge acquisition capability. *Industrial marketing management*, *50*, 18-29.

Chaston, I., & Scott, G. J. (2012). Entrepreneurship and open innovation in an emerging economy. *Management Decision*, 50(7), 1161–1177.

Chatterjee, P. (2004). Interfirm alliances in online retailing. *Journal of Business Research*, *57*(7), 714-723.

Chen, E. T. (2017). The Internet of Things: Opportunities, Issues, and Challenges. *The Internet of Things in the Modern Business Environment* (pp. 167-187). IGI Global.

Chen, H. H., Lee, P. Y., & Lay, T. J. (2009). Drivers of dynamic learning and dynamic competitive capabilities in international strategic alliances. *Journal of Business Research*, *62*(12), 1289-1295.

Chen, C. W., & Lien, N. H. (2013). Technological opportunism and firm performance: Moderating contexts. *Journal of Business Research*, *66*(11), 2218-2225.

Chen, K. H., Wang, C. H., Huang, S. Z., & Shen, G. C. (2016). Service innovation and new product performance: The influence of market-linking capabilities and market turbulence. *International Journal of Production Economics*, *172*, 54-64.

Chen, Y., Wang, Y., Nevo, S., Benitez-Amado, J., & Kou, G. (2015). IT capabilities and product innovation performance: The roles of corporate entrepreneurship and competitive intensity. *Information & Management*, *52*(6), 643-657.

Cheng, C. C., & Chen, J. S. (2013). Breakthrough innovation: the roles of dynamic innovation capabilities and open innovation activities. *Journal of Business & Industrial Marketing*, *28*(5), 444-454.

Chesbrough, H. (2003). Open innovation.

Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & leadership*, *35*(6), 12-17.

Chesbrough, H. (2010). Business model innovation: opportunities and barriers. *Long range planning*, *43*(2-3), 354-363.

Chesbrough, H., Rosenbloom, RS. (2002). The Role of Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-offs Companies*, Industrial and Corporate Change*, Volume 11, Issue 3, 1 June 2002, Pages 529–555.

Chesbrough, H., and Teece, D. (2002). Organizing for Innovation: When is Virtual Virtuous? (HBR Classic), *Harvard Business Review*, August, pp. 127-134.

Chirico, F., & Nordqvist, M. (2010). Dynamic capabilities and trans-generational value creation in family firms: The role of organizational culture. *International Small Business Journal*, *28*(5), 487-504.

Christensen, C. (1997). The Innovator's Dilemma: When New Technologies Cause Great Forms to Fall. Boston, MA: *Harvard Business School Press*, 1997.

Chui, M., Ganesan, V., & Patel, M. (2017). Taking the pulse of enterprise IoT. *McKinsey & Com*.

Church, A. H. (1993). Estimating the effect of incentives on mail survey response rates: A meta-analysis. Public Opinion Quarterly, 57, 62-79.

Churchill, G. A., Brown, T. J., & Suter, T. A. (2001). Basic marketing research.

Churchill, G. A., & Iacobucci, D. (2002). Marketing research 8th ed. *Florida: Harcourt College Publishers*.

Clausen, J., Göll, E., & Tappeser, V. (2017). Sticky Transformation–How path dependencies in socio-technical regimes are impeding the transformation to a Green Economy. *Journal of Innovation Management*, *5*(2), 111-138.

Clemons, E. K., Dewan, R. M., Kauffman, R. J., & Weber, T. A. (2017). Understanding the information-based transformation of strategy and society. *Journal of Management Information Systems*, *34*(2), 425-456.

Coakes, S. J., Steed, L. G. (2003). Multiple response and multiple dichotomy analysis. *SPSS: analysis without anguish: Version 11.0 for Windows*, 215-224.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective of learning and innovation. *Administrative Science Quarterly*, 35: 128-152.

Cohen, L., Manion, L., & Morrison, K. (2000). Action research. *Research methods in education*, *5*, 226-244.

Colbert, A., Yee, N., & George, G. (2016). The digital workforce and the workplace of the future.

Collis, DJ. (1994). Research note: how valuable are organizational capabilities? *Strategic Management Journal*, Winter Special Issue 15: 143-152.

Collins, D. (2003). Pretesting survey instruments: an overview of cognitive methods. *Quality of life research*, *12*(3), 229-238.

Combe, I. A., Rudd, J. M., Leeflang, P. S., & Greenley, G. E. (2012). Antecedents to strategic flexibility: Management cognition, firm resources and strategic options. *European Journal of Marketing*, *46*(10), 1320-1339.

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, *78*(1), 98.

Covin, J. G., & Slevin, D. P. (1989). Strategic management of small firms in hostile and benign environments. *Strategic Management Journal*, *10*(1), 75-87.

Covin, JG., Slevin, DP., Schultz, RL. (1994). Implementing strategic missions: Effective strategic, structural, and tactical choices. *Journal of Management Studies*, 31(4), 481- 503.

Creswell, J. (2003). Research Design: qualitative, quantitative, and mixed methods approaches (2nd ed.). London: Sage.

Cui, A. S., Griffith, D. A., & Cavusgil, S. T. (2005). The influence of competitive intensity and market dynamism on knowledge management capabilities of multinational corporation subsidiaries. *Journal of International Marketing*, *13*(3), 32-53.

Cyert, R. M., & March, J. G. (1963). A behavioral theory of the firm. *Englewood Cliffs, NJ*, *2*, 169-187.

Danneels, E. (2002). The dynamics of product innovation and firm competences. *Strategic Management Journal*, *23*(12), 1095-1121.

Danneels, E. (2011). Trying to become a different type of company: Dynamic capability at Smith Corona. *Strategic Management Journal*, *32*(1), 1-31.

DaSilva, C. M., & Trkman, P. (2014). Business model: What it is and what it is not. *Long range planning*, *47*(6), 379-389.

D'Aveni, RA. (1994). Hypercompetition: Managing the dynamics of strategic maneuvering. New York: Free Press.

D'Aveni, R. A., Dagnino, G. B. and Smith, K. G. (2010). The age of temporary advantage. *Strategic Management Journal*, 31: 1371-1385.

Daniel, E. M., & Wilson, H. N. (2003). The role of dynamic capabilities in e-business transformation. *European Journal of Information Systems*, *12*(4), 282-296.

Datta, S. (2017). Digital Twins. From URL: http://hdl.handle.net/1721.1/107989

Dave, M., Dave, M., & Shishodia, Y. S. (2013). Cloud Computing and Knowledge Management as a service: A collaborative approach to harness and manage the plethora of knowledge. *BVICAM's International Journal of Information Technology*, *5*(2), 619-622.

Davenport, T. H., & Westerman, G. (2018). Why so many high-profile Digital Transformations fail. *Harvard Business Review*, *9*.

Dayan, M. (2010). Managerial trust and NPD team performance: team commitment and longevity as mediators. *Journal of Business & Industrial Marketing*, *25*(2), 94-105.

Deeds, DL., DeCarolis, D., and Coombs, J. (2000). Dynamic capabilities and new product development in high technology ventures: an empirical analysis of new biotechnology firms, *Journal of Business Venturing,* 15 (2000), pp. 211-229.

Denzin, N. K., & Lincoln, Y. S. (2000). Strategies of inquiry. *Handbook of qualitative research*, *2*, 367-378.

Destan, K., Attila, Y., and Cavusgil, T.S. (2006). Alliance Orientation: Conceptualization, Measurement, and Impact on Market Performance. *Journal of the Academy of Marketing* Science, 34 (3), 324-340.

De Vaus, D. (2013). *Surveys in social research*. Routledge.

Diamantopoulos, A., & Schlegelmilch, B. B. (2000). *Taking the fear out of data analysis: a step-by-step approach* (No. 118). Cengage Learning EMEA.

Diamantopoulos, A., Reynolds, N., & Schlegelmilch, B. (1994). Pretesting in questionnaire design: the impact of respondent characteristics on error detection. *Market Research Society. Journal.*, *36*(4), 1-15.

Dijkman, R. M., Sprenkels, B., Peeters, T., & Janssen, A. (2015). Business models for the Internet of Things. *International Journal of Information Management*, *35*(6), 672-678.

Dillman, D. A. (2007). Mail and Internet surveys: the tailored design, 2007 update. *Hoboken: John Wiley*.

Dorner K., Edleman D., Seitz B. (2016). Podcast – Achieving a digital state of mind. McKinsey & Company, February 2016.

Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organization science*, *3*(2), 179-202.

Downes, L., & Nunes, P. (2013). Big bang disruption: A new kind of innovator can wipe out incumbents in a flash. Harvard Business School Publishing.

