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Master's Thesis- master Innovation Sciences

Digitalization in the apparel manufacturing process

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Summary

New digital technologies are constantly transforming our everyday life as well as the business world. Dynamic Capabilities is a key asset of a firm in order to deeply understand and integrate into the new digital era. Having mechanisms to identify and exploit innovation, research and development and analyzing the surrounding environment are important to sense the benefits that new technologies might offer to the company. Furthermore, it is crucial for a firm to redesign its business model, arrange alliances, upgrade and encourage the creative thinking of its employees in order to seize the sensed opportunities. The transformation and reconfiguration of its tangible and intangible assets is the last significant step for a firm to gain a competitive advantage and enhance its performance in the digital era.

The apparel industry is one good example where digital transformation is radically reshaping the way enterprises use technologies to enhance their performance and survive in this fast-changing world. But how Dynamic Capabilities can influence the digital transformation of an apparel firm? The purpose of this research study is to recognize the role of the Dynamic Capabilities in the digital transformation of seven different apparel manufacturing firms in Greece so far. A qualitative case study was applied to provide insight into the implications of the digital transformation in the apparel industry and to examine in depth the role of each aspect of Dynamic Capability and its influence. The data was collected from semi-structured interviews and complemented with secondary data collected from online databases and reports.

The results show that Greek apparel manufacturers have limited awareness of the digital technologies. They have the mechanisms to identify how the new digital era can influence their performance and transform its structures to gain a competitive advantage. Nevertheless, due to the financial situation in Greece, there is a slow pace of this transformation. At the same time other international large-sized firms have already undergone a digital transformation in its manufacturing process having gained the advantages from it.

The current research has some limitations regarding the sample size and case selection. In this research, it is shown that there are indications that large-sized apparel firms have already experienced fully digitalized transformation and have already obtained a competitive advantage. Further research on international apparel firms and medium and large-sized firms will provide a broader insight of how apparel industry is facing the digital transformation and more specific information on the influential role of the Dynamic Capabilities on this transition.

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1. Introduction

In a fast-changing world where technology advancements take place rapidly in almost all sectors of the business life, industries need to be adaptive and innovative in order to sustain and survive. Several experts claim that in the industrial world, a 4th revolution is underway, the so-called "Industry 4.0", a name that the German Government introduced during the Hannover Fair in 2011 (Ustundag & Cevikcan 2018). "Industry 4.0" targets to push the digital manufacturing ahead by expanding digitalization and "the interconnection of products, value chains, and business models" (European Commission 2017, p.3). More specifically, it aims to change established factories into smart, connected and autonomous plants (Kiel, Arnold, et al. 2017). Furthermore, the implementation of "sensors, RFID chips, 'cyber-physical' systems and the Internet of Things (IoT) are transforming manufacturing and services across the entire supply chain" (Smit et al. 2016, p.23). Cloud, Big Data, robotics, virtualization, smart devices, additive manufacturing (i.e. 3D printers) are some of the several smart technologies that are connected with the IoT and are applied in various fields on the manufacturing process (Kang et al. 2016; Smit et al. 2016).

Industry 4.0 contains the evolving technological developments to upgrade industries to overcome some of the challenges that manufacturers are facing; from global competition to environmental pollution and working conditions (Wang et al. 2016, p.2; Müller et al. 2018). Considering the ecological perspective, there are concerns about the climate warnings and the environmental pollution (Wang et al. 2016). The central target of the Industry 4.0 is the decrease in waste, resources and energy consumption (Kiel, Müller, et al. 2017). The contribution of Industry 4.0 in the manufacturing, facilitates the decrease in greenhouse gas emissions by providing data-center carbon footprint examines (Kiel, Müller, et al. 2017). Furthermore, wrong deliveries, waiting time and faulty products can be minimized with the implementation of smart technologies and therefore, reducing resource and energy consumption (Kiel, Müller, et al. 2017). In addition, digitalization results in the relocation of the manufacturing process "closer to where products and production equipment are purchased", this phenomenon is known as "reshoring", which influences the reduction of the transportation distances and thus minimizes the environmental pollution (Kiel, Müller, et al. 2017, p.6).

Manufacturing companies are using technology that aims the shifting from mass production to mass customization production (Newman 2017). The tendency of mass customization has given the advantage to producers to more capably respond to consumer demand (Newman 2017). Therefore, the social advantages of the implementation of digitalization are targeting at improving peoples' life standards by providing high quality customized products and a better working environment (Wang et al. 2016). In addition, some of the benefits for employees are to improve human learning through intelligent assistance systems and to increase employees' motivation and satisfaction (Müller et al. 2018). Moreover, new job profiles arise, maintaining the reduction of manual labor however with increasing IT-skills (Müller et al. 2018).

Taking into consideration the increasing consumers' demands and the globalization of the markets there is a growing need for firms to strengthen their competitive advantage (Wang et al. 2016). Applying digitalization in the manufacturing process enables better monitoring across the processes and therefore, enhancing efficiency, quality, transparency and flexibility (Müller et al. 2018). Moreover, having smart connected products and access to product data, the manufacturer gains competitive advantage through

the capability and the agility to alter and enhance product performance (Porter & Heppelmann 2014). Therefore, manufacturers can gain a competitive advantage by being agile to the continuous and volatile changes in their highly competitive environment and by responding rapidly and efficiently to changing markets; to do so it is important to implement innovative technologies in their production processes (Hallgren & Olhager 2009; Porter & Heppelmann 2014).

The apparel manufacturing is one of the industries that is characterized by labor-intensive factories, a great variety of product designs, a vast production volume, high competitiveness and high demand for product quality (Gereffi & Korzeniewicz 1994). The introduction of the latest technological advancements (3D printers, automation and robotics, advanced transport systems and so on) in the apparel manufacturing will upgrade the industry by providing "information transparency, autonomous control and sustainable manufacturing" (Radziwon et al. 2014, p.1185). This transformation will be crucial for the apparel industry, since today the industry is facing major problems with regard to "market research, monitoring competition, investing in one's own development, making original creation and scientific approach to introducing fashion products in the market" (Colovic 2014a, p.1; Parviainen et al. 2017). The latest technological development benefits the apparel industry by importing new methods and procedures in the manufacturing process and therefore, enhancing efficiency while using new fibers (yarns) and new knitting-weaving process that results to new technical textiles (Colovic 2014b). Moreover, by doing that the industry is approaching the more complex consumer's demands and the fashion trends more efficiently and rapidly (Colovic 2014b). The introduction of digitalization in the apparel industry provides a competitive advantage to the practitioner since it provides flexibility and agility by quickly picking up new fashion trends and rapidly respond to them, minimizing human intervention on the processes, increasing productivity and exploiting resources more efficiently (Porter & Heppelmann 2014; Jayatilake & Withanaarachchi 2016). For instance, the integration of cloud computing in the apparel industry not only facilitates the access to all functions of the manufacturing process anywhere at any time but also promotes the customization of the products and a clear transparency of the whole purchase process (Jayatilake & Withanaarachchi 2016; Suyati 2016).

Previous research on digitalization has highlighted the impact of the transformation towards on the business models of an organization (Teece et al. 2016; Teece & Linden 2017; Richter et al. 2017). Ibarra et al. (2018) proposed four different paths to transform the business model in a way to embrace the digital transformation; from optimizing internal and external processes or advancing customer interface to develop new value networks or an entirely novel business model based on smart technologies. Moreover, there is research on the environmental impacts of digital transformation in manufacturing, especially in the optimization of the resource and energy use through the digital technologies (Gabriel & Pessl 2016). Furthermore, Wang et al.'s (2018) research paper is focused on the implementation of digital technologies in the healthcare industry and on the identification of the organization benefits from formulating more data-driven strategies. Hanelt et al. (2015) explored the digital transformation of primarily physical industries, especially how the digital transformation impacts the business model of firms in the automotive industry. In addition, there is research analyzing the application of digitalized technologies and on digitizing information, but so far there is only little work done on the digital transformation of the manufacturing process in an organization (Parviainen et al. 2017). Thus, the focus of this thesis is on the

digital transformation of the manufacturing process of the apparel industry and the research question is illustrated as follows:

What is the role of Dynamic Capabilities in the digital transformation of the Greek apparel manufacturing?

For this purpose, a qualitative case study will be applied to examine the degree to which digital transformation has occurred in the manufacturing process of the apparel industry. Besides, interviews with people responsible for the production of apparel will be conducted to give a more in-depth analysis on the implementation of those advanced technologies.

Hence, the current paper contributes to research on digitalization by providing first insights on the transformational changes firms in the apparel industry encounter when moving towards a more technologically advanced manufacturing process. In addition, it will give helpful insights into how managers will adapt to the change and what the necessary steps are needed to be taken. Moreover, it will give helpful insights into major challenges and their solutions that firms in the apparel production encounter when undergoing a digital transformation.

The paper is structured as follows: the first section introduces the concept of the Dynamic Capabilities approach based on a literature review. Then, the second section analyzes the basic concepts of digitalization and digital transformation in the manufacturing in the apparel industry. It also examines the interrelationship of Dynamic Capabilities and the digital transformation of the apparel industry. The third section examines the methods that will be used to guide the research. Finally, the fourth section provides the planning of the study.

2. Theoretical background

This thesis analyzes the digital transformation in the production process of the apparel industry. According to Teece (2007), Dynamic Capabilities provide access to resources that a firm needs and facilitate the adaptation to the fast-changing environment. In the manufacturing process, the Dynamic Capabilities characterize the capacity of a firm to generate novel processes and novel products/services that will be rapidly adapted to the changing environment (Sarjana 2015). Digitalization is an ongoing development which is often applied to manufacturing technologies. To achieve effective and better monitoring of the process and rapid/agile adaptation to the changing consumers' needs, manufacturing firms must have the capability to rapidly sense, seize, adapt and transform. For this reason, this thesis examines how Dynamic Capabilities facilitate this transformation.

2.1 Dynamic Capabilities (DC)

The DC concept is defined as the "firm's ability to integrate, build, and reconfigure internal and external resources (including the firm's ordinary capabilities) to address and shape changing business environments" (Teece 2017a, p.3). Teece extended his original definition by stating that DC are forward-looking and are entrenched in the organizational routines which are the grounds of a company's values and culture(Teece 2017a). In addition, DC can be impoverished in the situation where there is a lack of sufficient analysis of competitive openings and vulnerabilities, carelessness, reckless reorganization and other management missteps (Teece 2017b). On the other hand, firms with the ability to adapt their

resources and capabilities will have a better chance of sustaining and developing a competitive advantage that other organizations with poorer DC (Teece 2012).

Teece (2012) investigated the DC concept in a framework consisting of three groups of certain organizational and managerial activities working together to achieve change: "(1) identification and assessment of an opportunity (sensing); (2) mobilization of resources to address an opportunity and to capture value from doing so (seizing); and (3) continued renewal (transforming)" (Teece 2012, p.1396; Yeow et al. 2017). These three DC (sense, seize and transform) have a significant role in overcoming inertia and path dependencies and succeeding in shaping a long-run competitive advantage for a company (Reilly & Tushman 2007). Moreover, DC influence the swift strategic change which leads to a positive influence on firms' performance (Endres 2017). Figure 1 shows the process of the DC chain from the prior paths and positions, which are the former path-dependent routines, resources and strategies to the new formation of them which lead to the acquisition or preservation of a competitive advantage (Teece 2007).
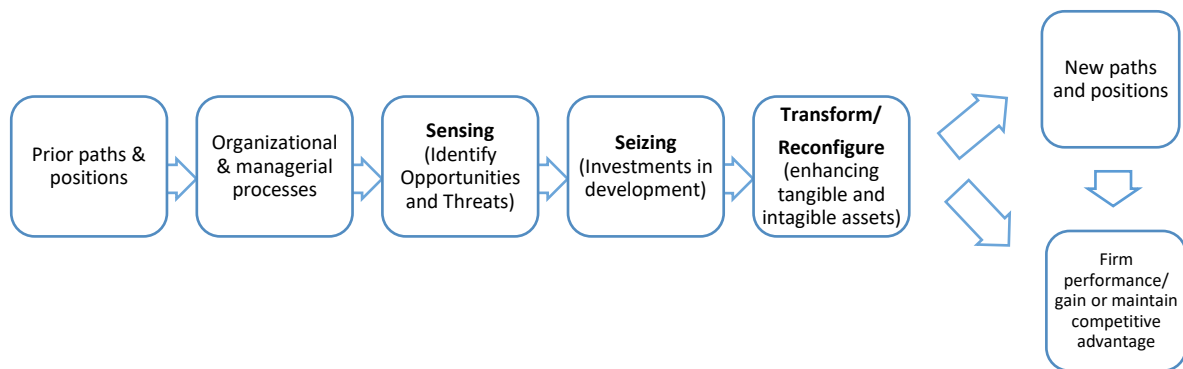
Figure 1 Dynamic Capabilities chain (Teece 2007; Endres 2017)

2.1.1   Sense

It is significant for a firm to have the right mechanism to identify and sense the opportunities and threats in order to gain and sustain competitive advantage (Teece 2007; Endres 2017). "Sensing opportunities and threats require scanning, searching and exploration" (Reilly & Tushman 2007, p.13). For an organization, sensing capability contains "a set of resources and routines such as a strategy-making process associated with variation, resources devoted to competitive intelligence and tracking technological change, and forums for discussions of new opportunities" (Reilly & Tushman 2007, p.13). Overall, sensing is the capability that includes mainly the gathering and interpretation of information with the aim of identifying threats or opportunities (Endres 2017). Organizations should use the sensing capability in their strategy, to sustain or gain competitive advantage (Ahmad et al. 2018). It is evident, that firms need to monitor the market in order to quickly respond and seize the opportunity (Ahmad et al. 2018).

2.1.2   Seize

Seizing capability enable firms to make the right decisions and implement them (Åberg et al. 2017; Reilly & Tushman 2007). In an organization, seizing capability requires managers that can envision and develop strategic decisions, establish the suitable organizational adjustments (exploitation or exploration), allocate complementary assets and decide resource allocations and timing. Consequently, firms will avoid failure in not having a direct response to catching opportunities and mitigating threats (Reilly & Tushman 2007). Firms need to have procedures that will enable them to assess the sensed opportunities and ultimately change the prevailing strategy (Teece 2007). The firm in order to address the sensed opportunities it is essential to change its resource base and create new products, processes or services (Teece 2007; Ahmad et al. 2018). Moreover, "this requires new investments in development and commercialization activity" (Teece 2007, p.1326). According to Teece (2007), a prosperous recognition and estimation of technological and market opportunities, a careful choice of "technologies and product attributes, the design of business models and the commitment of (financial) resources to investment opportunities can lead to company's development" (pp.1334–1335).

2.1.3   Transformation/Reconfiguration

As previously discussed, sensing is needed to identify opportunities and threats, a seizing capability is necessary to capture the sensed opportunities, while transforming/reconfiguration is needed to manage threats (Teece 2007). In addition, transforming includes the ability to improve and change tangible and intangible assets, while market and technologies are in a continuous development (Åberg et al. 2017). As Teece stated it is significant for firms to have the capability to recombine and rearrange the resource base and organizational structures (technologies, processes, knowledge skills, etc.) in order to have a continual beneficial development (Teece 2007; Ahmad et al. 2018; Maijanen & Ritala 2017). Reconfiguration is crucial for the developmental phase of a firm not only to adapt to the fast-changing environment but also to transform the ecosystem of the firm (Teece 2012).

3. Research Context

3.1 Digitalization

The world, so far, has experienced three industrial revolutions, while it is now undergoing the fourth industrial revolution (Lasi et al. 2014). The first industrial revolution took place in Britain at the end of the 18th century with the emergence of mechanization, a procedure that replaced agriculture with industry as the basis of the monetary structure of the society (Sentryo 2017; The Economist 2012). The second industrial revolution took place in the early 20th century, where new technological developments introduced the advent of a new source of energy: electricity, gas, and oil (Sentryo 2017). In addition, the second was characterized by the intensive use of electric power and the mass production of products (Lasi et al. 2014; Schwab 2015). The third industrial revolution happened in the second half of the 20th century with the growth of electronics, telecommunication and computers (Sentryo 2017). This revolution gave rise to the use of electronics and information technology in order to automate the production (Schwab 2015).

Nowadays, a fourth revolution is in progress, based on the advent of the Internet and it is characterized by disrupting almost every industry globally (Sentryo 2017; Schwab 2015). This revolution is the first that

is based on a new technological phenomenon, known as "digitalization" (Sentryo 2017; Lasi et al. 2014). Digitalization is defined as "the use of digital technologies and of data (digitized and natively digitized) in order to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core" (Schallmo & Williams 2018, p.6). There is a misconception in the notion among the definition of digitization and digitalization, in which the former is defined as the conversion from analog to digital and the latter as the essential change that is needed to be made to business operations and business models (Schallmo & Williams 2018). This digital transformation is built upon novel obtained knowledge acquired through "value-added digitization initiatives" (Schallmo & Williams 2018, p.2).

3.2 Digital transformation

"Digital transformation describes the fundamental transformation of the entire business world through the establishment of new technologies based on the internet with a fundamental impact on society as a whole" (Schallmo & Williams 2018, p.10). To achieve digital transformation, it is important not only to implement the advanced technologies into business processes but also to "reshape customer value propositions" and transform the business processes by means of digital technologies for superior customer communication and cooperation (Berman 2012, p.18). The reconfiguration of the customer value propositions can be done on three stages by enhancing, extending and redefining the value of the customer experience (Berman 2012). Organizations, in order to reshape the customer value proposition and transform their operations, should develop a new set of capabilities for agility and quick responsiveness to the fast-changing environment (Berman 2012). A successful digital transformation arises when organizations target to transform their business to exploit the potentials that new technologies offer (Westerman et al. 2011). Scholars have commented that the fourth industrial revolution is bringing a new essential paradigm shift to the industrial production (Savastano et al. 2018).

3.3 Digital transformation in apparel manufacturing

The apparel industry is one of the oldest and largest industries globally (Book et al. 2010). The apparel industry consists of firms that design, produce and retail clothing, footwear and accessories. The growing global competition and the volatile demand variations drive the apparel manufacturers to continuously trying to advance their performance of their production process in order to survive in today's world (Abd Jelil 2018).

The manufacturing of the apparel industry involves several steps. Figure 2 illustrates those steps, starting with the management of the raw materials till dispatching the shipment of the finished garments (Abd Jelil 2018). In addition, the manufacturing process is characterized by three main phases: Pre-production, production and post-production (Abd Jelil 2018; Prasanta 2013). Pre-production process includes the sampling, sourcing and handling of raw materials, while production includes the process of cutting, sewing, washing and checking (Abd Jelil 2018; Prasanta 2013). Last but not least, in the post-production process the procedures of pressing, finishing, packing and dispatching are taking place (Abd Jelil 2018; Prasanta 2013).

Apparel manufacturing starts with the pre-production process which included also the handling of raw fiber. For this purpose, textile firms are accountable for spinning fiber into yarn and then knitting and

weaving so as to make the needed fabric (Kumar 2005). Then, apparel manufacturers are responsible for cutting, value addition (embroidering, printing, fusing, etc.), sewing, checking and finalizing the end product (finishing and Ironing) (Pattanachai 2016; Kumar 2005). This part of the apparel manufacturing process is characterized by high labor intensity (Kumar 2005). The last part of the apparel manufacturing is packing and shipping the finished garments to the end customers (Kumar 2005).
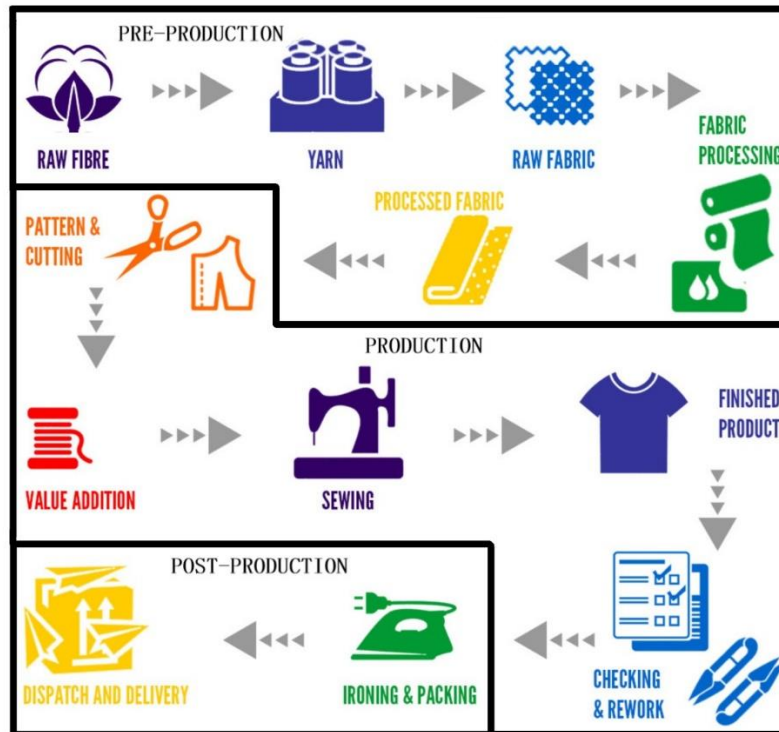
Figure 2 Apparel manufacturing activities (source: (Pattanachai 2016)

The need for the implementation of automated technologies to improve efficiency, product quality and flexibility has raised from the early 1980s (Byrne 2000). Nowadays, the clothing industry is underway the fourth industrial revolution, which transforms the industry into a "customized smart apparel production plant" (Jayatilake & Rupasinghe 2016, p.1). The apparel industry is characterized by short product life cycles, high volatility, high product variation and high manual labor intensity (Walter et al. 2009; Bruce et al. 2004). The implementation of advanced technologies targets at improving productivity, exploiting resources optimally and reducing labor intensity. The nine pillars of Industry 4.0 (see Figure 3) is transforming and optimizing the production line in the apparel industry into a fully digitalized and intelligent one (Vaidya et al. 2018).

Nowadays, the increasingly competitive environment of the apparel companies forced them to engage in new guidelines in order to survive and grow (Bonfanti et al. 2018). Large athletic companies are investing in Big Data technology in order to enable them to develop new fitness products and provide a greater consumer experience (Rindfleisch & Sachdev 2017). Moreover, apparel enterprises targeting in providing tailor-made products and increase the customer involvement in the product creation with the new of the new technologies (Bonfanti et al. 2018). Therefore, they will gain a competitive advantage against firms that target in mass production and cheap fast-fashion. Adidas, Nike and Levi Strauss are some of the

several apparel firms that have digitalized their manufacturing chain and disrupting the apparel manufacturing landscape. They have digitally transformed their processes and achieved to provide a more sustainable, faster and closer to customer experience (Green 2017; Loetscher et al. 2017; Cognizant 2017).

Nine pillars of Industry 4.0

Figure 3 Nine pillars of Industry 4.0 (source: Iscoop 2017)

The implementation of digital technologies by most of the firms who undergo digital transformation lead to the increased application of sensors and devices in the manufacturing process, therefore resulted in a constant and increasing volume of data (Oks et al. 2017). This data consists of large volumes of error lists, activities, history data and so on (Oks et al. 2017). In the apparel industry, *Big Data* is commonly used for "trend forecasting, supply chain management, analyzing customer behavior, preferences and emotions" (Jain et al. 2017, p.2).

Another digital technology which influences the manufacturing process in the apparel industry is *cloud computing*. This technology stimulates the new product development, the adaptabilities in production and supply chain management, and the handling of data analytics to optimize the manufacturing procedure (Oks et al. 2017). In the apparel industry, with cloud computing "production planning, raw material management, costing, processing of the orders, sampling, monitoring the preparation of the order and the final delivery of the products can be accessed anywhere at any time" (Suyati 2016, p.1).

S*imulation* techniques are used in the apparel manufacturing process to prevent crucial production and service failures and optimize the production process (Pazireh et al. 2017). 3D simulations of products and production processes allow workers to examine and optimize the machine settings for the following product in the virtual world before the real one take place in the physical world (Rüßmann et al. 2015). By doing this, the apparel manufacturer saves setup times and enhance the quality of the product and its development (Rüßmann et al. 2015).

Augmented-reality-based systems provide a range of services of the apparel manufacturing process "such as selecting parts in a warehouse and sending repair instructions over mobile devices" (Rüßmann et al. 2015, p.5). In the apparel manufacturing process, augmented reality-based systems can be used to

provide real-time information to the employees in order to enhance decision-making process and improve work procedures (Rüßmann et al. 2015). Moreover, augmented reality can provide virtual training to the workers regarding emergencies and how to interact with machines (Rüßmann et al. 2015).

The strong links between the physical, service and digital world can enhance planning, optimization and operation of manufacturing systems (Landherr et al. 2016). Therefore, the greater availability of data due to cyber-physical systems means that there will be high risks of data loss, hacking and spying (Oks et al. 2017). In addition, due to the increase of connectivity, *cybersecurity* is crucial for the protection of the production lines and an essential tool to ensure secure and reliable communications in the apparel industry (Vaidya et al. 2018).

Industry 4.0 facilitates the horizontal and vertical system integration. Apparel manufacturers can also benefit from the *system integration* since, companies, departments, functions and capabilities are becoming a more interconnected network, "as cross-company, universal data-integration networks evolve and enable truly automated value chains" (Rüßmann et al. 2015, p.6). The implementation of Industry 4.0 leads to an effective collaboration among the consumers, activities, manufacturing and logistics worldwide (Wang et al. 2016).

The *Industrial internet of things (IIoT)* is a network of devices with local intelligence, which is able to interconnect and operate not only with one another but also with centralized controllers (Rüßmann et al. 2015; Kadir 2017). The network of the IIoT contains artificial intelligence, Big Data technology, sensors, automation technologies and machine to machine communication (Kadir 2017). In the apparel manufacturing integrating the interconnected network it makes the production process more agile and controlled (Vaidya et al. 2018).

With the fourth industrial revolution, robots are becoming more independent, flexible and supportive, able to interact with one another and work safely next to humans (Bahrin et al. 2016; Rüßmann et al. 2015). The *autonomous robots* are revolutionizing the clothing manufacturing by increasing production. For instance, the newly automated sewing robot produces 1.146 t-shirts, while a human sewing line produces 669 t-shirts, which is a 71% increase in production with more accurate measurements and an increased in sewing quality (DevicePlus 2018).

Additive Manufacturing (AM) describes the technologies that shape 3D objects by adding layer-upon-layer of any kind of material (Savastano et al. 2018). Therefore, AM offers an agile, fast and flexible way of producing products that enable manufacturers in the apparel industry to gain competitive advantages (Savastano et al. 2018; Ustundag & Cevikcan 2018). Furthermore, *additive manufacturing or 3D printing* is rapidly changing the way clothes are produced and it allows for more customized products (Yap & Yeong 2014).

4. Literature Review

4.1 The interrelationship between Dynamic Capabilities and digital transformation of the manufacturing process in the apparel industry

There are several opportunities resulting from the digital transformation that facilitate the manufacturing process of clothes. A significant advantage of the implementation of digitalized technologies is the improvement on safety and ergonomics of the workplace (Liere-Netheler et al. 2018; Jayatilake & Rupasinghe 2016). Multifaceted and hazardous activities that previously were done by workers are being replaced by robotics making the environment more efficient and safer (Liere-Netheler et al. 2018). In addition, another benefit for the apparel industry is the improvement on the manufacturing process since

the production targets are met faster, more accurately and easier than with the previous methods (Liere-Netheler et al. 2018).

On the other hand, there are risks resulting from digital transformation that might hinder the manufacturing process. Organizational change always brings uncertainty and feelings such as insecurity, stress and anxiety to most of the employees (Bovey & Hede 2001; Neves & Caetano 2006; Weber & Weber 2001). Feelings of insecurity will come to the surface due to the loss of job positions since intelligent robotics and advanced technologies will replace human workers. In this case, the high resistance from employees may cause difficulties in the successful implementation of the advanced technologies (Neves & Caetano 2006; Armenakis & Bedeian 1999; Liere-Netheler et al. 2018).

Therefore, the diffusion of digital technologies has a significant impact on everyday activities, including societal and organizational changes (Newell & Marabelli 2015; Åberg et al. 2017). Digital transformation is changing the way business is done and is causing rapid shifts in the strategic decisions (Åberg et al. 2017). Firms need to know how to manage their resources in order to exploit opportunities and mitigate any hazardous situations that appear from the changes in their competitive environment (Endres 2017).

The Dynamic Capabilities of a firm contribute on managing best their resources and skills in order to exploit the aforementioned opportunities and mitigate risks, such as high resistance from employees, and easily adapt in the fast-changing environment. Figure 4 illustrates how the Dynamic Capabilities of the firm can facilitate the digital transformation of the manufacturing process. It is evident that firms should improve their knowledge base around the digital trends so as to create a new strategy in the digital era and quickly respond to the changing environment. More specifically, the Dynamic Capabilities of a firm in the apparel industry facilitate the adjustment of the new processes and products into the existing system and gain a competitive advantage (Teece 2017b).

Building IT skills in the manufacturing process enhances the sensing and seizing capabilities of a firm. Having those IT skills enable the firm to be flexible to deal with unpredictable and volatile situations that characterize the apparel industry (Anand & Ward 2009; Artschwager et al. 2009; McKinsey 2017). Apparel manufacturers should invest in enhancements of computing and technology capabilities to adapt to the changing environment and opening the way to the adopting of the aforementioned developments (see the section: 3.3) (Paritala et al. 2017).
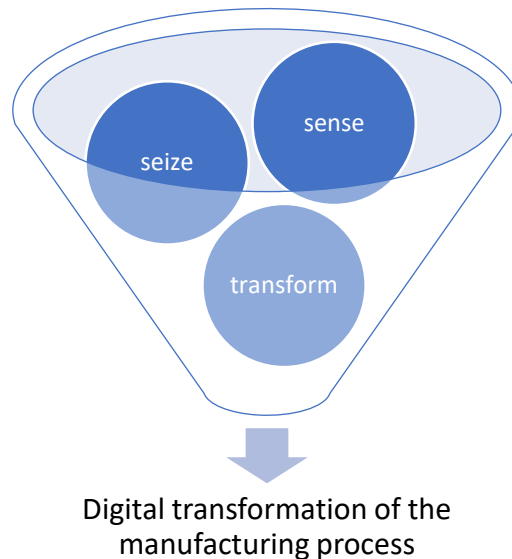
Figure 4 Schematic overview of the interrelationship between Dynamic Capabilities and the digital transformation of the manufacturing process

5. Methodology

This chapter discusses the research methodology. The objectives of the current study are two-fold. The first goal is to identify the extent to which the apparel industry in Greece is undergoing the digital transformation. The second goal is to identify the role of Dynamic Capabilities in the digital transformation, across different firms and different sizes of firms.

5.1 Research Method

5.1.1   Research design

The current study aims at exploring the implications of the digital transformation in the apparel industry. For this purpose, an exploratory qualitative case study will be conducted based on seven clothing firms. All of the firms are based in Greece and are varying from size and market segment (for instance women clothing, sportswear, swimwear, linen and etc.). Two of the firms have not implemented a digital technology in their manufacturing, yet, while the other five firms are in the transition process. An exploratory case study was chosen since it is suitable to provide implications of the digital transformation in the apparel industry so far and how Dynamic Capabilities are influencing the digitalization process.

Semi-structured interviews were conducted to examine the role of Dynamic Capabilities (sensing, seizing, transforming) in the digital transformation. In addition, is assessed how firms are understanding the trend. Moreover, it examines in depth the role of each aspect of Dynamic Capability and how it influences the digital transformation of firms.