Dunbrack, L., Ellis, S., Hand, L., Knickle, K., & Turner, V. (2016). IoT and Digital Transformation: A Tale of Four Industries. *IDC White Paper*.

Duncan, R.B. (1976). The ambidextrous organization: Designing dual structures for innovation. In R. H. Kilman, L. R. Pondy D. P. Slevin (Eds.), *The management of organizational design,* (pp. 167–188). New York: North Holland.

Dunn, G. D. (2009). *Statistical evaluation of measurement errors: Design and analysis of reliability studies*. John Wiley & Sons.

Dunsmuir, A., and Williams, L. (1991). *How to do social research*, London: Collins Educational.

Duysters, G., & De Man, A. P. (2003). Transitory alliances: an instrument for surviving turbulent industries? *R&D Management*, *33*(1), 49-58.

Drnevich, P.L., Kriauciunas, A.P. (2011). Clarifying the Conditions and Limits of Ordinary and Dynamic Capabilities to Relative Firm Performance, *Strategic Management Journal*, 32; 254-279).

Easterby-Smith, M. and Prieto, I. (2007). Dynamic capabilities and knowledge management: an integrative role for learning? *British Journal of Management*, Vol. 19, pp. 235-49.

Edmead, M. (2016). Digital Transformation: Why It's Important to Your Organization, CIO. CIO, February 14, 2018 from URL https://www.cio.com/article/3063620/it-strategy/digital-transformation-why-its-important-to-your-organization.html

Eisenhardt, K., & Martin, J. (2000). Dynamic Capabilities: What Are They? *Strategic Management Journal, 21*(10/11), 1105-1121.

Eisenhardt, K. (1989). Building Theories from Case Study Research. *Academy of Management Review*, 14(4): 532-550.

Eisenhardt, K. (1989). Making fast strategic decisions in a high-velocity environments. *Academy of Management Journal*, 32(3): 543-576.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of management journal*, *50*(1), 25-32.

Elahi, M., & Dehdashti, M. (2011, January). Classification of researches and evolving a consolidating typology of management studies. In *Annual Conference on Innovations in Business & Management London, UK*.

Ethiraj, S.K., Krishnan, M.S., Kale, P., and Singh, J.V. (2005). Where Do Capabilities Come from and How Do They Matter? A Study in the Software Service Industry. *Strategic Management Journal*. 26(1), January 2005.

Ettlie, J. E., & Pavlou, P. A. (2006). Technology-based new product development partnerships. *Decision Sciences*, *37*(2), 117-147.

Evans, P.C. & Annunziata. M. (2012). Industrial Internet: Pushing the Boundaries of Minds and Machines. November 2012. From URL http://www.ge.com/docs/chapters/Industrial_Internet.pdf

Felin T., Foss NJ., Heimeriks KH., Madsen TL. (2012). Microfoundations of Routines and Capabilities: Individuals, Processes and Structure. Journal of Management Studies, Volume 49, Issue 8, December 2012, Pages 1351–1374.

Fliess, S., & Becker, U. (2006). Supplier integration—Controlling of co-development processes. *Industrial Marketing Management*, *35*(1), 28-44.

Field, A. (2009). Discovering Statistics Using SPSS: Introducing Statistical Method (3rd ed.). Thousand Oaks, CA: Sage Publications.

Filipescu, D. A., Prashantham, S., Rialp, A., & Rialp, J. (2013). Technological innovation and exports: Unpacking their reciprocal causality. *Journal of International Marketing*, *21*(1), 23-38.

Finkelstein, S., Hambrick, D. C., & Cannella, A. A. (2009). *Strategic leadership: Theory and research on executives, top management teams, and boards*. Strategic Management (Oxford U.).

Folger, J. P., Hewes, D. E., & Poole, M. S. (1984). Coding social interaction. In *Progress in the communication sciences*. Ablex.

Fox-Wolfgramm, S., Boal, K., & Hunt JG. (1998). Organizational Adaptation to Institutional Change: A Comparative Study of First-Order Change in Prospector and Defender Banks. *Administrative Science Quarterly*, 43(1), 87-126.

Gajendran, T., Brewer, G., Gudergan, S., & Sankaran, S. (2014). Deconstructing dynamic capabilities: the role of cognitive and organizational routines in the innovation process. *Construction Management and Economics*, *32*(3), 246-261.

Gandhi, P., Khanna, S., & Ramaswamy, S. (2016). Which industries are the most digital (and why). *Harvard Business Review*, *1*.

Gao, T., & Tian, Y. (2014). Mechanism of supply chain coordination based on dynamic capability framework-the mediating role of manufacturing capabilities. *Journal of industrial engineering and management*, *7*(5), 1250-1267.

García-Morales, V. J., Jiménez-Barrionuevo, M. M., & Gutiérrez-Gutiérrez, L. (2012). Transformational leadership influence on organizational performance through organizational learning and innovation. *Journal of Business Research*, *65*(7), 1040-1050.

Garton, L., Haythornthwaite, C., & Wellman, B. (1999). Studying on-line social networks. *Doing Internet research: Critical issues and methods for examining the Net*, *75*.

Garrett, R.P., Covin, J.G., and Slevin, D.P. (2009). Market responsiveness, top management risk taking, and the role of strategic learning as determinants of market pioneering. *Journal of Business Research*, 62(8):782-788.

Gatignon, H., & Xuereb, J. M. (1997). Strategic orientation of the firm and new product performance. *Journal of Marketing research*, 77-90.

Gawer, A., & Cusumano, M. A. (2008). Platform Leaders. *MIT Sloan management review*.

Gebauer, H., Friedli, T., & Fleisch, E. (2006). Success factors for achieving high service revenues in manufacturing companies. *Benchmarking: An International Journal*, *13*(3), 374-386.

Gersick, C. J. (1991). Revolutionary change theories: A multilevel exploration of the punctuated equilibrium paradigm. *Academy of Management Review*, *16*(1), 10-36.

Geissbauer,R., Kuge,S., Schrauf,S. and Koch,V. (2015). Industry 4.0: Opportunities and challenges of the Industrial Internet in Strategy [Online], From URL http://www.strategyand.pwc.com/reports/industry-4-0

Glaessgen, E. H.; Stargel, D. S. (2012). The Digital Twin Paradigm for Future NASA and U.S. Air Force Vehicles. In 53rd Struct. Dyn. Mater. Conf. S

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*.

Gibson, C. B., & Birkinshaw, J. (2004). The antecedents, consequences and mediating role of organizational ambidexterity. *Academy of Management Journal*, 47: 209-226.

Gibbs, G. R. (2008). Analyzing qualitative data. Sage.

Gilbert, C. G. (2005). Unbundling the structure of inertia: Resource versus routine rigidity. *Academy of Management Journal*, *48*(5), 741-763.

Gnizy, I., E. Baker, W., & Grinstein, A. (2014). Proactive learning culture: A dynamic capability and key success factor for SMEs entering foreign markets. *International Marketing Review*, *31*(5), 477-505.

Goldstone, J. A. (1998). Initial conditions, general laws, path dependence, and explanation in historical sociology. *American journal of sociology*, *104*(3), 829-845.

Golden, P. A., & Dollinger, M. (1993). Cooperative alliances and competitive strategies in small manufacturing firms. *Entrepreneurship theory and practice*, *17*(4), 43-56.

González-Benito, Ó., González-Benito, J., and Muñoz-Gallego, P. A. (2014). On the Consequences of Market Orientation across Varied Environmental Dynamism and Competitive Intensity Levels. *Journal of Small Business Management*, 52: 1-21.

Gorsuch, R. L. (1997). Exploratory factor analysis: Its role in item analysis. *Journal of personality assessment*, *68*(3), 532-560.

Gordon, W., & Langmaid, R. (1988). *Qualitative market research: a practitioner's and buyer's guide*. Routledge.

Govindarajan, V., & Immelt, J. R. (2019). The Only Way Manufacturers Can Survive. *MIT Sloan Management Review*, *60*(3), 24-33.

Gulati, R., Dialdin, D. A., & Wang, L. (2002). Organizational networks. *The Blackwell companion to organizations*, 281-303

Gurate J.M. Barrios E.B. (2007). Estimation Under Purposive Sampling. Communication in Statistics – Simulation and Computation, volume 35, 2006 – Issue 2.

Grant, R. M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization science*, *7*(4), 375-387.

Grieves, M., & Vickers, J. (2017). Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems. 85-113. 10.1007/978-3-319-38756-7_4.

Griffin, A. (1997). PDMA research on new product development practices: Updating trends and benchmarking best practices. *Journal of Product Innovation Management: An International Publication of the Product Development & Management*, 14(6), 429-458.