5.1.2   Data Collection

The data collection was divided into three phases that lead to answer the research question as described in Figure 5. First, desk research is conducted on the digital transformation of apparel manufacturing in order to gain a deeper understanding on the trend and how international, large firms approach this trend. This step further facilitated the preparation and formulation of the interview questions.
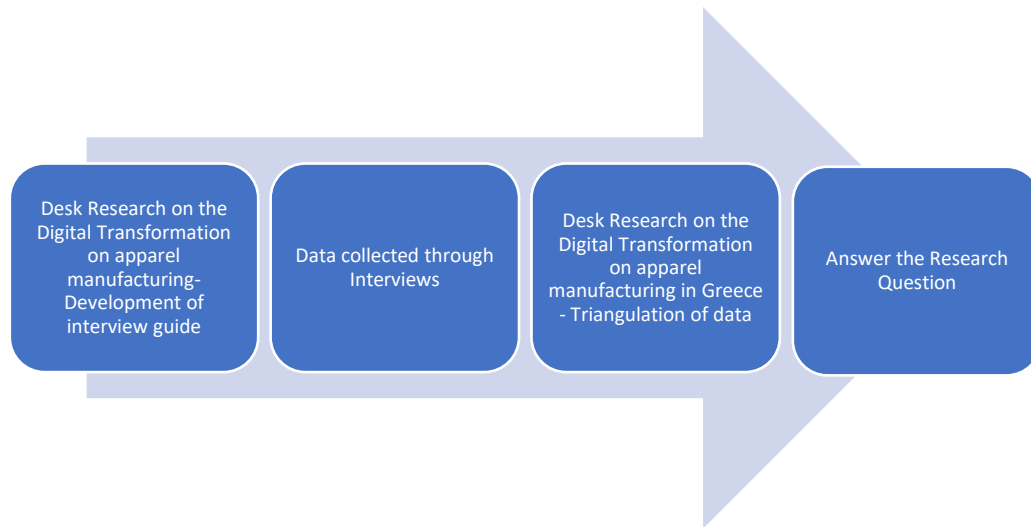
Figure 5 Data collection model

The second step of data collection comprises the most important part of the research. The primary data was collected in the form of semi-structured interviews with open-ended questions (see Appendix I). The interviews aimed at providing in-depth insights into the way the apparel industry senses and seizes the opportunities of the digital transformation and to what extent the respective firm has adapted to the changing environment, yet. Therefore, thirteen interviews with seven different apparel manufacturing firms were conducted to provide an in-depth view of the digital transformation in the manufacturing process in Greece. Table 1 illustrates the operationalization table that translates the concept of Dynamic Capabilities and digitalization into measurable indicators. The last column provides the indicators around which the interview questions were designed.

The third step of the data collection includes desk research on the digital transformation of the apparel manufacturing in Greece based on public databases and reports. The data collected through this process are used as robustness checks and to further validate the interview results.

Categories	Indicators	
Dynamic Capabilities	Sense	Identifying and assessing opportunities outside the company
	Seize	Capturing value from those opportunities
	Transform/ Reconfigure	Redesigning of the business model and realignment of tangible and intangible assets
Digitalization	Digital transformation	Implementation of digital technologies

Table 1 Operationalization table

5.1.2.1 Desk Research

To investigate the digital transformation in the apparel manufacturing in Greece, a detailed understanding of the ongoing transition process in the industry is necessary. Literature, databases, policy documents, magazines, publications and company reports were the main sources of the secondary data collection.

In addition, the in-depth understanding of the digital transformation in the apparel industry, as a result from the desk research, was used to detect the processes which were affected most during the digital transformation of manufacturing. Moreover, it helped to identify the relationship between the Dynamic Capabilities of a firm and the digital transformation of the apparel industry. In the later stage, the data collected from desk research was used to triangulate them with data from the interviews and to further increase the validity of the study.

5.1.2.2 Interviews

Semi-structured interviews provide in-depth qualitative data in the form of the interviewee's detailed responses to questions (Bryman 2012). In addition, semi-structured interviews allow the respondent or the interviewer to deviate and seek an idea or response in more detail (Gill et al. 2008).

The interviews have two main focus areas. The first is to explore how firms understand the digital transformation and what are the main drivers of it. The second is to examine the role of Dynamic Capabilities of a firm in the digital transformation of the manufacturing process. The interview questions, which can be found in Appendix A: Interview structure are formulated based on the indicators illustrated in Table 1.

Seven companies from the domain of the apparel manufacturing were selected. The cases were chosen based on the size of the company and if they have implemented some of the digital technologies in any of their manufacturing processes. In addition, interviewees were selected based on their job position in the respective firm. The interviewees were as much as possible evolved in the production, financial and marketing department. In order to have a broader scope of the research, the selection of the firms was based on the size (micro, small, medium and large) and on their specialization (producing apparel such as clothing, sports and swimwear). I arranged and conducted thirteen interviewees with managers/decision-makers responsible for the company's (innovation) strategy and people involved in the production process of the firm with seven Greek clothing firms. All the interviewees were questioned for the manufacturing process in all the three phases, from designing the product until handling the dispatch of the end product to the customers (pre-production, production and post-production).

The interviewees were approached through email at the beginning of the project. Thirteen interviews were conducted for the purpose of this study. The data collection started mid-June and stopped in mid-July. The interviewees were mainly located in Athens, Greece and they were conducted in person with one exemption located in Xanthi (Southern Greece) and for this purpose, there was a phone connection. All the interviews were conducted in Greek and lasted on average thirty minutes. Table 2 includes a description of the interviewees and the characteristics of the firm.

No	Company	Market segment	Interviewee's position	Manufacturing phase	Digital technologies	Size of the firm[1]	Age of the firm (years)
1	A	Female clothing	Warehouse Coordinator	Pre-production & Post-production	Yes	Small	11
2	A	Female clothing	Financial Analyst	Pre-production & Post-production	Yes	Small	11
3	A	Female clothing	Marketing manager	Pre-production & Post-production	Yes	Small	11
4	A	Female clothing	Warehouse manager	Pre-production & Post-production	Yes	Small	11
5	B	Female Clothing	Marketing Assistant	Pre-Production & production & post-production	Yes	Small	6
6	C	Female clothing	Production specialist	Pre-Production & production	No	Small	8
7	C	Female clothing	Financial controller	Pre-Production & production	No	Small	8
8	D	Linen	Marketing consultant	Pre-Production & production & post production	No	Medium	29
9	E	Female clothing/ accessories/ footwear	Creative director	Pre-Production & production & post production	Yes	Large	29
10	E	Female clothing/	Marketing consultant	Pre-Production & production &	Yes	Large	29

[1] The size of the company was determined based on the European defined standards (Eurostat 2018).

		accessories/ footwear		post production			
11	F	Swimwear	Founder/ Designer	Pre-Production & Production & Post-production	No	Micro	3
12	G	Female clothing	Founder	Pre-Production & Production & Post-production	Yes	Small	25
13	G	Female clothing	Marketing manager	Pre-production & production & post-production	Yes	Small	25

Table 2 Description of the interviewees that participated in the research

5.2 Data Analysis

The interview questions are designed in the context of the Dynamic Capabilities approach (sense, seize and transform) and the digital transformation. Digital transformation describes the implementation of digital technologies, such as Big Data analytics, Cloud computing and artificial intelligence in the manufacturing process.

The interviews were recorded, transcribed and translated into English. In addition, the data gathered from the interviews were analyzed with the help of the software NVivo, by applying a coding scheme to the full interview transcripts. In this study, I followed Saldana (2014) (see Figure 6) on the codification to conduct the analysis of the collected data (2014). The coding process was completed in three cycling coding. First of all, with the use of NVivo, open coding was applied to form the basic nodes and codes of the analysis. Then, in the second step based on the nodes, axial coding was conducted to identify all the important aspects and relationships of the nodes and form categories. After the second cycling coding, there was the phase of identifying relationships among the categories and create the main themes of the analysis.
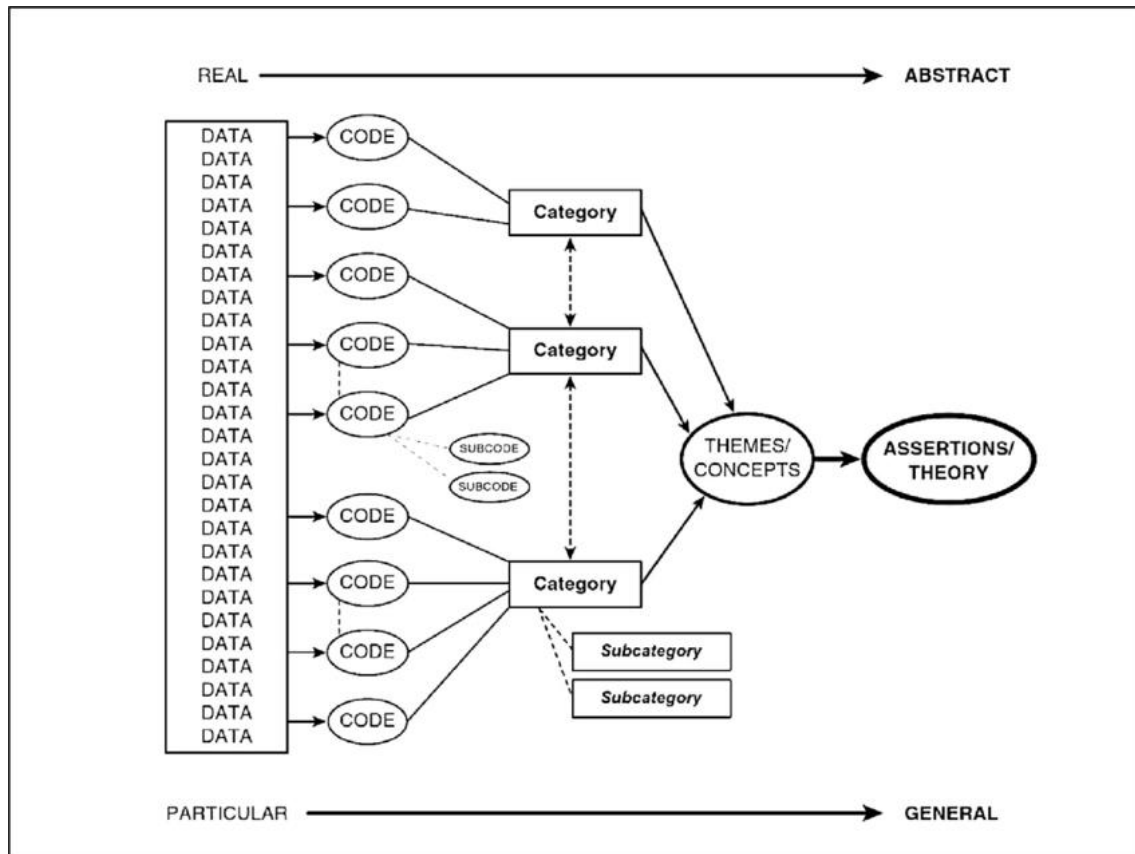
Figure 6 "A streamlined coded-to-theory model" (Source: (Saldana 2014, p.14)*)*

5.3 Reliability and Validity

To enhance the reliability of the project it is significant the exploration of the trustworthiness of the research (Golafshani 2003). The reliability of the research is enriched by recording and transcribing the interviews afterward. In each interview, the same question list was discussed and analyzed. All the topics and necessary explanations were given to the participants prior to and during the interview so to ensure that the interviewee has a full understanding of the questions. Moreover, to avoid bias, most of the interviewees were asked to interpret the results and comment whether the results are representative of their views. Furthermore, secondary data was collected from online databases to verify and support the results.

The validity of a qualitative research is ensured when it is acceptable to the research community (Biggam 2008). To be acceptable by the research community the study was based on research strategies and data collection techniques (Biggam 2008). For the collection of the data an appropriate technique (interviews) was utilized by the author, to ensure that the collective data meet the projects' objectives.

6. Findings

6.1 Digital Transformation in apparel manufacturing

The fashion industry is undergoing an ultimate digital challenge due to the technological development (Roger 2017). Many fashion brands are trying to approach digital transformation, concentrating on digitalizing their processes. Adidas, Nike and Levi's Strauss are some of the big companies that have been experiencing digital transformation in their manufacturing process. Examples from companies that have

already experienced digital transformation and are proven to be successful so far, were useful to get an overview of the changes that were taken place during the transformation as well as the transition phases.

Adidas Group

Adidas, a well-known sporting brand, is one of the big firms that are one step ahead of the digital transformation in manufacturing and has just been awarded the German Innovation Award for 2018 in the category of Large Enterprises (Chin 2018). Adidas opened the Speedfactory in Germany, the first automated facility with an "intelligent robotic technology" of footwear production, changing the future of apparel manufacturing (Louise 2015). In 2017, the R&D expenditures increased significantly by 25% while the number of people employed in the R&D department also increased, from 1,021 to 1,062 employees (Adidas 2017). Not only did Adidas invest in R&D, but also in training programs to enhance employee's digital skills but also to embrace them to engage in the digital transformation of the firm (Meister 2014).

Adidas Group is targeting to digitalize the entire supply chain, from design to the distribution of the final garments. In the designing process, Adidas is investing in data analytics to increase the design time while increasing accuracy. To achieve this, in 2015 it bought the fitness tracking app Runtastic, which allowed Adidas to have access to data from 70 million users (Reuters staff 2015). Then Adidas launched a product which was developed based on athlete's data and an open source co-creation. In the annual report of 2017, Adidas mentioned that digital transformation is altering the way consumers behave and consequently the way they work. Technology has enabled Adidas to accelerate building relationships with customers. Thus, they are targeting how they will increase this relationship. Their first goal was to enhance their digital capabilities along the entire supply chain. First, they establish a "Digital leadership Team" to drive the preparation of the digital initiatives across the firm and support functional teams in the decision-making process. This "Digital Leadership Team" defined a clear roadmap of the digital priorities. In order to enhance the relationship with the customer they invest in changing their e-commerce sites, by introducing new features and technologies on the online platform, improving the shopping experience.

To simplify manufacturing and enable product innovation and increase speed-to-market, they invest in bringing the production closer to the consumer. Adidas' Speedfactory was first opened in Germany at the end of 2015 and another one is opening in Atlanta (Green 2018). The Speedfactory is an automated facility pairing a small human workforce with digital technologies, including 3D printing, robotic arms and computerized knitting to create and produce running shoes, products that are mass produced in far-off countries such as China, Indonesia and Vietnam (Wiener 2017). With this factory, Adidas targeting in serving the European market directly with digital designs that are easily and simply modified from robots into footwear and adapted to the continuously changing preferences. Moving the factories closer to the customers, Adidas aims to eliminate shipping delays and costs. Gerd Manz, vice president of Adidas innovation group, mentioned that with Speedfactory they facilitate speed and can "*react to customer needs within days*" (Wiener 2017). In the picture below, the reduction of the manufacturing lead time is evident that a giant sportswear company needs to produce millions of pairs of shoes.

Exhibit 16:

The traditional shoemaking process is about to change

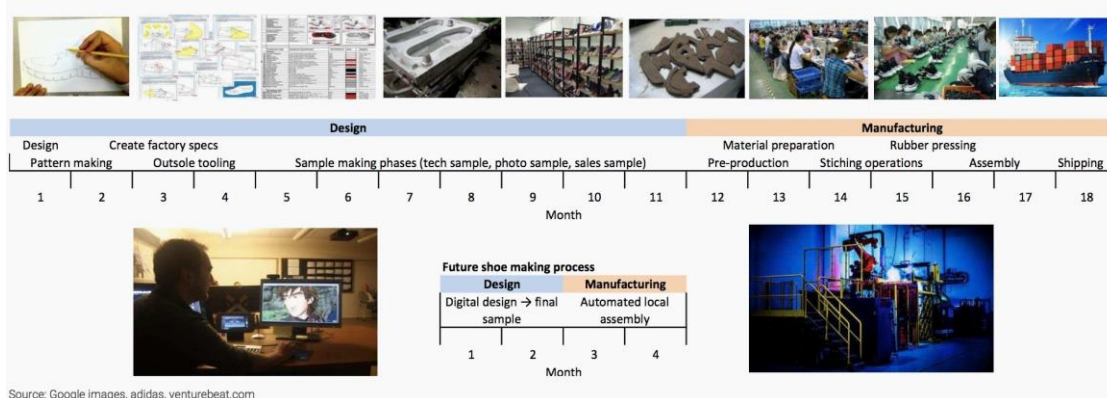Traditional shoe making process - from initial design to final product landed at brand's warehouse

Figure 7 Adidas manufacturing lead time

Figure 8 Adidas's Speedfactory

Nike

Nike is the top company in the sportswear apparel worldwide and has been undergoing digital transformation since the early 2000's where it first started selling customized shoes. In 2010, the firm significantly improved its mass customization capabilities by using data analytics. Big Data helped Nike to sense the new trends by analyzing data from its customers (Tannou & Westerman 2013). Nike engaged its employees in the digital transformation by teaming up marketers, designers and IT specialists to work together as innovation groups to develop new digital capabilities and innovations (Tannou & Westerman 2013). The groups investigated the digital technologies and techniques to identify possible applications in products or in customer commitment (Tannou & Westerman 2013). This organizational change enables Nike to produce new digital-enriched products to fit buyer's preference and needs and due to a large amount of customer's data, Nike gained an advantage over the highly competitive digital world (Tannou & Westerman 2013). In 2010, Nike formed the Nike Digital Sport a unit responsible for developing devices and technologies to track personal statistics and improve its consumer relationship (Tannou & Westerman 2013).
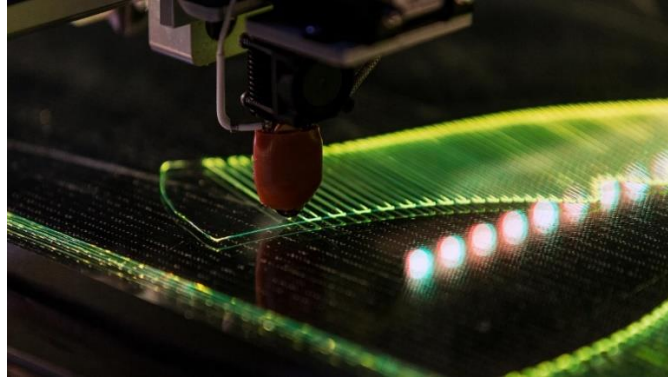
Figure 9 Nike 3D print process (source: Nike 2018)

Nike is currently investing in additive manufacturing and trying to create the first 3D-printed textile that is using to create an upper layer of the shoe (Figure 5 shows the 3D printing process). This process starts by gathering athlete data, then analyze it to create the ideal composition of the material and then produce the final textile (Nike 2018). In 2015, Nike announced a partnership with Flex, a global manufacturer, to accelerate Nike's vision to bring innovation to its manufacturing supply chain (Nike 2015). Nike has been investing in automation, innovation, sustainability and novel new methods of manufacturing (such as the 3D-printed textile) so as to improve its manufacturing business model (Nike 2015). The partnership with Flex, facilitated this process by bringing new capabilities and expertise from outside of the footwear industry (Nike 2015). In addition, expenditures on R&D has risen over the years, spending 2.5$ billion the last five years (Green 2017).
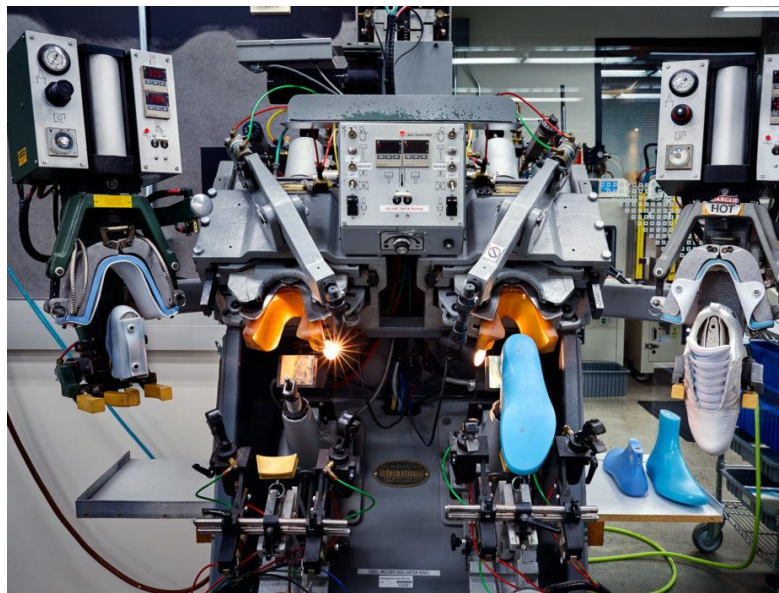
Figure 10 Nike's machine used for heels production

Levi Strauss & Co

Levs Strauss is a 165-year-old blue jeans company pioneering the last years in the field of production by implementing digital technologies. The company started investing in IT domain the last years as a solution to the fast-paced environment (Cognizant 2017). Levi Strauss & Co followed some steps to approach digital transformation. Firstly, they ensured that IT is structured and resourced in a way that they can be agile and sustainable in today's world, meaning that they invested in training and hiring IT people but also

to form partnerships in order to gain external knowledge (Cognizant 2017). They used Big Data to improve the firm's performance (Cognizant 2017). By presenting results with reports they created a transparent and reliable relationship with the partners (Cognizant 2017). Thus, the reliable relationship facilitated the company to take risks and make investments in innovation projects (Cognizant 2017). Levi Strauss & Co not only invest in Big Data and Business Intelligence tools, but also in the Internet of Things. They are using RFID sensors to track inventory in the store and achieve restock in real-time. By doing that they accomplished to improve accuracy in their inventory and improve the delivery of the consumer expectations (Cognizant 2017). In addition, Levi Strauss & Co implemented an advanced Big Data technology to handle their inbound logistics and have full visibility through the entire supply chain. This benefitted the company to reduce a lot of manual work and improve staff efficiency and lead times, as well as improve the inventory management (Ebner et al. 2013).

Figure 11 Digitalization in the Levi Strauss & Co manufacturing process

The company developed a future-led execution (F.L.X) project which converts its traditional manufacturing techniques to automated methods. Figure 11 illustrates the old processes that were replaced by the new one. The benefits that the company gains from this transformation is reducing time to market and eliminating chemical formulations from jeans finishing, thus they achieved being more responsive to market changes and make the manufacturing process more sustainable (LS & Co. Unzipped Staff 2018a). More specifically, the F.L.X project benefitted the transformation of a time-consuming, labor-intensive and chemical-reliant process of hand finishing (LS & Co. Unzipped Staff 2018b). Moreover, they implemented a revolutionary imaging tool, which simulates the finished design and the development process. This advanced technology enables LS &Co designers to create the finished and the final garments easier and faster, cutting the manufacturing time from months to weeks or even sometimes days (LS & Co. Unzipped Staff 2018b).

Summary

Table 3 illustrates the methods that three giant international companies sensed, seized and transformed to the new digital era. The data was collected through a desk research in the first step (see Figure 5), by reading the company's reports, consultancy reports and e-magazines.

Dynamic Capabilities	Methods	Adidas	Nike	Levi's Strauss & Co
Sense	Internal R&D	R&D investments	R&D investments	Recognize the trend Being risk takers
	Identify market changes & form collaborations	Form the Digital Leadership group: Digital motives and awareness among the employees	Partnership with Flex: to gain external knowledge	Form partnerships to gain external knowledge
Seize	Changes in strategic structure & enhance knowledge skills to avoid "bottlenecks"	Training and workshops around digital skills	Forming Innovation Groups to raise awareness	Enhance the IT department with resources and partnerships
	Loyalty & Commitment	Engage employees in the Digital Transformation	Engage employees in the Digital Transformation	Engage employee to Digital transformation and provide transparency across the processes by reporting results
Transform	Strengthen governance	Use of Big Data to improve the product that fits best to consumer preferences	Form the Nike Digital Sport: to improve consumer relationship Use of Big Data	Use of Big Data to improve supply chain
		Launch the Speedfactory (late 2015), an automated facility- bringing manufacturing closer to the consumer	Use of 3D printed textile based on the customer's statistics to improve performance	Use of simulation program to improve the way of working, be more agile and sustainable

	identification of the benefits	Increase speed and accuracy in the manufacturing	Increase speed and accuracy in the manufacturing	Increase time -to market, inventory management and staff efficiency

Table 3 Digital transformation roadmap in three giant apparel companies

6.2 Digital Transformation in the Greek apparel manufacturing

Interviews were conducted to collect primary data on how Greek apparel manufacturers cope with the digital transformation and understand at which scale they have undergone the transition. The Dynamic Capabilities framework (Figure 12) was used to facilitate the understanding of the digital transformation of the Greek apparel industry. To support my primary data, secondary data was gathered through desk research on public statistical data and reports on the digital transformation of the Greek apparel manufacturing. The primary data was collected from seven various sized apparel firms and from different sectors. This research uses four cases of these various sized companies. Case studies are giving a clear overview of how a business deals with digital transformation in today's fast-changing world. In the discussion section, there is an examination of findings, identify similarities and differences and compare them to the theory introduced at the beginning of the research and concluded in answering the research question.
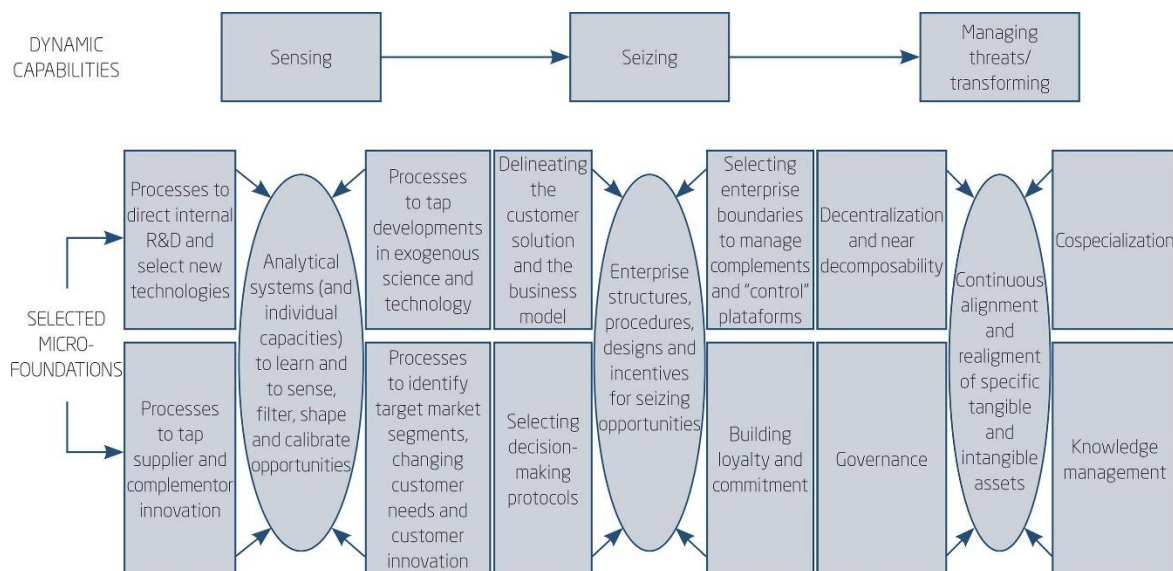
Figure 12 Dynamic Capabilities Framework by Teece (Teece 2007)

6.2.1   Case Studies

A company is classified into various groups according to their size. The most common parameter of this classification is the numbers of persons employed by the company (OECD 2018). The main classes of companies are micro-sized (fewer than 10 employees), small-sized (10 to 49 employees), medium-sized (50 to 249 employees) and large-sized enterprises (250 or more employees) (Eurostat 2018).

In the population examined for this study, there are four small-sized companies, all of the four operate in the female clothing (Company A, company B, company C and company G). There is one medium-sized company (Company D) operating in the Linen production; Company E is a large-sized firm and operates in female clothing, accessories and footwear. Lastly, there is a micro-sized company that operates in

swimwear production and employs only 4 people, having also an external manufacturer to produce the garments (Company F).

The hierarchic graphs that were used in the analysis of the case studies were created with the use of NVivo software. The graphs were shaped based on the resulting themes and categories from the coding analysis. In addition, the graphs are formed based on the coding references, a larger area indicates more coding references.

6.2.1.1 Case Study 1: Micro-sized Company

Company F is a micro-sized company that was established in 2015. It operates in the swimwear production, which has a small market share in the Greek apparel market. It currently employs 4 people and has external partners specialized in the financial and marketing domain. In addition, Company F collaborates with an external manufacturer, specialized in the swimwear production. The respondent was the founder of the company who also is responsible for the designing process of the garments.

From the coding analysis, in terms of Dynamic Capabilities it appears that the company lacks several features of sensing, seizing and transforming competences. The analysis of the resulted themes and categories were based on the Dynamic Capabilities Framework by Teece (Figure 12). Below there is an extensive analysis of the results for each aspect of the Dynamic Capabilities.

Sense

Below it is illustrated a hierarchic graph, which shows the main areas of how a micro-sized company senses the digital transformation. It is evident that, a micro-sized company hardly have an in-house R&D department that would facilitate the sensing of potential technological implementations. However, they can recognize the potential benefits of the digital technologies by having access to information with the use of the internet and doing investments in going to exhibitions and forums on the topic. In addition, they can identify market changes and monitor competitor activity, although, they do not have internal R&D mechanisms. For instance, a respondent from company F mentioned that competitors outside Greece are using digital technologies, however the Greek market is still using traditional techniques in the swimwear production. For instance, the respondent said, "*I know that some designers in the US are using 3Dprinters and their results (clothes) are seem truly amazing*" and "*The competitors (in the Greek market) use the same methods and techniques in swimwear manufacturing as me, they are not using any new technology yet*".

Moreover, it is important to mention that the current micro-sized company is searching for suppliers specialized in sustainable textiles as potential collaborators. By searching and embracing collaborations benefit firm to notice what is going on the business ecosystem and therefore, sensing new technological developments (Teece 2007). More specifically, a respondent from company F stated that "*we invest in visiting textile firms to find the right sustainable textiles, that will be durable and of high quality. For instance, we are using Econyl fibers, which is nylon waste from landfills and oceans around the world*". Econyl is a recent innovative fiber which is recyclable and reusable for several life cycles (Perella 2015).
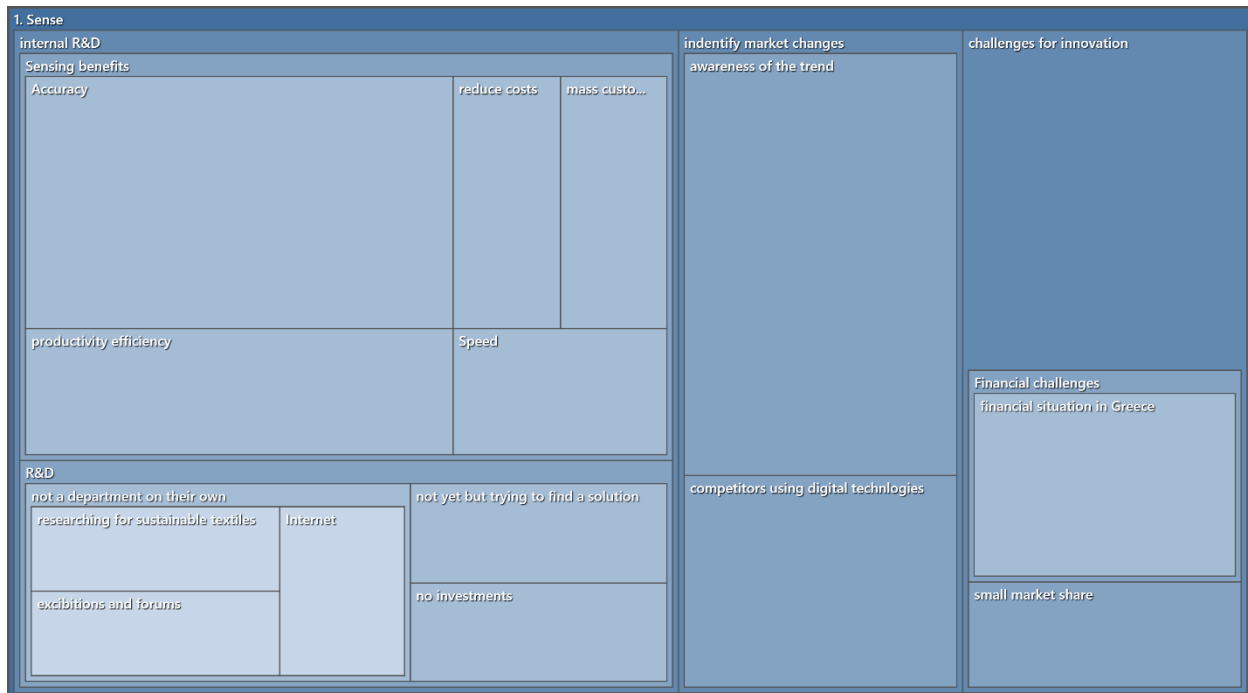
Figure 13 Sense Capability of micro-sized company

In conclusion, a micro-sized company may not have an internal R&D department to filter all the information but has mechanisms that facilitate the sensing and gathering of the information. Searching and collaborating with external suppliers that are active in innovation activity benefit the company to stay alert and sense of what is going on in the periphery of the business ecosystem. Moreover, they are aware of the benefits that digital technologies offer, but they lack mechanisms that would help them identify where those technologies can be implemented in their manufacturing chain and grasp those opportunities. More specifically, lack of specific R&D knowledge and from specialized employees that would help to sense completely the benefits from the digital transformation in their manufacturing chain.