Griffis, S. E., Goldsby, T. J., & Cooper, M. (2003). Web-based and mail surveys: a comparison of response, data, and cost. *Journal of Business Logistics*, *24*(2), 237-258.

Griffith, D. A., Noble, S. M., & Chen, Q. (2006). The performance implications of entrepreneurial proclivity: A dynamic capabilities approach. *Journal of Retailing*, *82*(1), 51-62.

Grönlund, J., Sjödin, D. R., & Frishammar, J. (2010). Open innovation and the stage-gate process: A revised model for new product development. *California management review*, *52*(3), 106-131.

Groves, R. M. (2011). Three eras of survey research. Public Opinion Quarterly, 75(5), 861-871.

Gruman, G. (2016). What digital transformation really means. *InfoWorld*.

Haag, S., & Anderl, R. (2018). Digital twin–Proof of concept. *Manufacturing Letters*, *15*, 64-66.

Hagedoorn, J., & Duysters, G. (2002). External sources of innovative capabilities: the preferences for strategic alliances or mergers and acquisitions. *Journal of management studies*, *39*(2), 167-188.

Haffke, I., Kalgovas, B. J., & Benlian, A. (2016). The Role of the CIO and the CDO in an Organization's Digital Transformation.

Haleblian, J., & Finkelstein, S. (1993). Top management team size, CEO dominance, and firm performance: The moderating roles of environmental turbulence and discretion. *Academy of Management journal*, *36*(4), 844-863.

Hair, J. F. (2010). Black, WC, Babin, BJ, & Anderson, RE (2010). *Multivariate data analysis*, *7*.

Hair, J. F., Celsi, M., Ortinau, D. J., & Bush, R. P. (2008). *Essentials of marketing research*. New York, NY: McGraw-Hill/Higher Education.

Hambrick, D. C., Geletkanycz, M. A., & Fredrickson, J. W. (1993). Top executive commitment to the status quo: Some tests of its determinants. *Strategic Management Journal*, *14*(6), 401-418.

Han, J. K., Kim, N., & Srivastava, R. K. (1998). Market orientation and organizational performance: is innovation a missing link? *The Journal of Marketing*, 30-45.

Hardaker, G., Ahmed, P. K., & Graham, G. (1998). An integrated response towards the pursuit of fast time to market of NPD in European manufacturing organizations. *European Business Review*, *98*(3), 172-177.

Hartman, B., King, W.P., & Narayanan, S. (2015). Digital Manufacturing – The revolution will be virtualized. From URL https://www.mckinsey.com/business-functions/operations/our-insights/digital-manufacturing-the-revolution-will-be-virtualized

Hedberg, T., Lubell, J., Fischer, L., Maggiano, L., & Feeney, A. B. (2016). Testing the Digital Thread in support of model-based manufacturing and inspection. *Journal of computing and information science in engineering*, *16*(2), 021001.

Helfat, C. E. (1997). Know-how and asset complementarity and dynamic capability accumulation: the case of R&D. *Strategic Management Journal*, *18*(5), 339-360.

Helfat, C., and Peteraf. MA., (2003), The dynamic resource-based view – Capability lifecycles, *Strategic Management Journal*, 24:997-1010(2003).

Helfat, C., and Peteraf. MA., (2009), Understanding dynamic capabilities: progress along a development path.

Helfat CE, and Peteraf MA. 2014. Managerial cognitive capabilities and the microfoundations of dynamic capabilities. Strategic Management Journal (Early View) 1–20.

Helfat, C.E. and Peteraf, M. A. (2015), Managerial cognitive capabilities and the microfoundations of dynamic capabilities. *Strategic Management Journal*, 36: 831-850.

Helfat, C.E., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D. J., Winter, S.G. (2007). Dynamic capabilities – understanding strategic change in organizations – Blackwell publishing, 2007.

Helfat, C. E., & Martin, J. A. (2015). Dynamic managerial capabilities: Review and assessment of managerial impact on strategic change. *Journal of management*, *41*(5), 1281-1312.

Helfat, C. E., & Raubitschek, R. S. (2018). Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. *Research Policy*, *47*(8), 1391-1399.
Helfat, C.E. and Winter SG. (2011). Untangling dynamic and operational capabilities: strategy for the (n) ever-changing world. *Strategic Management Journal* 32(11): 1243-1250.

Heimeriks, K. H., & Schreiner, M. (2010). Relational quality, alliance capability, and alliance performance: An integrated framework. In *Enhancing Competences for Competitive Advantage* (pp. 145-171). Emerald Group Publishing Limited.

Helu, M.M., Hedberg, T.D., and Feeney, A.B. (2017). Reference architecture to integrate heterogeneous manufacturing systems for the digital thread, NIST publications, May 22, 2017 from URL https://www.nist.gov/publications/reference-architecture-integrate-heterogeneous-manufacturing-systems-digital-thread.

Henderson, J. C., & Venkatraman, N. (1992). Strategic alignment: a model for organizational transformation through information technology. *Transforming organizations*, 97-116.

Heskett James, L. (1977). The Coming of the New Organization. *Harvard Business Review*, *55*(6), 85-96.

Hess, T., Matt, C., Benlian, A., & Wiesböck, F. (2016). Options for formulating a digital transformation strategy. *MIS Quarterly Executive*, *15*(2).

Hirst, P. (2018). How Can Organizations Succeed in Digital Transformation When One in Five Execs Think It's a Waste of Time? IEEE USA Insight. From URL: https://insight.ieeeusa.org/articles/how-can-organizations-succeed-digital-transformation/

Hornsby, J. S., Kuratko, D. F., & Zahra, S. A. (2002). Middle managers' perception of the internal environment for corporate entrepreneurship: assessing a measurement scale. *Journal of business Venturing*, *17*(3), 253-273.

Hou, J., & Neely, A. (2013). Barriers of servitization: Results of a systematic literature review. *Frameworks and Analysis*, *189.*

Hox, J. J., & De Leeuw, E. D. (1994). A comparison of nonresponse in mail, telephone, and face-to-face surveys. *Quality and Quantity*, *28*(4), 329-344.

Huang, P. Y., Ouyang, T. H., Pan, S. L., & Chou, T. C. (2012). The role of IT in achieving operational agility: A case study of Haier, China. *International Journal of Information Management*, *32*(3), 294-298.

Hudson, J. M., & Bruckman, A. (2004). "Go away": participant objections to being studied and the ethics of chatroom research. *The Information Society*, *20*(2), 127-139.

Hufnagel, E. M., & Conca, C. (1994). User response data: The potential for errors and biases. *Information Systems Research*, *5*(1), 48-73.

Hui, G. (2014). How the Internet of Things changes business models. *Harvard Business Review*, July 2014.

Hwang. J., and Christensen, C. (2008). Disruptive Innovation in Health Care Delivery: A Framework For Business-Model Innovation. Health Affairs 2008 27:5, 1329-1335.

Ireland, R. D., Hitt, M. A., & Vaidyanath, D. (2002). Alliance management as a source of competitive advantage. *Journal of management*, *28*(3), 413-446.

Ismail, N. (2017). IoT the top priority in driving digital transformation. Information Age, From URL: https://www.information-age.com/iot-top-priority-driving-digital-transformation-123466916/.

Jackson, J. E. (2005). *A user's guide to principal components* (Vol. 587). John Wiley & Sons.

Jansen, J.J.P, Tempelaar, M.P, van den Bosch, F.A.J, & Volberda, H.W. (2009). Structural differentiation and ambidexterity: The mediating role of integration mechanisms. Organization Science, 20(4), 797–811.

Jaworski, B. J. and Kohli, A.K. (1993). Market Orientation: Antecedents and Consequences. *Journal of Marketing*, 57(3), pp. 53–70.

Jeschke, S., Brecher, C., Somg, H., Rawat, D.B. (2017). Industrial Internet of Things, Cybermanufacturing Systems, Springer Series in Wireless Technology.

Jiao, H., Alon, I., Cui, Y. (2011). Environmental dynamism, innovation, and dynamic capabilities: the case of China, *Journal of Enterprising Communities: People and Places in the Global Economy*, Vol. 5 Issue: 2, pp.131-144.

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinvesting Your Business Model, w HBR's Must-Reads on Strategy,". *Harvard Business Review", December*.

Johnson, W. H., & Filippini, R. (2013). Integration capabilities as mediator of product development practices–performance. *Journal of Engineering and Technology Management*, *30*(1), 95-111.

Johnson, W. H., & Luo, C. (2008). NPD project timeliness: the project-level impact of early engineering effort and customer involvement. *International Journal of Product Development*, *6*(2), 160-176.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, 1(2): 112-133.

Kaganer, E. (2016). Webinar “Fostering digital mindset to transform your business”. IESE Business School, University of Navarra, Spain.

Kaganer, E., Sieber, S., and Zamora, J. (2014). The 5 keys to a Digital Mindset. IESE. From URL: http://www.forbes.com/sites/iese/2014/03/11/the-5-keys-to-a-digital-mindset/2/#47c6c5e94f5f

Kale, P., & Singh, H. (1999, August). Alliance Capability & Success: A Knowledge-Based Approach. In *Academy of management proceedings* (Vol. 1999, No. 1, pp. O1-O6). Briarcliff Manor, NY 10510: Academy of Management.

Kale, P., & Singh, H. (2007). Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. *Strategic Management Journal*, *28*(10), 981-1000.

Kale, P., Singh, H., & Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic Management Journal*, *21*(3), 217-237.

Kale, P., Dyer, J. H., & Singh, H. (2002). Alliance capability, stock market response, and long-term alliance success: the role of the alliance function. *Strategic Management Journal*, *23*(8), 747-767.

Kandemir, D., Yaprak, A., & Cavusgil, S. T. (2006). Alliance orientation: conceptualization, measurement, and impact on market performance. *Journal of the Academy of Marketing Science*, *34*(3), 324-340.

Kane, G.C., Palmer, D., Phillips, A.N., Kiron, D., and Buckley, N. (2015), Strategy, Not Technology, Drives Digital Transformation, *MIT Sloan Management Review*, July, 2015.

Karim, S. (2006). Modularity in organizational structure: The reconfiguration of internally developed and acquired business units. *Strategic Management Journal* 27(9): 799–823.

Karim, S. (2009). Business unit reorganization and innovation in new product markets. *Management Science* 55(7): 1237–1254.

Karim, S. and Capron, L. (2016). Reconfiguration: Adding, redeploying, recombining and divesting resources and business units, *Strategic Management Journal*, 37: E54-E62.

Karim, S., & Kaul, A. (2015). Structural recombination and innovation: Unlocking intraorganizational knowledge synergy through structural change. *Organization Science*, *26*(2), 439-455.

Karim, S. and Mitchell, W. (2000). Path-dependent and path-breaking change: Reorganizing business resources following acquisitions in the U.S. medical sector, 1978–1995. *Strategic Management Journal* 21(10–11) 1061–1081.

Karna, A., Richter, A., and Riesenkampff, E. (2016). Revisiting the role of the environment in the capabilities–financial performance relationship: A meta-analysis. Strategic Management Journal, 37: 1154–1173.

Kauppila, O. P. (2015). Alliance management capability and firm performance: Using resource-based theory to look inside the process black box. *Long Range Planning*, *48*(3), 151-167.

Kaynak, H., & Hartley, J. L. (2008). A replication and extension of quality management into the supply chain. *Journal of Operations Management*, *26*(4), 468-489.

Kazdin, A. E. (1992). *Methodological issues & strategies in clinical research*. American Psychological Association.

Kazdin, A. E. (2003). Research design in clinical psychology.

Keeter, S., Christian, L. M., Dimock, M., & Gewurz, D. (2012). Nonresponse and the Validity of Estimates from National Telephone Surveys. In *Paper presentado en la conferencia anual de la American Association for Public Opinion Research*.

Keane, P. (2018). Digital Twins: Where Are We Now? Engineering.com, From URL https://www.engineering.com/DesignSoftware/DesignSoftwareArticles/ArticleID/16772/Digital-Twins-Where-Are-We-Now.aspx

Kemery, E. R., & Dunlap, W. P. (1986). Partialling factor scores does not control method variance: A reply to Podsakoff and Todor. *Journal of Management*, *12*(4), 525-530.

Kinnear, T. 1991. *Marketing Research, An Applied Approach. Mc. Graw Hill, New York.*

Kinnunen, R.-E., & Turunen, T. (2012). Identifying Servitization Capabilities of Manufacturers: A Conceptual Model. *The Journal of Applied Management and Entrepreneurship*, 2012 (Vol. 17, No. 3), pp. 55 - 78.

Kiron, D., Kane, G. C., Palmer, D., Phillips, A. N., & Buckley, N. (2016). Aligning the organization for its digital future. *MIT Sloan Management Review*, *58*(1).

Köffer, S. (2015). Designing the digital workplace of the future–what scholars recommend to practitioners.

Kortmann, S., Gelhard, C., Zimmermann, C., & Piller, F. T. (2014). Linking strategic flexibility and operational efficiency: The mediating role of ambidextrous operational capabilities. *Journal of Operations Management*, *32*(7-8), 475-490.

Koryak, O., Lockett, A., Hayton, J., Nicolaou, N., & Mole, K. (2018). Disentangling the antecedents of ambidexterity: Exploration and exploitation. *Research Policy*, *47*(2), 413-427.

Kosters, M., & Van der Heijden, J. (2015). From mechanism to virtue: Evaluating Nudge theory. *Evaluation*, *21*(3), 276-291.

Krauss, S. E. (2005). Research paradigms and meaning making: A primer. *The qualitative report*, *10*(4), 758-770.

Krishner, B. (2017). Ecosystems: when digital transformation grows up. CIO, from URL: https://www.cio.com/article/3197463/ecosystems-when-digital-transformation-grows-up.html.

Kurti, E., Haftor, D. (2014). The Role of Path Dependence in the Business Model Adaptation. From Traditional to Digital Business Models. *MCIS 2014 Proceedings*, Paper 28.

Laaksonen, O., & Peltoniemi, M. (2018). The essence of dynamic capabilities and their measurement. *International Journal of Management Reviews*, *20*(2), 184-205.

Lasi, H., Fettke, P., Kemper, Hans-Georg., Feld, T., & Hoffmann, M. (2014). Industrie 4.0. WIRTSCHAFTSINFORMATIK. 56. 261-264. 10.1007/s11576-014-0424-4.

Lawson, B., & Samson, D. (2001). Developing innovation capability in organizations: a dynamic capabilities approach. *International Journal of Innovation Management*, *5*(03), 377-400.

Lavie, D., & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, *49*(4), 797-818.

Lee, C. Y. (2010). A theory of firm growth: Learning capability, knowledge threshold, and patterns of growth. *Research Policy*, *39*(2), 278-289.

Lee, R. P. (2010). Extending the environment–strategy–performance framework: The roles of multinational corporation network strength, market responsiveness, and product innovation. *Journal of International Marketing*, *18*(4), 58-73.

Lee, N., & Lings, I. (2008). *Doing business research: A guide to theory and practice*. Sage.

Leinhardt, G., & Leinhardt, S. (1980). Chapter 3: Exploratory data analysis: New tools for the analysis of empirical data. *Review of Research in Education*, *8*(1), 85-157.

Levitt, B., & March, J. G. (1988). Organizational learning. *Annual review of sociology*, *14*(1), 319-338.

Llieva, J., Baron, S. & Healey, N.M. (2002). Online surveys in marketing research: pros and cons. *International Journal of Market Research*, 44, 3, pp. 361–376.

Liao, J., Kickul, J. R., & Ma, H. (2009). Organizational dynamic capability and innovation: An empirical examination of internet firms. *Journal of Small Business Management*, *47*(3), 263-286.

Lightfoot, H., Baines. T., and Smart, P. (2013). The Servitization of Manufacturing: A Systematic Literature Review of Interdependent Trends. *International Journal of Operations & Production Management* 2013; 33:1408–34.

Li, D. Y., & Liu, J. (2014). Dynamic capabilities, environmental dynamism, and competitive advantage: Evidence from China. *Journal of Business Research*, *67*(1), 2793-2799.

Lincoln, S.Y., and Guba, E.G. (1985). Naturalistic Inquiry, Sage Publication.

Lindell, M. K., & Whitney, D. J. (2001). Accounting for common method variance in cross-sectional research designs. *Journal of Applied Psychology*, *86*(1), 114.

Linder, M. & Willander, M. (2017). Circular Business Model Innovation: Inherent Uncertainties, Business Strategy and the Environment, vol. 26, pp.182–196.

Lockett, A., Thompson, S., & Morgenstrn. (2009). The development of the resource-based view of the form: A critical Appraisal. *International Journal of Management Reviews*, Volume 11, Issue 1, pp. 9-28.

Lofland, J., Lofland, L.H. (1995). Developing analysis. *Analyzing Social Setting*, 183-203.

Leber, J. (2012). General Electric Pitches an Industrial Internet. *MIT Technology Review*, November 2012.

Macher, J. T., and Mowery, D. C. (2009). Measuring Dynamic Capabilities: Practices and Performance in Semiconductor Manufacturing. *British Journal of Management*, 20: S41-S62.