Seize

Figure 17 illustrates the seize capability of a micro-sized company. According to Teece framework (Figure 12), the company lacks mechanisms that would facilitate the seize of the sensed opportunities. To address the sensed opportunities it is essential to invest in development and commercialization activity (Teece 2007).

As Teece (2007) mentioned, a new opportunity will effectively be evaluated and embraced regarding on the quality of the enterprise's routines, decision rules and strategies. The respondent company does not use standardized procedures in the decision-making process to avoid decision errors at inflection points. In addition, micro-sized companies lack from standardized procedures that would help them overcome decision-making biases and faults and encourage the digital transformation of the company.

On the other hand, they understand the need to reshape the business model to embrace the digital transformation successfully. More specifically, a respondent from company F mentioned that the structure and the strategic plan have to change in order to effectively embrace the new opportunities from the digital technologies. Moreover, respondent 6 stated that for a smooth change it is crucial to engage and motivate the employees into the digital transformation. Advancing employees' skills with training and workshops it is one of the steps that is needed to be considered in the new strategic plan.
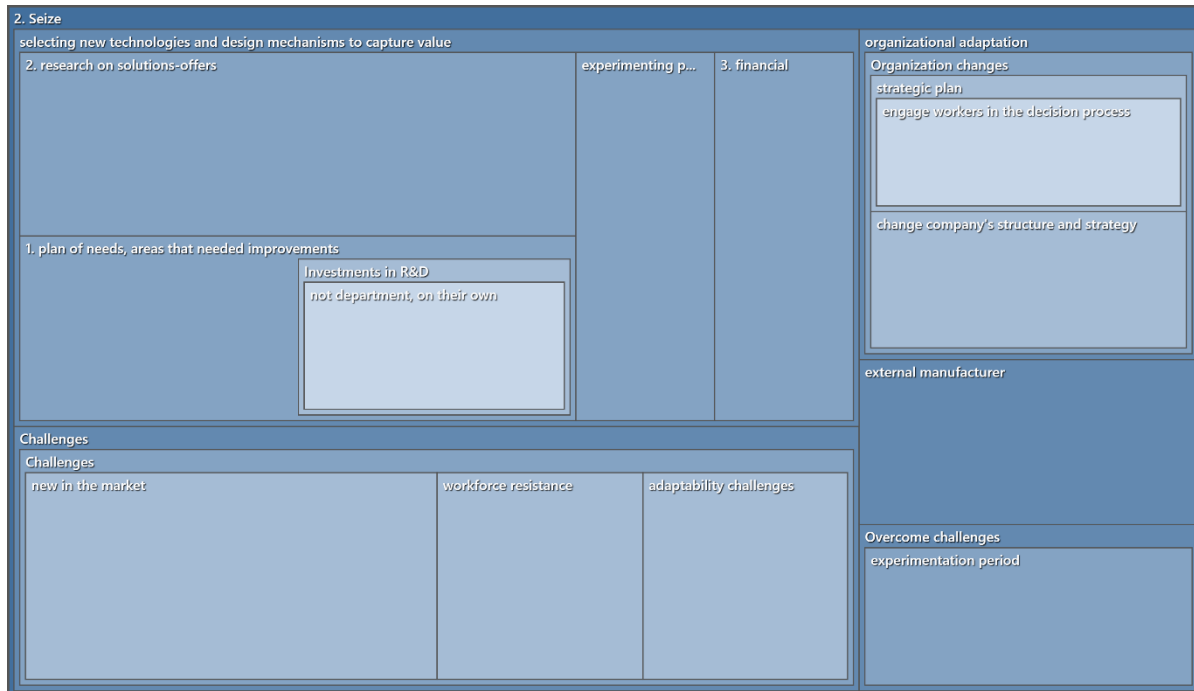
Figure 14 Seize Capability of micro-sized company

In conclusion, a micro-sized company lack some aspects of the seize capability. For instance, they have not got a standardized decision-making process to avoid mistakes and bias. However, they understand the need to reshape the business model in order to effectively gain competitive advantage through the digital transformation. Moreover, they employed an external manufacturer which help the firm capture the same benefits as was a larger company. In addition, it is also important for them to give motivation to the employees and engage them in the transformation process.

Transform

Taking into consideration the Dynamic Capability Framework (Figure 12), regarding the transformation capability the company understands the importance of knowledge management and the continuously organizational adaptation and fit. For instance, a respondent from company F stated that it is "*important to have a department specialized in these technologies, an IT may be, that would support this transition*".

The company is still at the beginning of the transition process and they are in research of future investments in the production process, such as robotics, additive manufacturing and a simulation design software. Moreover, the company is currently new to the market and has not changed yet most of the tangible assets. In addition, has implemented a digital technology in the domain of the ordering process and on the distribution domain, although not at an advanced level. They have implemented an ERP system where they can control all the processes before and after the production. This system allows the company to manage and handle all the products and their orders from their wholesalers in order to have an accurate quantity of production. In the post-production process, they can manage the distribution to the wholesalers accurately and faster. So far, they have not seen a change in the competitive position as a consequence of the implementation of the digital technologies (in this case cloud and Big Data).
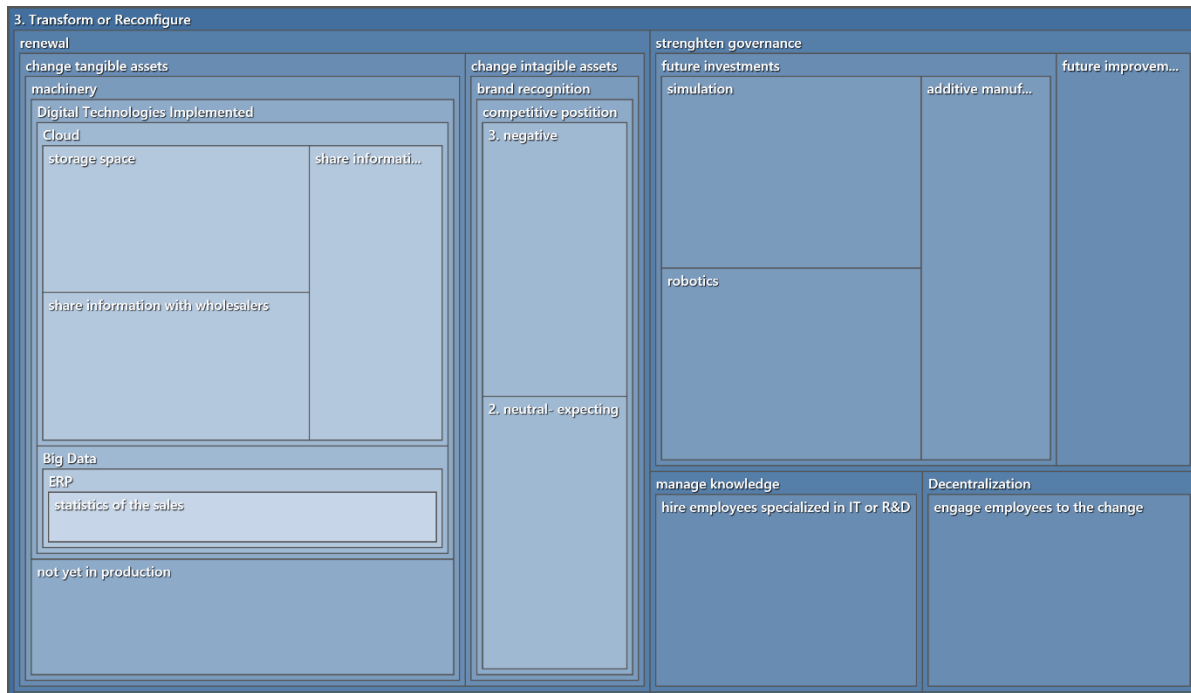
Figure 15 Transform Capability of micro-sized company

In conclusion, the micro-sized company has not yet changed most of the tangible assets, the due financial situation in Greece and because the current company is new to the apparel market. However, they are seeking future investments that will help them earn a competitive advantage. They are in search for hiring employees specialized in IT and R&D that would allow them to ensure an effective adjustment of the technological opportunities in their manufacturing chain.

6.2.1.2 Case Study 2: Small-sized Company

Company A is a family business, operates in the female clothing industry and was established in 2007. It currently employs 15 people, but also has external partners in the IT field. The respondents were from the financial, marketing and distribution department.

Company B is a clothing company which was established in 2012. Currently, employs 12 people, but also collaborate with an external partner specialized in the consultancy of fashion logistics and is helping them to improve their performance not only in the production process but also to manage better their inventory. The respondent was in a managerial position with some of the main responsibilities of supervision of the production process, coordinating daily operations such as the orders, payments and monitoring the store inventory.

Company C is a clothing company which was established in 2010. It currently employs 11 people, but also working with external partners which helping them with the warehousing operations. The warehouse is an external partner. The respondents were from the financial and the production department.

Company G is a family business, operates in the female clothing production and was established in 1993. It currently employs 15 people. The respondents were from a managerial position and from the production department.

From the coding analysis it comes out that in terms of Dynamic Capabilities, they lack specific aspects that have to do with sensing, seizing and transformation. The analysis of the resulted themes and categories

were based on the Dynamic Capabilities Framework by Teece (Figure 12). Below there is an extensive analysis of the results for each aspect of the Dynamic Capabilities.

Sense

Below it is illustrated a hierarchic graph (see Figure 16) which shows the main areas of how small-sized companies sense the digital transformation. It is evident that, small-sized companies can identify market changes, the deviations in the customer's needs, but lacks a proper R&D mechanism to entirely sense the trend. Although they do not have an R&D department or R&D specific knowledge on the digital technologies, they invest in going to exhibitions and forums on the topic to get informed about the latest technological development in the apparel manufacturing. They mentioned during the interview that the financial situation in Greece makes difficult to invest in innovation projects, due to the uncertainty that prevails in the market. For instance, a respondent from company A mentioned "*If the financial situation in Greece was better, I mean without this uncertainty, we would have implemented more advanced technologies in our processes. So, for that reason the transition to the digital transformation is undergoing at a slower pace".* Moreover, they mentioned that in Greece, there is still no huge awareness around the potential applications in the apparel manufacturing. According to their responses, there is a small-scale awareness of the digital transformation of the apparel manufacturing and its potential applications in the manufacturing.

Moreover, small-sized companies are opting out to collaborate with external partners. Therefore, it facilitates the sensing capability and increases their awareness of what is happening in the business ecosystem. More specifically, respondent company B mentioned that "*we collaborate with an external partner specialized in the consultancy of fashion logistics and is helping us to improve our performance not only in the production process but also to manage better our inventory*".
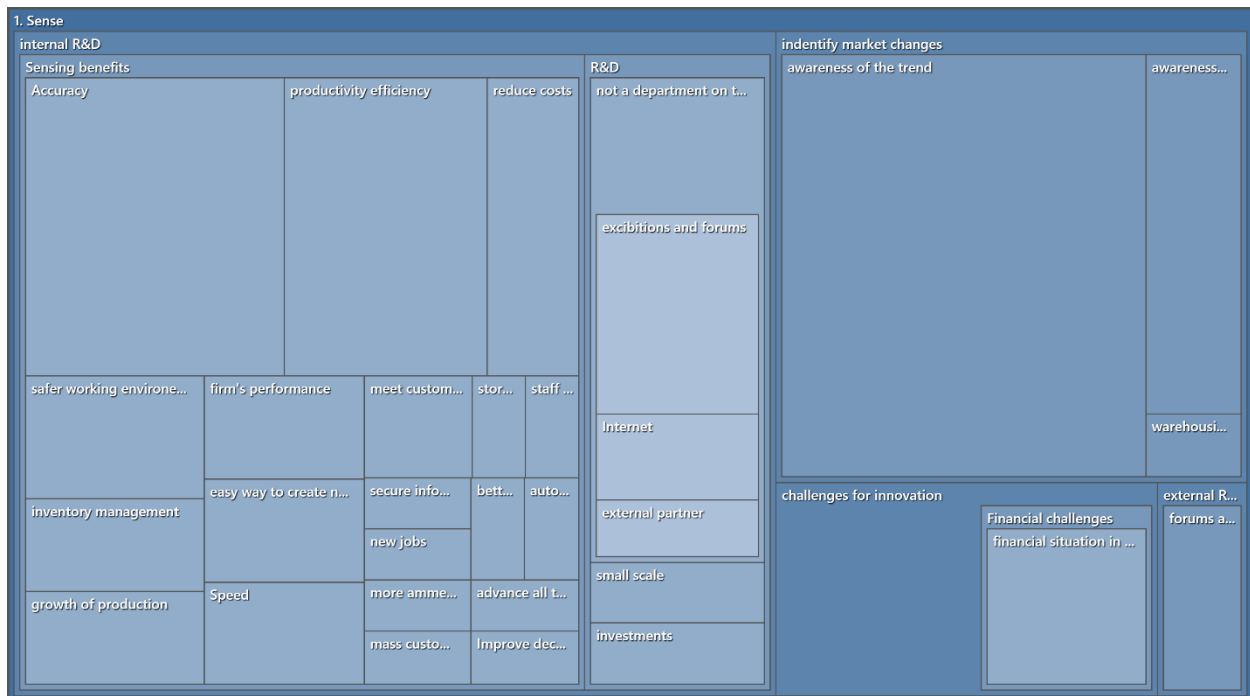

Figure 16 Sense Capability of small-sized company

In conclusion, a small-sized company do not have an internal R&D department to filter all the information but has mechanisms that facilitate the sensing and gathering of the information. They have mechanisms that help them identify market changes. Having external suppliers benefit the company to stay alert and

sense of what is going on in the periphery of the business ecosystem. Moreover, they are aware of the benefits that digital technologies offer, and which areas will benefit most from those technologies.

Seize

Figure 17 illustrates the seize capability of small-sized companies. According to Teece framework, the company lacks from the aspect of "decision-making protocols". They do not use standardized procedures in the decision-making process to avoid decision errors at inflection points. However, to identify, avoid and control "bottlenecks" situations during the transition, small firms are collaborating with external partners. Respondents mentioned that they cooperate with consultants specialized in logistics and IT to increase the possibility to capture value from the new technologies and overcome arose challenges.

The current companies have implemented digital technologies. In the pre and post production process they have implemented an ERP system where they can control all the processes before and after the production. This system allows the company to manage and handle all the products and their orders from their wholesalers in order to have an accurate quantity of production. In the post-production process, they can manage the distribution to the wholesalers accurately and faster. Moreover, this ERP system allows real-time information anytime anywhere. As a respondent from company A mentioned during the interview "*the implementation of this technology helped us a lot to make the ordering process much faster and much accurately. We avoided mistakes and extra costs for the compan*y".