Madhok, A., & Osegowitsch, T. (2000). The international biotechnology industry: a dynamic capabilities perspective. *Journal of international business studies*, *31*(2), 325-335.

Mahoney, J. T., & Pandian, J. R. (1992). The resource-based view within the conversation of strategic management. *Strategic Management Journal*, *13*(5), 363-380.

Malhotra, N.K., & Briks, D.F. (2003). Marketing research, an applied approach (2nd European Edittion). London: Prentice Hall, financial times.

Maltz, E., & Kohli, A. K. (2000). Reducing marketing's conflict with other functions: the differential effects of integrating mechanisms. *Journal of the Academy of Marketing Science*, *28*(4), 479.

Marczyk, G., DeMatteo, D., & Festinger, D. (2005). *Essentials of research design and methodology*. John Wiley & Sons Inc.

Masiello, T. (1988). Developing market responsiveness throughout your company. *Industrial Marketing Management*, *17*(2), 85-93.

Matt, C., Hess, T., and Benlian, A. (2015). Digital Transformation Strategies, *Business & Information Systems Engineering*: vol. 57: issue 5, 339-343.

Maxwell, J.A. (2005). Qualitative Research Design – An Interactive Approach, Sage Publication.

McAfee, A., Brynjolfsson, E., Davenport, T. H., Patil, D. J., & Barton, D. (2012). Big data: the management revolution. *Harvard Business Review*, *90*(10), 60-68.

McConnell, J. (2015). The company cultures that help (or hinder) Digital Transformation. *Harvard Business Review*, 1-6.

McGrath, R.G. (2013). The End of Competitive Advantage. *Harvard Business Review Press, Boston, Massachusetts.*

McGrath, R. G., & MacMillan, I. C. (2000). The entrepreneurial mindset: Strategies for continuously creating opportunity in an age of uncertainty (Vol. 284).

McKelvie, A., & Davidsson, P. (2009). From resource base to dynamic capabilities: an investigation of new firms. *British Journal of Management*, *20*, S63-S80.

McNish, J., and Silcoff S. (2015). Losing the Signal, The untold story behind the extraordinary rise and spectacular fall of Blackberry. *Flatiorn Books, New York.*

Mehta, R., & Sivadas, E. (1995). Comparing response rates and response content in mail versus electronic mail surveys. *Market Research Society. Journal.*, *37*(4), 1-12.

Meier, M., Lütkewitte, M., Mellewigt, T., & Decker, C. (2016). How managers can build trust in strategic alliances: a meta-analysis on the central trust-building mechanisms. *Journal of Business Economics*, *86*(3), 229-257.

Menon, A., Bharadwaj, S. G., Adidam, P. T., & Edison, S. W. (1999). Antecedents and consequences of marketing strategy making: a model and a test. *The Journal of Marketing*, 18-40.

Merriam, S.B. (1997). Qualitative Research and Case Study Applications in Education: Revised and Expanded from Case Study Research in Education, Wiley Publication.

Metallo, C., Agrifoglio, R., Schiavone, F., & Mueller, J. (2018). Understanding business model in the Internet of Things industry. *Technological Forecasting and Social Change*, *136*, 298-306.

Miles, M.B., Huberman, M.A, and Saldana, J. (1994). Qualitative data analysis – A Methods Sourcebook, Sage Publication.

Miller, T. D., & Elgard, P. (1998). Defining modules, modularity and modularization. In *Proceedings of the 13th IPS research seminar, Fuglsoe*.

Miller, D., & Friesen, P. H. (1980). Momentum and revolution in organizational adaptation. *Academy of Management Journal*, *23*(4), 591-614.

Miller, D., Hartwick, J. (2002). The problem of solutions: balancing clients and capabilities, *Business Horizons*, No. March/April, pp.3-12.

Mirsch, T., Lehrer, C., & Jung, R. (2016). Channel integration towards omnichannel management: A literature review.

Mithas, S., Tafti, A., & Mitchell, W. (2013). How a Firm's Competitive Environment and Digital Strategic Posture Influence Digital Business Strategy. *Mis Quarterly*, *37*(2).

Moghaddam, K., Bosse, D. A., & Provance, M. (2016). Strategic Alliances of Entrepreneurial Firms: Value Enhancing Then Value Destroying. *Strategic Entrepreneurship Journal*, *10*(2), 153-168.

Moliterno, TP., and Wiersema MF. (2007). Firm performance, rent appropriation, and the strategic resource divestment capability. *Strategic Management Journal* 28(11): 1065–1087.

Morgan, G., & Smircich, L. (1980). The case for qualitative research, *Academy of Management Review*, *5*(4), 491-500.

Moorman, C., & Slotegraaf, R. J. (1999). The contingency value of complementary capabilities in product development. *Journal of Marketing Research*, 239-257.

Morgan, S. L., & Harding, D. J. (2006). Matching estimators of causal effects: Prospects and pitfalls in theory and practice. *Sociological methods & research*, *35*(1), 3-60.

Mu, J., Peng, G., & MacLachlan, D. L. (2009). Effect of risk management strategy on NPD performance. Technovation, 29(3), 170-180.

Muro, M., Liu, S., Whiton, J., & Kulkarni, S. (2017). Digitalization and the American workforce. Brookings India. http://hdl.handle.net/11540/7892.

Mutch, C. (2005). Doing educational research: A practitioner's guide to getting started, NZCER Press.

Muzellec, L., Ronteau, S., & Lambkin, M. (2015). Two-sided Internet platforms: A business model lifecycle perspective. *Industrial Marketing Management*, *45*, 139-150.

Najjar, M. S., & Kettinger, W. J. (2013). Data Monetization: Lessons from a Retailer's Journey. *MIS Quarterly Executive*, *12*(4).

Nassar, A. R., & Reutzel, E. W. (2013). A proposed Digital Thread for additive manufacturing. *Solid Freeform Fabrication*, 19-43.

Nelson, RR., and Winter SG. (1982). The Schumpeterian Trade Off Revisited, *The American Economic Review*, Vol. 72, No. 1, 1982, pp. 114-132.

Neely, A. (2008). Exploring the financial consequences of the servitization of manufacturing. *Operations management research*, *1*(2), 103-118.

Neuman, W.L. (2003). Qualitative and Quantitative Approaches, Allyn and Bacon, 2003.

Nott, G., (2017). Organizational structure for digital transformation: 4 archetypes emerge. CIO. From URL: [https://www.cio.com.au/article/626946/organisational-structures-digital-transformation-4-archetypes-emerge/.](https://www.cio.com.au/article/626946/organisational-structures-digital-transformation-4-archetypes-emerge/)

Nunnaly, J. C. (1967). Psychometric theory (1st ed.). New York: McGraw-Hill.

Nunnally, J. (1978). C. (1978). *Psychometric theory*, *2*.

Olivia, R.L. and Kallenberg, R. (2003). Managing the transition from products to services, *International Journal of Service*, Vol. 14 No. 2, pp. 160-72.

O'Reilly, C. and Tushman, M. (2007). Ambidexterity as a Dynamic Capability: Resolving the Innovator's Dilemma, Research Paper No. 1963, Research Paper Series, Stanford Graduate School of Business, March 2007.

Oppenheim, A. N. (2000). *Questionnaire design, interviewing and attitude measurement*. Bloomsbury Publishing.

Osborne, J. W. (2008). *Best practices in quantitative methods*. Sage.

Palattella, M. R., Dohler, M., Grieco, A., Rizzo, G., Torsner, J., Engel, T., & Ladid, L. (2016). Internet of things in the 5G era: Enablers, architecture, and business models. *IEEE Journal on Selected Areas in Communications*, *34*(3), 510-527.

Parasuraman, A., Grewal, D. and Krishnan, R. (2007). Marketing Research, Second Edition, Houghton Mifflin Company: Boston.

Pavlou, P.A., El Sawy, O.A. (2006). From IT Leveraging Competence to Competitive Advantage in Turbulent Environments: The Case of New Product Development, *Information Systems Research*, vol. 17, No. 3.

Pavlou, PA., El Sawy, Omar A. 2011. Understanding the Elusive Black Box of Dynamic Capability. Decision Sciences, 42(1), 239-273.

Pavlou, P. A., & El Sawy, O. A. (2011). Understanding the elusive black box of dynamic capabilities. *Decision Sciences*, *42*(1), 239-273.

Penrose, E.T. (1959). *The Theory of the Growth of the Firm*. New York: John Wiley.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: A resource-based view, *Strategic Management Journal,* 14(3), pp. 179-191.

Pettigrew, A. (1990). Longitudinal Field Research on change: Theory and Practice. *Organization Science*, 1(3): 267-292.

Penrose ET. (1959). The Theory of the Growth of the Firm. Oxford University Press: New York.

Peteraf, M., Di Stefano, G., Verona, G. (2013). The elephant in the room of dynamic capabilities: Bringing two diverging conversations together. Strat. Mgmt. J., 34: 1389–1410.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879.

Porter, M. E. (1980). Competitive strategy: techniques for analyzing industries and competitors.

Porter, M. E. (1985). Competitive advantage: creating and sustaining superior performance. 1985. *New York: FreePress*, *43*, 214.

Porter, M. E. (2008). The five competitive forces that shape strategy. *Harvard Business Review*, *86*(1), 78-93.

Porter, M., & Heppelmann, J.E. (2014). How smart connected products are transforming competition. *Harvard Business Review*, Nov 2014, pp. 64-88.

Pothukuchi, V., Damanpour, F., Choi, J., Chen, C. C., & Park, S. H. (2002). National and organizational culture differences and international joint venture performance. *Journal of international business studies*, *33*(2), 243-265.

Preece, S. B., Miles, G., & Baetz, M. C. (1999). Explaining the international intensity and global diversity of early-stage technology-based firms. *Journal of Business Venturing*, *14*(3), 259-281.

Podsakoff, P. M., & Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. *Journal of management*, *12*(4), 531-544.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879.

Ponterotto, J. G. (2005). Qualitative research in counseling psychology: A primer on research paradigms and philosophy of science. *Journal of counseling psychology*, *52*(2), 126.

Porter, M.E. (1980). *Competitive Strategy*, New York: Free Press, 1980.

Porter, M.E. (2008). The five competitive forces that shape strategy, Harvard Business Review, 2008.

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, *92*(11), 64-88.

Portogerou, A., Caloghirou, Y., and Lioukas, S. (2008). Dynamic Capabilities and Their Indirect Impact on Firm Performance, Danish Research Unit for Industrial Dynamics, ISBN 978- 87-7873-265-1.

Prem, E. (2015, December). A Digital Transformation business model for innovation. In *ISPIM Innovation Symposium* (p. 1). The International Society for Professional Innovation Management (ISPIM).

Provost, F., & Fawcett, T. (2013). Data science and its relationship to big data and data-driven decision making. *Big data*, *1*(1), 51-59.

Quinn, J. B. (1992). *Intelligent Enterprise: A Knowledge and Service Based Paradigm for Industry*. Simon and Schuster.

Rajagopalan, N., Rasheed, A. M., & Datta, D. K. (1993). Strategic decision processes: Critical review and future directions. *Journal of management*, *19*(2), 349-384.

Raisch, S., & Zimmermann, A. (2017). A process perspective on the Exploration–Exploitation paradox. *The Oxford Handbook of Organizational Paradox*, 315.

Rapley Tim (2004), *Interviews in Qualitative Research Practice*, Seale Clive, Gobo Giampietro, Gubrium F. Jaber and Silverman David (Eds), London: Sage Publications Inc., pp.15-34.

Rathmann, C. (2017). Industrial Internet of Things and Digital Transformation. IoT, Digital Transformation and Role of Enterprise Software. IFS Whitepaper, from URL https://blog.ifsworld.com/.

Rickards, T., Smaje, K., & Sohoni, V. (2015). Transformer in Chief: The New Chief Digital Officer, McKinsey&Company.

Robert, G. (1991). The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation, *California Management Review*, Spring 1991.

Roberts, N., Campbell, D. E., & Vijayasarathy, L. R. (2016). Using information systems to sense opportunities for innovation: Integrating postadoptive use behaviors with the dynamic managerial capability perspective. *Journal of Management Information Systems*, *33*(1), 45-69.

Rindfleisch, A., Malter, A. J., Ganesan, S., & Moorman, C. (2008). Cross-sectional versus longitudinal survey research: Concepts, findings, and guidelines. *Journal of Marketing research*, *45*(3), 261-279.

Ringim, K. J., Razalli, M. R., & Hasnan, N. (2012). Moderating effect of information technology (IT) capability on the relationship between business process reengineering factors and organizational performance of Bank. *African Journal of Business Management*, *6*(16), 5551-5567.

Rothaermel, F. T., & Deeds, D. L. (2004). Exploration and exploitation alliances in biotechnology: A system of new product development. *Strategic Management Journal*, *25*(3), 201-221.

Rothaermel, F. T., & Deeds, D. L. (2006). Alliance type, alliance experience and alliance management capability in high-technology ventures. *Journal of business venturing*, *21*(4), 429-460.

Rothaermel, F. T., & Hess, A. M. (2007). Building dynamic capabilities: Innovation driven by individual-firm and network-level effects. *Organization science*, *18*(6), 898-921.

Roy Morgan Research (1993). *International values audit, 22/23 May*. Melbourne: Roy Morgan Research Centre.

Saebi, T., & Foss, N. J. (2015). Business models for open innovation: Matching heterogeneous open innovation strategies with business model dimensions. *European Management Journal*, *33*(3), 201-213.

Sanchez, R. (1995). Strategic flexibility in product competition. *Strategic Management Journal*, *16*(S1), 135-159.

Sanchez R. (2001). Building Blocks for Strategy Theory: Resources, Dynamic Capabilities and Competences. In Rethinking Strategy. Volberda HW, Elfring T (eds). Sage Publications: London: p. 143-157.

Sambamurthy, V., Bharadwaj, A., & Grover, V. (2003). Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS quarterly*, 237-263.

Sarantakos S. (2005). *Social Research* (3rd ed.). Palgrave Macmillan: Hampshire.

Sargut, G. and McGrath, R.G. (2011), Learning to live with complexity. Harvard Business Review, 89(9): 68-76).

Sarma, S. (2017). Digital Twins, IoT and the Future of Business – An Interview with Sanjay Sarma. Marketingjournal.com, From URL http://www.marketingjournal.org/digital-twins-iot-business-sanjay-sarma/

Schilke, O. (2014). On the contingent value of dynamic capabilities for competitive advantage: The nonlinear moderating effect of environmental dynamism. *Strategic Management Journal*, *35*(2), 179-203.

Schilke, O., & Goerzen, A. (2010). Alliance management capability: an investigation of the construct and its measurement. *Journal of Management*, *36*(5), 1192-1219.

Schroeder, L., Sjoquist, D., & Stephan, P. (1986). Understanding Regression Analysis. An Introductory Guide. Beverly Hills: SAGE.

Schmarzo, B. (2017). *What is Digital Transformation*? From URL: https://www.cio.com/article/3199030/analytics/what-is-digital-transformation.html

Schneider, B., Brief, A. P., & Guzzo, R. A. (1996). Creating a climate and culture for sustainable organizational change. *Organizational dynamics*, *24*(4), 7-19.

Schulze, S. (2003). *Views on the Combination of Quantitative and Qualitative Research Approaches***.** University of South Africa. Progressio 25(2): 8-20.

Schumacher, A., Erol, S., & Sihn, W. (2016). A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. *Procedia CIRP*, *52*, 161-166.

Schmid, A. M., Recker, J., & vom Brocke, J. (2017). The socio-technical dimension of inertia in digital transformations. *50th Hawaii International Conference on System Sciences (HICSS 2017).*

Sexton, M., & Barrett, P. (2003). A literature synthesis of innovation in small construction firms: insights, ambiguities and questions. *Construction Management and Economics*, *21*(6), 613-622.

Sharma, S., & Sharma, S. (1996). Applied multivariate techniques.

Shan, W., Walker, G., & Kogut, B. (1994). Interfirm cooperation and startup innovation in the biotechnology industry. *Strategic Management Journal*, *15*(5), 387-394.

Shavelson, R. J., & Towne, L. (2002). *Scientific research in education*. National Academy Press, 2101 Constitution Avenue NW, Lockbox 285, Washington, DC 20418.

Shepherd, C., & Ahmed, P. K. (2000). From product innovation to solutions innovation: a new paradigm for competitive advantage. *European journal of innovation management*, *3*(2), 100-106.

Shi, X., Li, F., & Bigdeli, A. Z. (2016). An examination of NPD models in the context of business models. *Journal of Business Research*, *69*(7), 2541-2550.

Singer, J. D., Willett, J. B., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. Oxford university press.

Sirmon, D. G., & Hitt, M. A. (2009). Contingencies within dynamic managerial capabilities: Interdependent effects of resource investment and deployment on firm performance. *Strategic Management Journal*, *30*(13), 1375-1394.

Sirmon, DG., Hitt, MA., and Ireland, RD. (2007). Managing Firm Resources in dynamic environments to create value: looking inside the black box. *Academy of Management Review* 32(1):273-292.