In addition, there were also digital technologies implemented in the production process. For instance, Company B is in the transition phase with the implementation of a 3D technology in the manufacturing process and company G convert their machines into digital ones. More specifically, a respondent from company B said about the 3D technology that they will use it "*in the design phase to create the samples easily and fast and in the production process to create the clothes. But we are experimenting right now. At the moment, we continue using our current system".*

All the respondents mentioned that is important to first identify the areas that need improvements and will benefit from the implementation of the digital technologies. By doing this, will facilitate to design mechanisms to capture value from the new technologies. More specifically, a respondent from company C stated, "*first we have to create a plan of our needs, which areas are obstructing the speed and the of production and in which areas we have most of the failures".*

In addition, a respondent from company G mentioned that it is important to engage the employees in this process so as to identify faster the problematic areas. By engaging the employees in the transformation process not only develop feelings of commitment and loyalty but also motivate them more to participate in the transition. Building loyalty and commitment is an important aspect of seizing capability since it can boost the effectiveness of the transition process.

Furthermore, almost all the respondents stated that reshaping the business model is inevitable in the digital transformation. More specifically, a respondent from company C mentioned that it is necessary for the company to do organizational changes. Changing the strategic plan, it is crucial since the implementation of the new technologies will change completely all the procedures from the decision making in the pre-production process to having a better and faster production line.
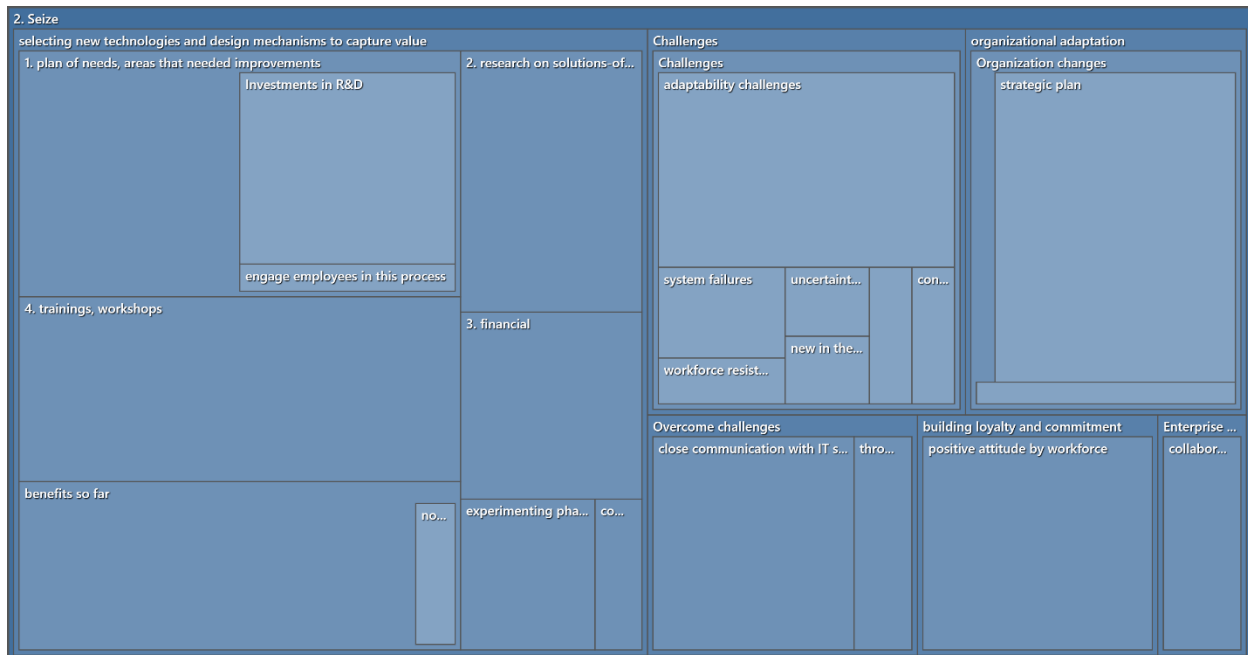
Figure 17 Seize Capability of small-sized company

In conclusion, a small-sized company can seize the digital transformation, although lacking some aspects. More specifically, they have not got a standardized decision-making process to avoid mistakes and bias. However, they can design mechanisms to capture value from the new technologies. Also, they recognize that redesign the business model is necessary and important through the digital transformation. In addition, it is also important for them to give motivation to the employees and engage them in the transformation process.

Transform

Figure 18 shows the basic themes and categories that came out from the codifying process of the interviews from small-sized companies. Most all the respondents from the small-sized companies mentioned that they are in the transition process. A respondent from company A stated, "*this transition process is still in progress, we are always enriching the programme with future improvements to facilitate the automated work*".

So far, the implemented digital technologies in all the three stages of the production process facilitate the company to improve their competitive position in the market. In addition, they gained the advantage to improve their clientele since now they can handle larger amounts of data accurately and faster. More specifically respondent from company A mentioned *"the implementation of the ERP system benefitted us in growing our productivity and also it gave us the advantage to grow our clientele".*

Taking into consideration the Dynamic Capability Framework, the companies are trying to adapt to the change not only by reshaping their business model, but also by changing their intangible and tangible assets. They are in research of future hiring with specialization in the IT and R&D domain and they are in process of improving their employees' skills. More specifically, a respondent from company C mentioned *"either the company has to provide training to the employees so as to develop new skills that will help the transition to the new era or hire employees with the required skills".* Furthermore, they provide incentives to their employees during the process, which empowers the motivation to achieve a profitable performance.
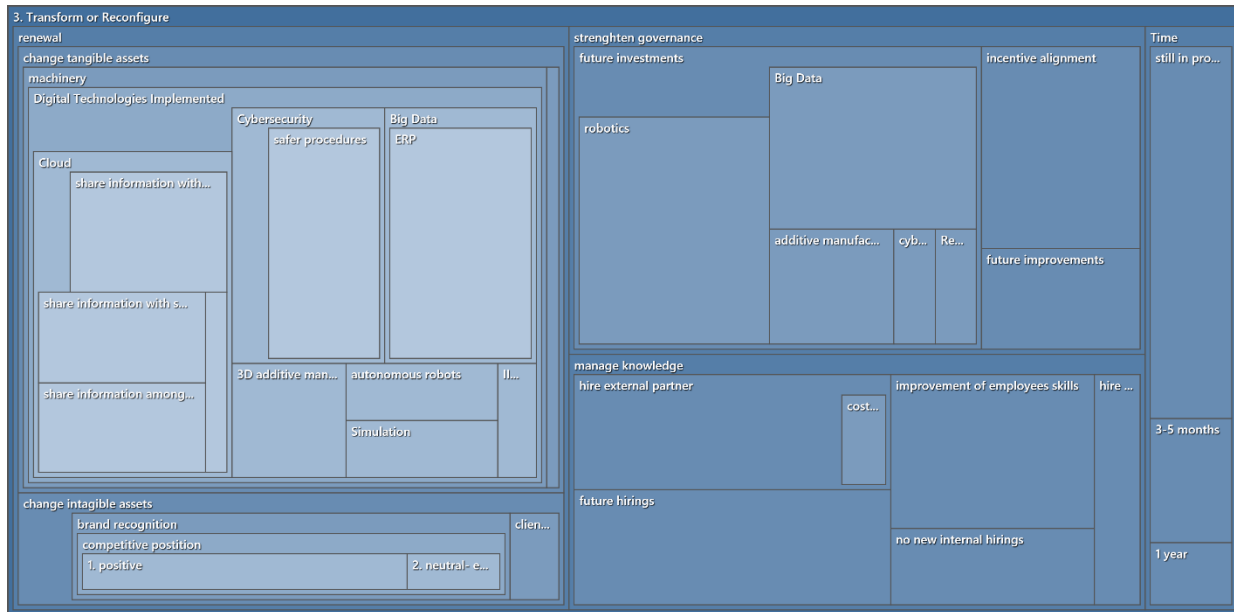
Figure 18 Transform Capability of small-sized Company

6.2.1.3 Case Study 3: Medium-Sized Company

Company D was founded in 1989, in Athens from three people. They started its activity with the handmade fabrication of layers of natural products and in 1992, the company transferred its headquarters to the industrial area of Xanthi (north-eastern Greece), where they expanded into linen (blankets, towels, bathrobes, bridal blankets etc.). It currently employs 230 people. The respondent was from the marketing department.

Sense

Below, it is illustrated the hierarchic graph (Figure 19) of the sense capability of the medium-sized company. It is evident, that there is an awareness of the trend and a medium-sized company can identify the market changes. In particularly respondent from this company stated that *"There is a very active R&D department in the company that monitors the developments and tries to locate those that would be applicable to our manufacturing processes"*.

Although Company D has a very active R&D department and can identify faster and easier the market changes than a smaller company is a little more reluctant to implement new technologies in the manufacturing process. Although they have applied digital technologies in the pre and post production process, they have not applied digital technologies in the production process. They are researching for the best fit for their manufacturing process, but they have standardized processes that need time to be replaced with a new one. In addition, a respondent from this company mentioned that regarding the restrictions they have in their production process (custom-made products) they are quite up to date and aware of what is happening in the manufacturing process of the apparel industry.
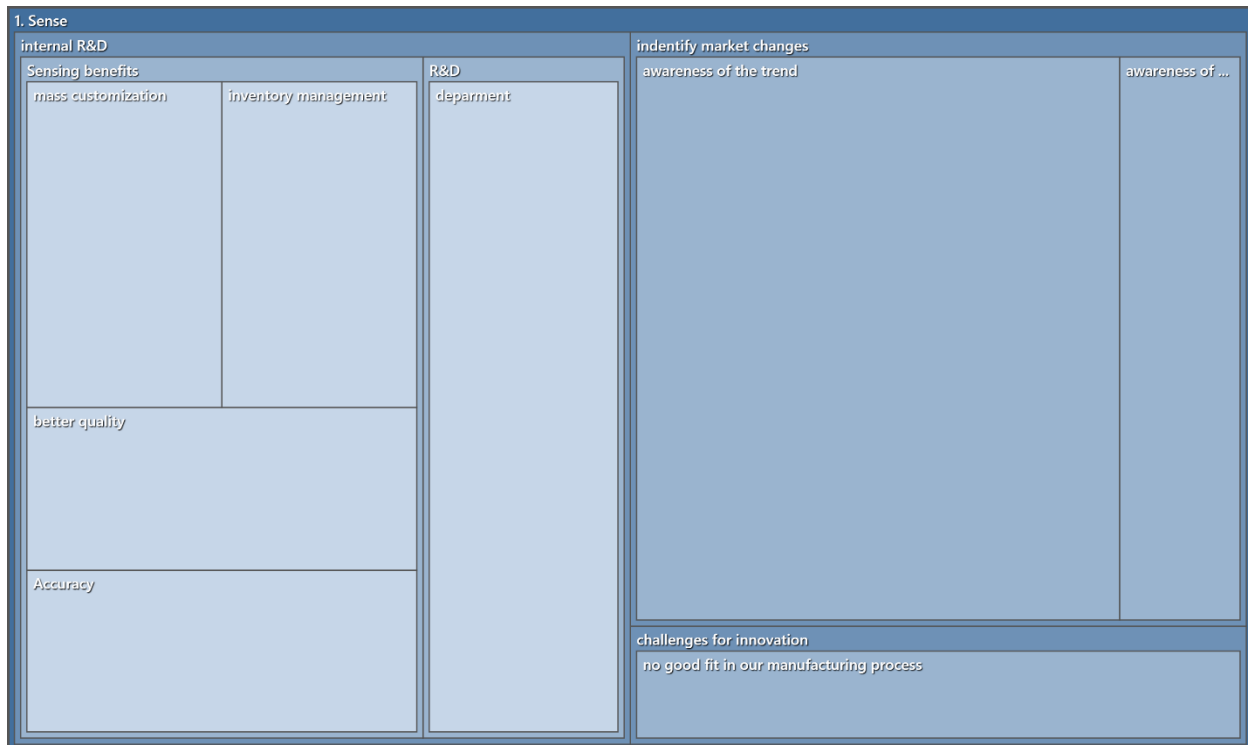
Figure 19 Sense Capability of medium-sized Company

In conclusion, medium-sized companies are qualified with mechanisms that facilitate the sensing capability. Mechanisms such as an in-house R&D department that helps the company to identify what is happening in the market. However, the current company lacks exogenous resources and from collaborations with external partners that would benefit the company having a complete overview of the business ecosystem.

Seize

Figure 20 shows the categories and themes that were concluded from the analysis of a medium-sized company. Taking into consideration the Dynamic Capability Framework (Figure 12), for the seize capability it is crucial for a firm to reshape the business model and design mechanisms to grasp value from the implementations. Company D consider important to first do a "*market survey and a study that would focus on what would be the benefits of investing in these technologies*". The market survey will help the company to capture value from the potential technological implementations.

In addition, it is evident that medium-sized companies are more methodological than smaller sized companies. More specifically, a respondent from company D stated that to capture value it is crucial to forming a "*group to deal with the process of selecting new technologies (the project). This group would have individuals from all the departments involved. There would be someone from the R&D department, who would have the overall supervision as a project manager, people from the production and from which other domains it could be involved, perhaps from the IT department there might also someone participate in that group*".

Furthermore, organizational adaptation is also a necessary mechanism in order to seize the sensed opportunities. Changing strategic plan and engaging workers in the decision making are of the main changes that medium-sized companies take into considerations. Company D mentioned "*employees are encouraged to communicate their ideas and their problems without censorship. Direct communication*

between the employees and the Management is Company's basic philosophy. [...] Employees involvement in the decision-making process is a focal point for the smooth operation of the company."
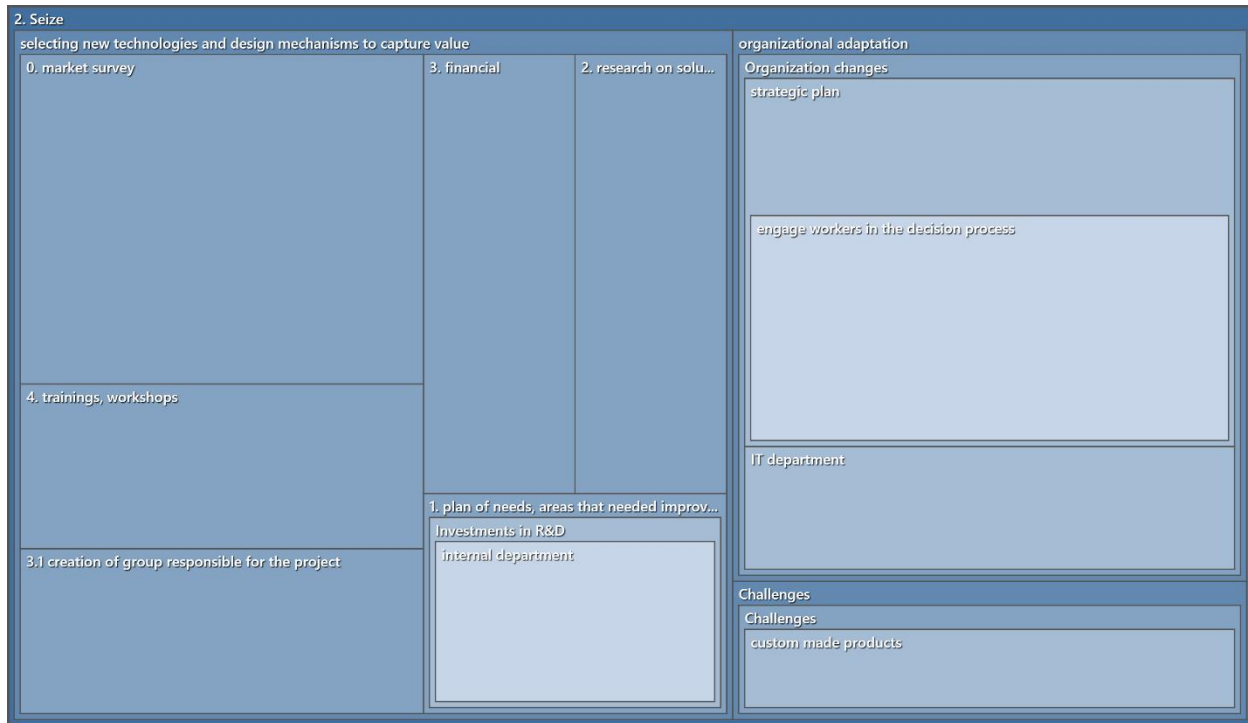
Figure 20 Seize Capability of medium-sized Company

In conclusion, the role of the seize capability in the medium-sized companies is significant for an effective digital transformation. Medium-sized companies not only can identify the benefits that new technologies offer, but also have mechanisms that allow them to effectively capture value from them. In addition, they do have standardized procedures that allow them a smoother transition, for instance the formation of responsible groups, but also, they are agile to organization adaptation and fit.