Sirmon, DG., Hitt, MA., Arregle, JL., and Campbell, JT. (2010). The dynamic interplay of capability strengths and weaknesses: investigating the base of temporary competitive advantage. *Strategic Management Journal* 31(13).

Slack, N. (2005). Operations strategy: will it ever realize its potential? *Gestão & Produção*, *12*(3), 323-332.

Slater, F.S., Jakki, Mohr, J.J., Sengupta, S. (2014). Radical Product Innovation Capability: Literature Review, Synthesis, and Illustrative Research Propositions, Journal of Product Innovation Management, 31(3):552–566

Smith, W. K., & Tushman, M. L. (2005). Managing strategic contradictions: A top management model for managing innovation streams. *Organization science*, *16*(5), 522-536.

Soh, P. H. (2003). The role of networking alliances in information acquisition and its implications for new product performance. *Journal of business venturing*, *18*(6), 727-744.

Somekh, B., & Lewin, C. (2005). Research methods in the social sciences. Thousand Oaks: Sage.

Song, M., Di Benedetto, C. A., & Nason, R. W. (2007). Capabilities and financial performance: the moderating effect of strategic type. *Journal of the Academy of Marketing Science*, *35*(1), 18-34.

Song, X. M., & Parry, M. E. (1997). A cross-national comparative study of new product development processes: Japan and the United States. *The Journal of Marketing*, 1-18.

Soto-Acosta, P., Popa, S., & Palacios-Marques, D. (2015). E-business, organizational innovation and firm performance in manufacturing SMEs: an empirical study in Spain. Technological and Economic Development of Economy. 22. 1-20. 10.3846/20294913.2015.1074126.

Spector, P. E. (1992). *Summated rating scale construction: An introduction* (No. 82). Sage.

Stanton, J. M. (1998). An empirical assessment of data collection using the Internet. *Personnel Psychology*, *51*(3), 709-725.

Stadler, C., Helfat, CE., and Verona, G. (2013). The impact of Dynamic Capabilities on Resource Access and Development, *Organization Science*, Vo. 24, No. 6, November-December 2013, pp. 1782- 1804).

Stefano, G.D., Peteraf, M., Verona, G. (2010). Dynamic capabilities deconstructed: a bibliographic investigation into the origins, development, and future directions of the research domain. Oxford Journals, *Industrial and Corporate Change,* Volume 19, Issue 4, pp. 1187-1204.

Stonebraker, P. W., & Liao, J. (2004). Environmental turbulence, strategic orientation: Modeling supply chain integration. *International Journal of Operations & Production Management*, *24*(10), 1037-1054.

Sudman, S., & Bradburn, N. M. (1982). Askinq Questions. *San Francisco: Josey-Bass Inc. Publishers*.

Sund, K. J., Bogers, M., Villarroel, J. A., & Foss, N. (2016). Managing tensions between new and existing business models. *MIT Sloan Management Review*, *57*(4), 8.

Sunstein, C., & Thaler, R. (2008). Nudge. *The politics of libertarian paternalism. New Haven*.

Sydow, J., Schreyögg, G., & Koch, J. (2009). Organizational path dependence: Opening the black box. *Academy of Management Review*, *34*(4), 689-709.

Tai, Y. M., & Ku, Y. C. (2016, July). Capabilities Driving Competitive Advantage in New Product Development: Coordination Capability, Absorptive Capability, and Information Technology Capability. In *International Conference on Human-Computer Interaction* (pp. 78-83). Springer, Cham.

Tao, F., Sui, F., Liu, A., & Qi, Q. (2018). Digital twin-driven product design framework. *International Journal of Production Research*. 1-19.

Tao, F., Cheng, J., Qi, Q., Zhang, M., Zhang, H., & Sui, F. (2018). Digital twin-driven product design, manufacturing and service with big data. *The International Journal of Advanced Manufacturing Technology*, *94*(9-12), 3563-3576.

Taylor, A., & Helfat, C. (2009). Organizational Linkages for Surviving Technological Change: Complementary Assets, Middle Management, and Ambidexterity. *Organization Science, 20*(4), 718-739.

Taylor, R. (1990). Interpretation of the correlation coefficient: a basic review. *Journal of diagnostic medical sonography*, *6*(1), 35-39.

Teece, D. J. (1996). Firm organization, industrial structure, and technological innovation'.

Teece, D. J. (2006). Reflections on "profiting from innovation". *Research Policy*, *35*(8), 1131-1146.

Teece, D.J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strat. Mgmt. J., 28: 1319-1350.

Teece, D. J. (2009). *Dynamic capabilities and strategic management: Organizing for innovation and growth*. Oxford University Press on Demand.

Teece, D. J. (2010). Business models, business strategy and innovation. *Long range planning*, *43*(2-3), 172-194.

Teece, D.J. (2012). Dynamic Capabilities: Routines versus Entrepreneurial Action, *Journal of Management Studies*, 49:8 December 2012.

Teece, D.J. (2014). The Foundations of Enterprise Performance: Dynamic and Ordinary Capabilities in an (Economic) Theory of Firms. Academy of Management Perspective, November 1, 2014 vol. 28 no. 4 328-352.

Teece, D.J. and Pisano, G. (1994). The Dynamic Capabilities of Firm: An Introduction. International Institute for Applied Systems Analysis, October 1994

Teece D.J., Pisano, G., Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7): 509-533.

Teece, D.J., Rumelt, R.P., & Schendel, D. (1994). *Funadamental issues in strategy: a research agenda.* Harvard Business School Press, Boston, Mass.

Teece, D., Peteraf, M., & Leih, S. (2016). Dynamic Capabilities and Organizational Agility: Risk, Uncertainty, and Strategy in the Innovation Economy. *California Management Review*, *58*(4), 13–35.

Teubner, R. A. (2013). Information systems strategy. *Business & Information Systems Engineering*, *5*(4), 243-257.

Thompson, E. P. (1967). Time, work-discipline, and industrial capitalism. *Past & present*, (38), 56-97.

Thompson, L. F., Surface, E. A., Martin, D. L., & Sanders, M. G. (2003). From paper to pixels: Moving personnel surveys to the Web. *Personnel Psychology*, *56*(1), 197-227.

Tilson, D., Lyytinen, K., & Sorensen, C. (2010, January). Desperately seeking the infrastructure in IS research: conceptualization of" digital convergence" as co-evolution of social and technical infrastructures. In *System Sciences (HICSS), 2010 43rd Hawaii International Conference on* (pp. 1-10). IEEE.

Tuegel, E. J., Ingraffea, A. R., Eason, T. G., & Spottswood, S. M. (2011). Reengineering aircraft structural life prediction using a Digital Twin. *International Journal of Aerospace Engineering*, *2011*.

Tuli, F. (1997). The Basis of Distinction Between Qualitative and Quantitative Research in Social Sciences: Reflection on Ontological, Epistemological and Methodological Perspectives, Vol. 6 No 1, September 2010).

Tushman, M. L., & O'Reilly, C. A. (1996). Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review*, 38: 8-30.

Tushman, M. L., & Romanelli, E. (1985). Organizational evolution: A metamorphosis model of convergence and reorientation. *Research in organizational behavior*.

Tracy S.J. (2013). Qualitative Research Methods - Collecting Evidence, Crafting Analysis. Communicating Impact January 2013, ©2013, Wiley-Blackwell.

Tripas, M. (1997) Surviving radical technological change through dynamic capability: evidence from the typesetter industry, Ind. & Corporate Change 6(2), 342-78.

Tsai, K.H., Hsu, T.T. (2014). Cross-Functional Collaboration, Competitive Intensity, Knowledge Integration Mechanisms, and New Product Performance: A Mediated Moderation Model. *Industrial Marketing Management*: 293-303.

Tsai, K. H., & Yang, S. Y. (2013). Firm innovativeness and business performance: The joint moderating effects of market turbulence and competition. *Industrial Marketing Management*, *42*(8), 1279-1294.

Tseng, S. M., & Lee, P. S. (2014). The effect of knowledge management capability and dynamic capability on organizational performance. *Journal of Enterprise Information Management*, *27*(2), 158-179.

Turner., V. (2017). Understanding and Creating Successful IoT Business Models. IDC Perspectives, Doc # US42573917. From URL: https://www.idc.com/getdoc.jsp?containerId=US42573917.

Van de Ven, A. H. (2007). *Engaged scholarship: A guide for organizational and social research*. Oxford University Press on Demand.

Vandermerwe, S., & Rada, J. (1988). Servitization of business: adding value by adding services. *European Management Journal*, *6*(4), 314-324.

Vergne, J. P., & Durand, R. (2011). The path of most persistence: An evolutionary perspective on path dependence and dynamic capabilities. *Organization Studies*, *32*(3), 365-382.

Verona, G., Ravasi, D. (2003). Unbundling dynamic capabilities: an exploratory study of continuous product innovation, *Industrial and Corporate Change*, Volume 12, Issue 3, Pages 577–606.

Vidal, E., Mitchell, W. (2015). Adding by subtracting: The relationship between performance feedback and resource reconfiguration through divestitures, Organization Science, vol. 26, issue 4, 1101-1118

Visnjic, I., Wiengarten, F., & Neely, A. (2016). Only the brave: Product innovation, service business model innovation, and their impact on performance. *Journal of Product Innovation Management*, *33*(1), 36-52.

Voss, G. B., & Voss, Z. G. (2000). Strategic orientation and firm performance in an artistic environment. *Journal of Marketing*, *64*(1), 67-83.

Wang, Y. (2016). Environmental dynamism, trust and dynamic capabilities of family businesses. *International Journal of Entrepreneurial Behavior & Research*, *22*(5), 643-670.

Wang, C. and Ahmed, P. (2007). Dynamic capabilities: a review and research agenda, *International Journal of Management Reviews*, 9, pp. 31–51.

Wang, Y., & Rajagopalan, N. (2015). Alliance Capabilities: Review and Research Agenda. *Journal of Management*, *41*(1), 236–260.

Wang, G., Dou, W., Zhu, W., & Zhou, N. (2015). The effects of firm capabilities on external collaboration and performance: The moderating role of market turbulence. *Journal of Business Research*, *68*(9), 1928-1936.

Wassmer, U., Li, S., & Madhok, A. (2017). Resource ambidexterity through alliance portfolios and firm performance. *Strategic Management Journal*, *38*(2), 384-394.

Wei, Z., Yi, Y., & Guo, H. (2014). Organizational learning ambidexterity, strategic flexibility, and new product development. *Journal of Product Innovation Management*, *31*(4), 832-847.

Weill, P., & Woerner, S. L. (2015). Thriving in an increasingly digital ecosystem. *MIT Sloan Management Review*, *56*(4), 27.

Wernerfelt B. (1959). A Resource-based view of the Firm. Strategic Management Journal, Vol. 5, 171-180 (1984).

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171-180.

West, T.D. & Blackburn, M. (2017). Is Digital Thread/Digital Twin Affordable? A Systematic Assessment of the Cost of the DOD's Latest Manhattan Project. Procedia Computer Science, vol. 114, 47-56.

Westerlund, M., Leminen, S., & Rajahonka, M. (2014). Designing Business Models for the Internet of Things, *Technology Innovation Management Review*, 4(7): 5-14.

Wengraf, T. (2001). *Qualitative research interviewing: Biographic narrative and semi-structured methods*. Sage.

Widaman, K. F. (1993). Common factor analysis versus principal component analysis: Differential bias in representing model parameters? *Multivariate behavioral research*, *28*(3), 263-311.

Wilden, R., & Gudergan, S. P. (2015). The impact of dynamic capabilities on operational marketing and technological capabilities: investigating the role of environmental turbulence. *Journal of the Academy of Marketing Science*, *43*(2), 181-199.

Wilden, R., Devinney, T. M., & Dowling, G. R. (2016). The architecture of dynamic capability research identifying the building blocks of a configurational approach. *The Academy of Management Annals*, *10*(1), 997-1076.

Wilden, R., Gudergan, S. P., Nielsen, B. B., & Lings, I. (2013). Dynamic capabilities and performance: strategy, structure and environment. *Long Range Planning*, *46*(1-2), 72-96.

Williams, L. J., Cote, J. A., & Buckley, M. R. (1989). Lack of method variance in self-reported affect and perceptions at work: reality or artifact? *Journal of Applied Psychology*, *74*(3), 462.

Williamson, O. E. (1975). Markets and hierarchies. *New York*, *2630*.

Winter, S. (2000). The Satisficing Principle in Capability Learning, *Strategic Management Journal*, 21: 981-996.

Winter, S. (2003). Understanding dynamic capabilities, *Strategic Management Journal*, 24, pp. 991–995.

Wise, R. and Baumgartner, P. (1999). Go downstream: the new imperative in manufacturing, *Harvard Business Review*, Vol. 77 No. 5, pp. 133-41.

Witmer, D.F., Colman, R.W., & Katzman, S.L. (1999). From paper-and-pencil to Screen-and-keyboard, in Doing Internet Research, Jones S. (Eds.),145-61. Sage, London.

Woods. D. (2018). How Digital Twins Can Optimize Technology Investments. Forbes.com, From URL https://www.forbes.com/sites/danwoods/2018/07/20/how-digital-twins-can-optimize-technology-investments/#1bb5f8983d23.

Woodhead, R., Stephenson, P., & Morrey, D. (2018). Digital construction: From point solutions to IoT ecosystem. *Automation in Construction*, *93*, 35-46.

World Economic Forum. (WEF, 2018, May). The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution. From URL: http://reports.weforum.org/digital-transformation/wp-content/blogs.dir/94/mp/files/pages/files/dti-executive-summary-20180510.pdf.

Wortmann, F., & Flüchter, K. (2015). Internet of things. *Business & Information Systems Engineering*, *57*(3), 221-224.

Wright, K. B. (2005). Researching Internet-based populations: Advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services. *Journal of Computer-mediated Communication*, *10*(3), JCMC1034.

Wu, L. Y. (2006). Resources, dynamic capabilities and performance in a dynamic environment: perceptions in Taiwanese IT enterprises. *Information & Management*, *43*(4), 447-454.

Wu, L. Y. (2007). Entrepreneurial resources, dynamic capabilities and start-up performance of Taiwan's high-tech firms. *Journal of Business research*, *60*(5), 549-555.

Wu, L. Y. (2010). Applicability of the resource-based and dynamic-capability views under environmental volatility. *Journal of Business Research*, *63*(1), 27-31.

Wu, J., & Pangarkar, N. (2010). The bidirectional relationship between competitive intensity and collaboration: Evidence from China. *Asia Pacific Journal of Management*, *27*(3), 503-522.

Xinchun, HXL., and Haiying, F. (2006). Measuring and Efficiency of Dynamic Capabilities: An Empirical Study in China, Management World, 2006.

Yeager, D. S., Krosnick, J. A., Chang, L., Javitz, H. S., Levendusky, M. S., Simpser, A., & Wang, R. (2011). Comparing the accuracy of RDD telephone surveys and internet surveys conducted with probability and non-probability samples. *Public opinion quarterly*, *75*(4), 709-747.

Yin, R. K. (1981). The case study as a serious research strategy. *Science Communication*, *3*(1), 97-114.

Yin, R. K. (1994). *Case Study Research:* Design and Methods. Beverly Hills: Sage.

Yun, G. W., & Trumbo, C. W. (2000). Comparative response to a survey executed by post, e-mail, & web form. *Journal of Computer-mediated Communication*, *6*(1), JCMC613.

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, *27*(2), 185-203.

Zahra, S. A., Sapienza, H.J., Davidsson. P. (2006). Entrepreneurship and Dynamic Capabilities: A Review, Model and Research Agenda, *Journal of Management Studies*, 43, 4, June, 917-955.

Zhou, K. Z., & Li, C. B. (2010). How strategic orientations influence the building of dynamic capability in emerging economies. *Journal of Business Research*, *63*(3), 224-231.

Zhou, K. Z., & Wu, F. (2010). Technological capability, strategic flexibility, and product innovation. *Strategic Management Journal*, *31*(5), 547-561.

Zhu, K., S. Dong, S. Xin Xu et K. Kraem. (2006). Innovation diffusion in global contexts: determinants of post-adoption Digital Transformation of European companies, *European Journal of Information Systems*, 15, 601–616.

Zimmermann, A., Schmidt, R., Sandkuhl, K., Wißotzki, M., Jugel, D., & Möhring, M. (2015, September). Digital enterprise architecture-transformation for the internet of things. In *Enterprise Distributed Object Computing Workshop (EDOCW), 2015 IEEE 19th International* (pp. 130-138). IEEE.

Zollo, M., & Winter, S.G. (2001). Deliberate learning and the evolution of dynamic capabilities, INSEAD working paper series, 2001/60/SM.

Zollo, M. & Winter, S.G. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. *Organization Science*, 13(3), 339-51.

Zott, C. (2003), Dynamic capabilities and the emergence of intraindustry differential firm performance: insights from a simulation study. *Strategic Management Journal*, 24: 97-125

Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research, *Journal of Management*, May, 2011.

Zott, C., & Amit, R. (2015). Business model innovation: Toward a process perspective. *The Oxford Handbook of Creativity, Innovation, and Entrepreneurship*, 395-405.