Transform

Figure 21 demonstrates the transformation capability of a medium-sized Company. It is significant that a medium-sized company design motive for their employees during the transformation process, enhancing the potential of attaining gainful results. A respondent from company D stated "*employees continuously receive training and recognition for personal achievements as well as people from "special social groups" are given special working terms depending on their needs and abilities*".

In addition, from the graph below it comes out that a medium-sized company targets also to be decentralized. They consider very importantly to them to engage their employees in the decision-making process. An interviewee from company D mentioned "*we usually ask for their opinion because the workers in the manufacturing department are the ones who know best of the situation there [...] We have mechanisms in our strategy that we ask employee engagement. There are people that can sense difficulties in the production process. Generally, the company attempts to involve all the employees to feel the company as their own, so that they can propose improvement actions*".
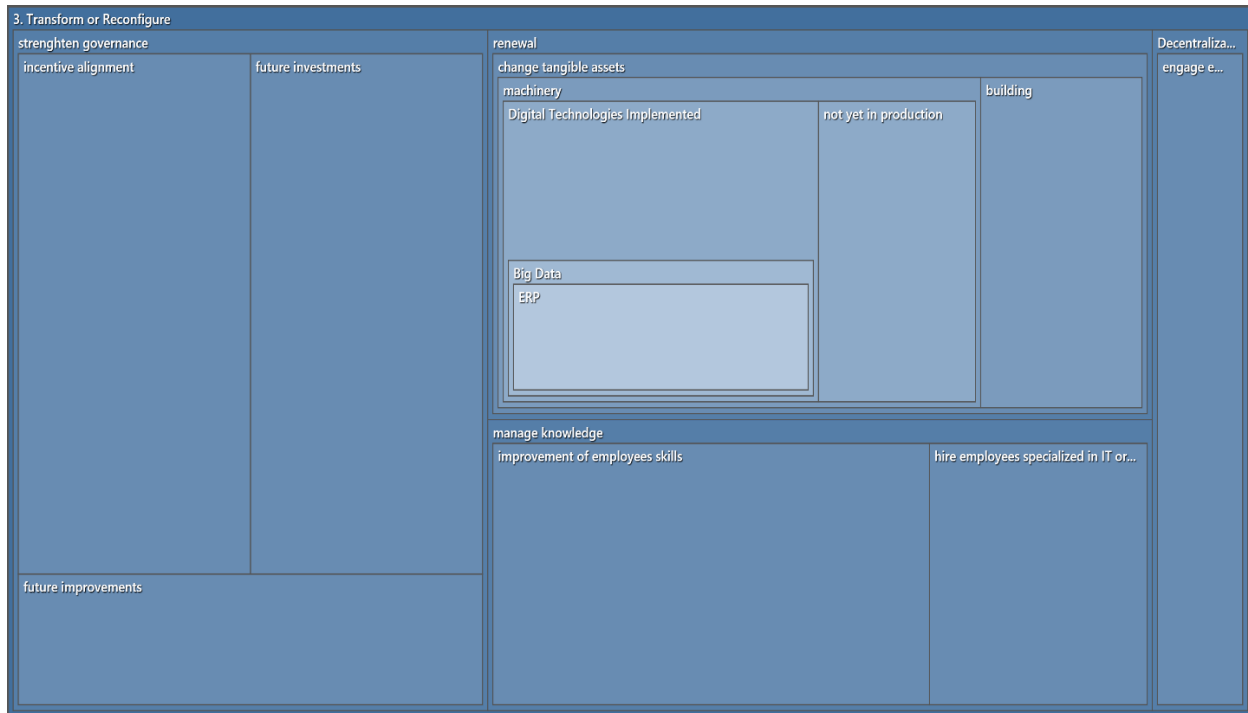
Figure 21 Transform capability of medium-sized Company

In conclusion, based on Teece Capability Framework (2007), for a medium-sized company to enhance its tangible and intangible assets, it is crucial to provide incentives to their employees during the process and to engage them in the transformation. They consider an important tool to have their workers opinion over the changes, because they knew better what is happening in the production than top management people. Also, they are investing in advancing their employees' skills, which let them feel motivated and passionate to work in such an environment.

6.2.1.4 Case Study 4: Large-Sized Company

Company E is an international company established in 1989. It operates in the female clothing, accessories and footwear production. It currently employs 250 people. The company is active in the design, production and marketing of clothing, accessories, footwear and jewelry. Also, it has an ever-expanding network of corporate and franchise stores in Greece and abroad (Cyprus, Czech Republic, Turkey, Poland, Serbia and Saudi Arabia). The respondents were from the marketing and supply chain department.

The coding analysis sheds light on the role of the Dynamic Capabilities in the digital transformation. The analysis of the resulted themes and categories were based on the Dynamic Capabilities Framework by Teece (Figure 12). Below there is an extensive analysis of the results for each aspect of the Dynamic Capabilities.

Sense

Figure 22 illustrates the way a large-sized apparel company senses the digital transformation. Although there are challenges that hinder innovation not only in small-sized but also in Large-sized companies, such as the financial situation in Greece, there is evidence that there is an arising development. Large-sized companies usually have their own R&D department that facilitates the sensing of the emerging opportunities. Having active R&D activities helps the company to recognize where the problematic areas are and what are the ideal solutions for it.
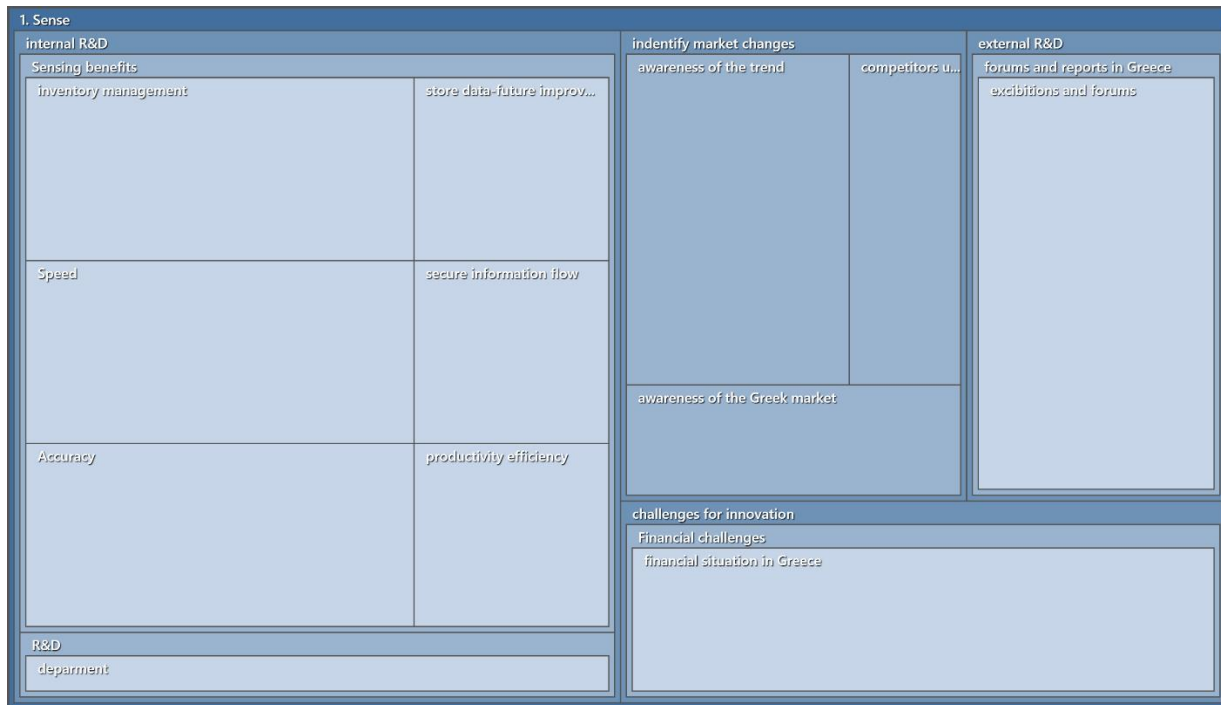
Figure 22 Sense capability of a large-sized Company

In addition, R&D is not the only way to sense the new potentials, the ability to identify faster the market changes is also very crucial for a company to gain and sustain its competitive advantage. Being responsiveness to the new trend and having knowledge of what other apparel manufacturers are using is a significant sensing capability that can be used to identify faster the potentials from the digital transformation. An interviewee from a large-sized company mentioned that "big sportswear companies have already implemented some of the new technologies in their production line and they are revolutionizing the industry, the way things are conceived, made and shipped to the customers". Thus, it is very important to have knowledge of what is happening in the apparel market in order to adapt easier to the new era and act faster than your competitor.

Seize

The seize capability is very important to address the sensed opportunities and capture value from them. Figure 23 illustrates the mechanisms that a large-sized firm use to address the sensed opportunities. Addressing opportunities requires improvements and investments in technological and complementary resources.

In a large-sized company once the opportunities have been sensed, it is essential to design mechanisms that would capture the value from them. After spotting the new prospects of the digitalization, they are creating a plan of where those new prospects can be implemented in their manufacturing process and improve the current processes. It is crucial to detect exactly which technologies are the best fit for their manufacturing in order to be able to capture value from them. Ways of seizing the new opportunities are enhancing employees' skills in order to motivate them and engage them in the transition phase. Moreover, they not only invest in having in-house R&D activities, but also, they collaborate with external partners in order to have a full overview of the benefits. An interviewee from company E mentioned that

they collaborate with external consultants in order to have a complete advice on how they can manage effectively the digital transformation.
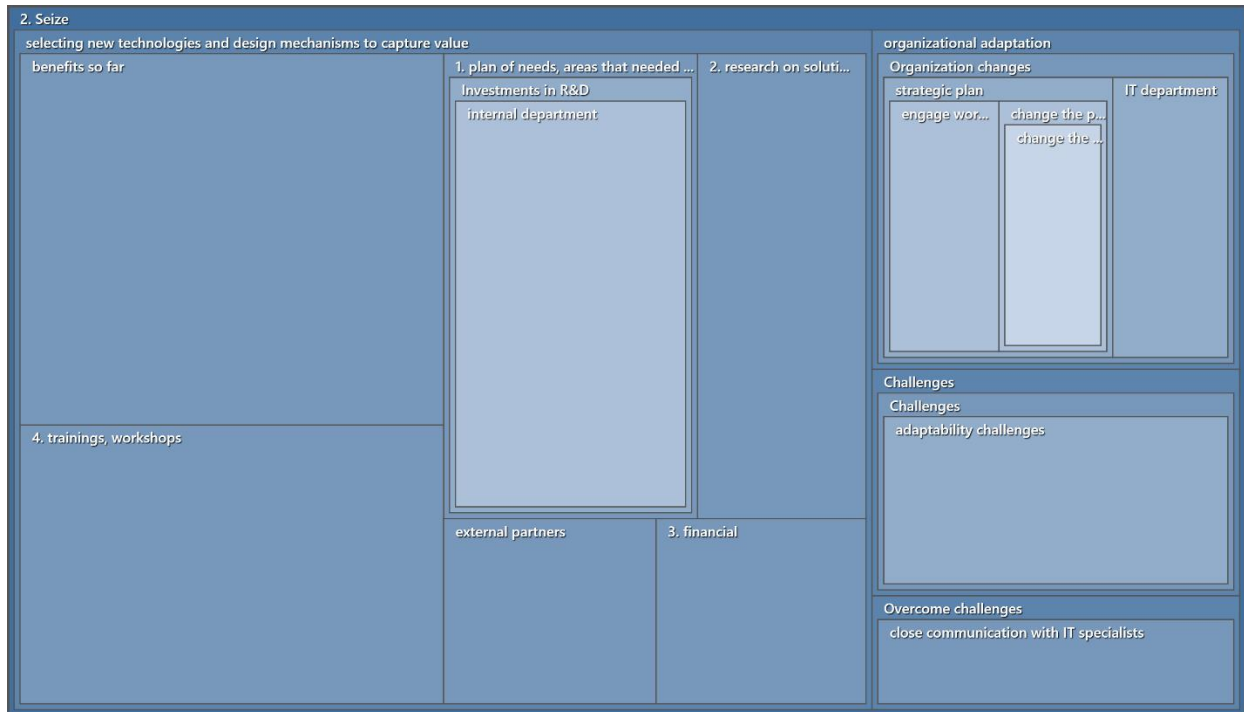

Figure 23 Seize capability of a large-sized Company

In addition, they invest in reshaping its business model. It is evident, that changes in the strategic plan and structure have to be done in order for those investments to be proved beneficial for the company. Currently they are investing in a motivation strategy to empower employees to participate in the digital transformation. Furthermore, they hired external employees with advanced IT skills in order to support the transition to the digital era.

Transform

Figure 24 illustrates the transforming capability of a large-sized company. The role of the Dynamic Capabilities is crucial for a firm to adapt to the digitalization world. Taking into consideration the aspects of the Teece Capability Framework (Figure 12), a large-sized company invests in reconfiguring its organizational and technological assets.

For a smooth transition, the company design mechanisms in order to avoid tensions among the activities of employees and the actions required to attain a profitable performance. Incentive alignments are necessary to motivate and empower workers to participate in the digitalization of the manufacturing process. Company E targets in advancing employee's skills to strengthen their motives for the transformation. Interviewee specified that the company "provides the opportunity to the employees to advance some of their skills, for instance technical skills but also the opportunity to broaden their knowledge around management, marketing and awareness around fashion trends with seminars".

Furthermore, a respondent from company E mentioned that they are still in the transition phase, but they have seen changes regarding their competitive position in the market. The respondent stated that the digital transformation of the company has increased by far their competitive position and they are seeking for future investments in order to maintain the competitive advantage. Future investments are

significant not only for staying active in the transformation but also to continuously trying to enhance their performance.
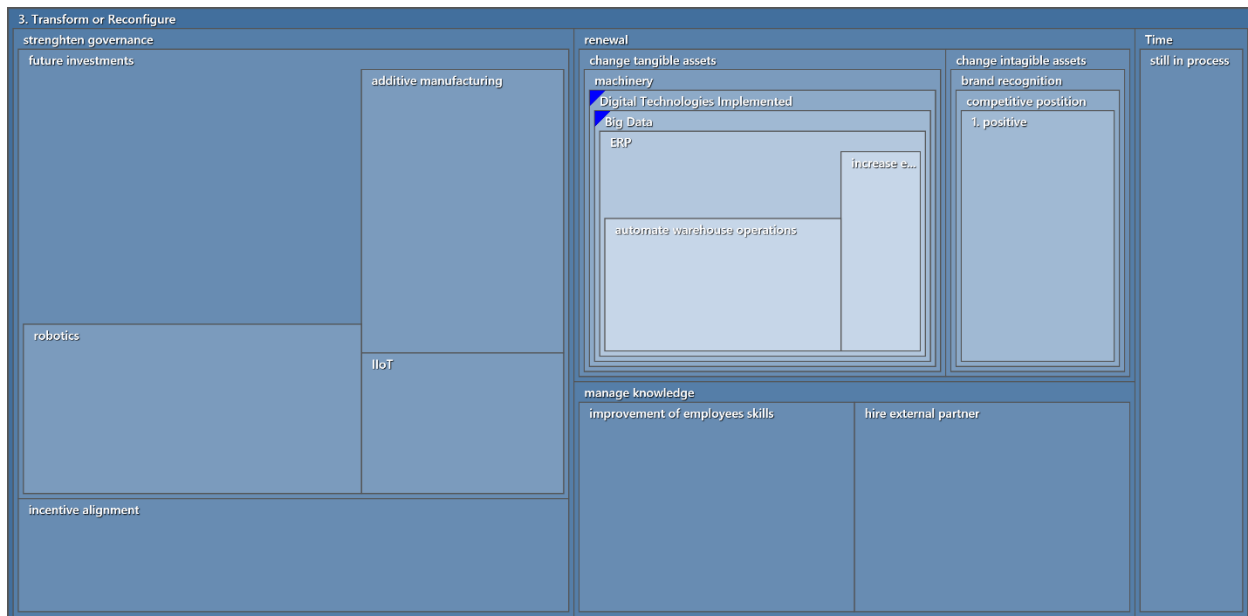
Figure 24 Transform capability of a large-sized company

Eurostat data and reports on the digital transformation of Greek apparel manufacturing

Secondary data was gathered from public databases and consultancy reports to increase the validity of the data gathered from the interviews. In addition, there is a comparison of the interview responses and the data gathered from online databases and reports to increase the strength of the research. Firstly, it is introduced a general overview of the situation of the apparel manufacturing in Greece and if they can sense the benefits. Secondly, it is presented how firms are seizing and transforming their dynamics around digital transformation.

Statistical data on the number of enterprises operating in the apparel manufacturing are showing in the graph below (Figure 25). It is evident that there is a significant reduction in the number of the companies over the years.

Figure 25 Number of enterprises operating in the wearing apparel (source: Eurostat)

Figure 26 shows the gross investment enterprises have done in machinery and equipment in the time period 2010-2015. It is evident, that in 2014 although the number of enterprises was slightly improved in comparison with the previous year the gross investment in machinery and equipment was decreased. However, in 2015 with much fewer companies the investment was increased. In the mid of 2015, there was a financial cr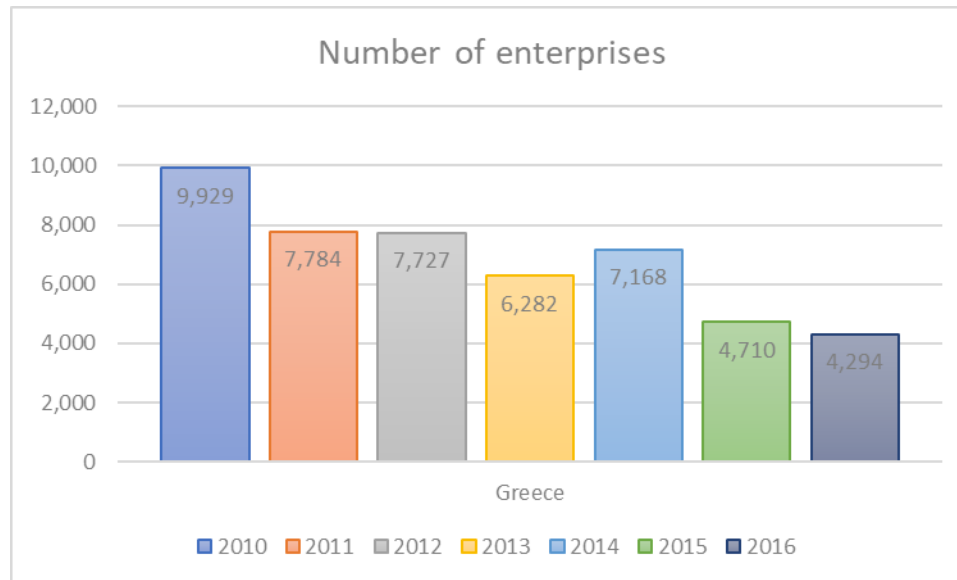isis in Greece where a lot of manufacturing activities were crashed out (Khan 2017). Based on the observation from the two graphs it is evident that despite the significant reduction of the apparel firms, the apparel manufacturers concentrated more on investment in machinery and equipment. The available data on R&D expenditure is illustrated in Figure 27. It is evident that in 2015 there was an increase in the business expenditure in R&D activities in comparison with 2013, where the expenses on R&D were much lower.

Furthermore, there is an increase in the R&D activities and in the investment in equipment and machinery the last year. Figure 28 illustrated the available data for 2014 for all the innovation activities that took place in the Greek apparel manufacturing. It is obvious that there is significant investment in R&D activities and in the acquirement of machinery, equipment and software. From this data, significant insights can be extracted that describes that there are actions that take place around the sensing of the digital era. In Figure 29 it is illustrated the challenges to not innovate for the year 2014. The reasons that are confirmed also from the data collected from the interview are the financial barriers and the uncertainty in the market demand. Moreover, there are also confessions from the interviews that they want to invest in innovation but there are large barriers, such as the uncertainty of the investment. More specifically, an interviewee mentioned "Because sometimes when something is very new, you do not trust it 100% of how profitable this will be, so you may wait first to see some results on others before investing".

Figure 26 Gross investment in machinery and equipment period 2010-2015 (source: Eurostat)
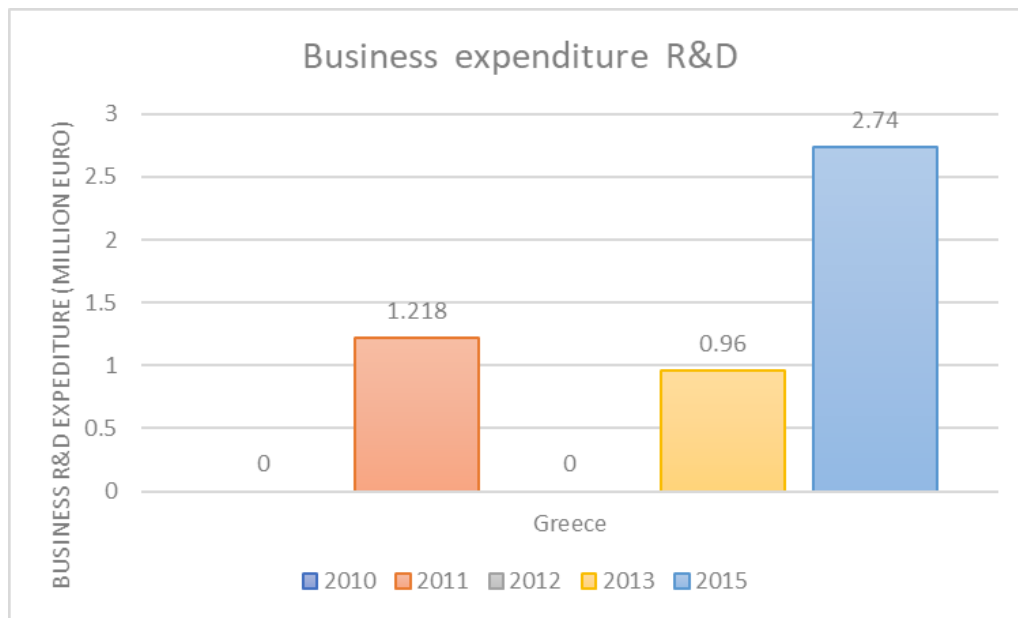

Figure 27 Business expenditure on R&D time period 2010-2015 (source: Eurostat)
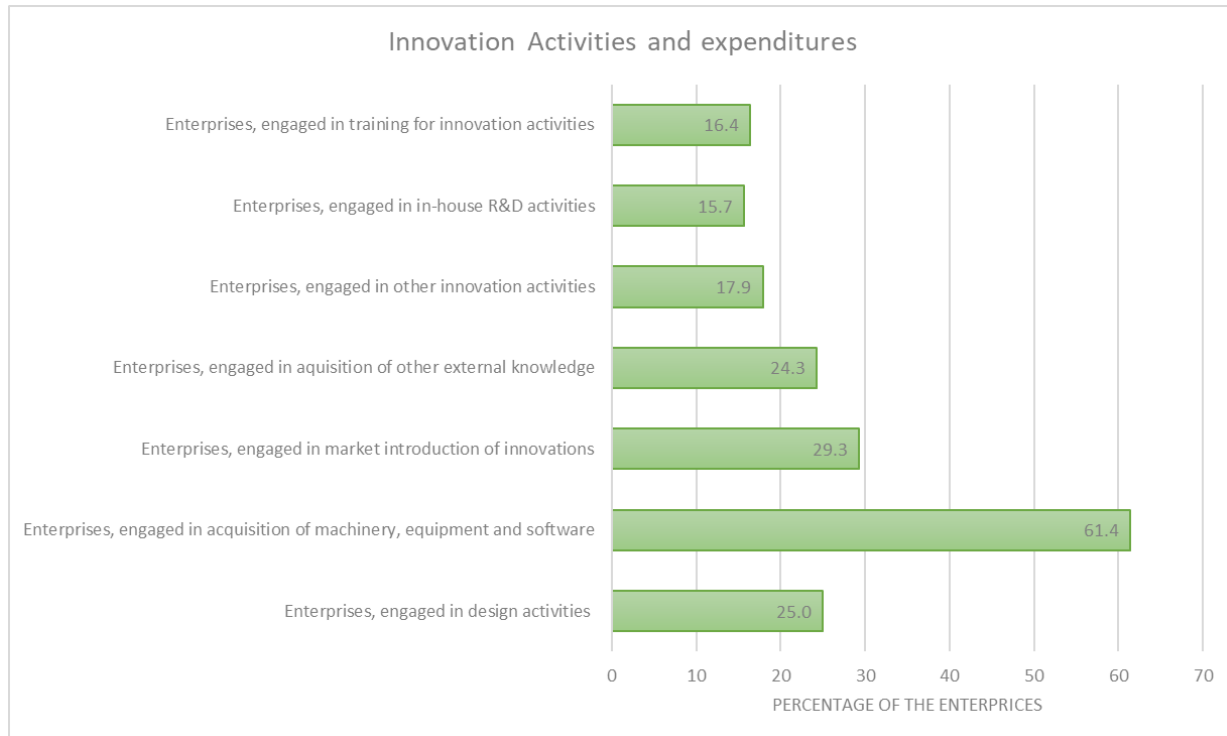
Figure 28 Innovation activities in apparel manufacturing for 2014 (source: Eurostat)
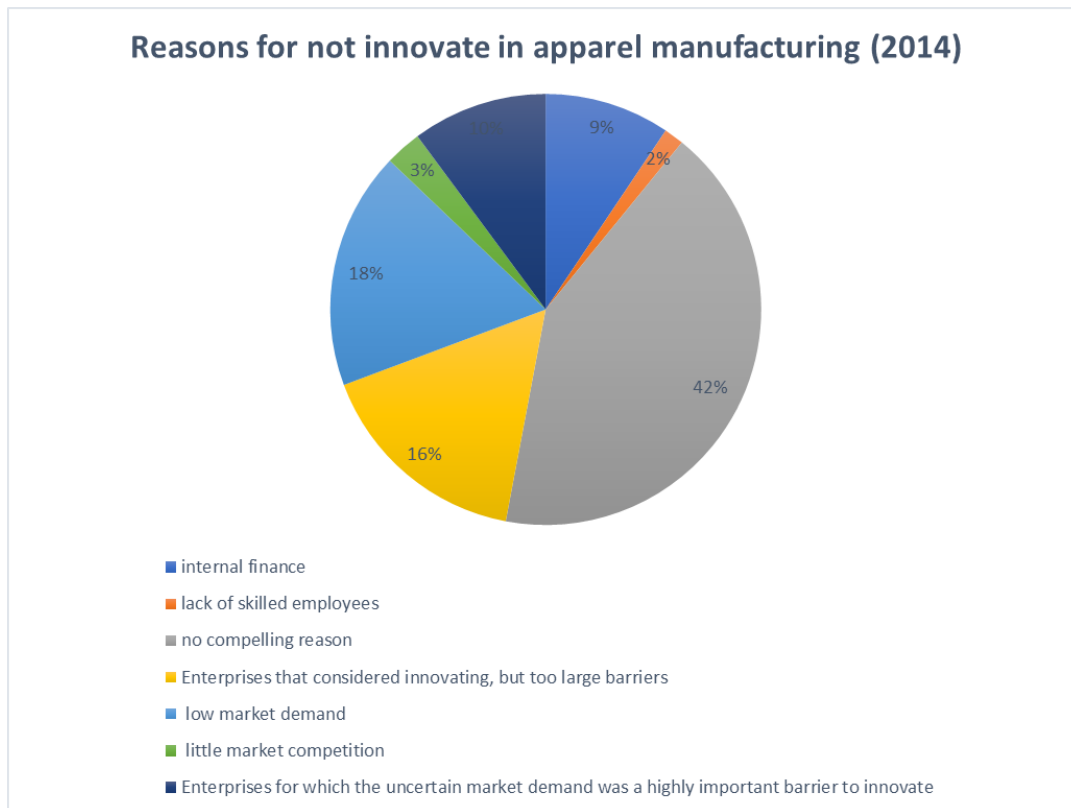
Figure 29 Reasons for not innovating in apparel manufacturing for 2014 (source: Eurostat)

The Internet is a basic tool on digital technologies, having connectivity among the devices and processes facilitate the digital transformation. From Figure 30 it is evident that the internet is in almost every apparel manufacturing company, covering 94% of the sector in 2017. All respondents mentioned that they use the Internet in most of their activities.

Another important "tool" that facilitate the road to digital transformation is acquiring IT skills in the company. Figure 31 demonstrates the percentage of enterprises that have invested in training their employees to develop and upgrade their ICT (Information and Communication Technology) skills. It is observed a slight decrease in 2017. In comparison with the other European countries as shown in Figure 32, 2016 was the year that there was a general action on training their employees around ICT skills in order to embrace them into the digital transformation. In comparison with the responses from the interviews, most of them revealed that if they do not acquire yet specialized IT personnel, they are in search for future hiring; as they consider an important knowledge to obtain during the transition process to gain most of the benefits from the new technologies.

Figure 30 Percentage of apparel manufacturers that have internet access (source: Eurostat)
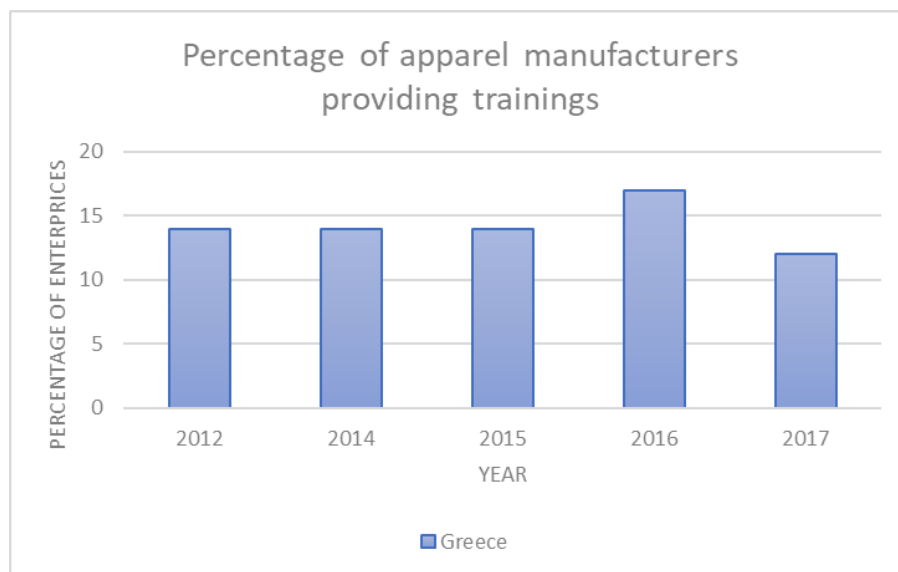
Figure 31 Percentage of apparel manufacturers that provide training to their employees (source: Eurostat)

All the respondents in the interviews mentioned that they have implemented an ERP system to facilitate warehousing operations while also the ordering process before the production. More specifically, respondent stated that "*The implementation of the ERP system automated a lot of the processes in the pre and post-production process and definitely improved the productivity and the efficiency of the tasks*". According to Figure 33 the percentage of the apparel manufacturers having an ERP software is more than 50 % in 2015, due to limited data there is not available for more recent years. However, Figure 34 shows the enterprises that are using Big Data to analyze data not only by using personnel but also using external resources. The graph illustrates data from 2016 and shows quite a significant movement analyzing data from internal resources, which leads us to the conclusion that enterprises have trained or hired employees with IT skills and have a Big Data technology, such as an ERP software.
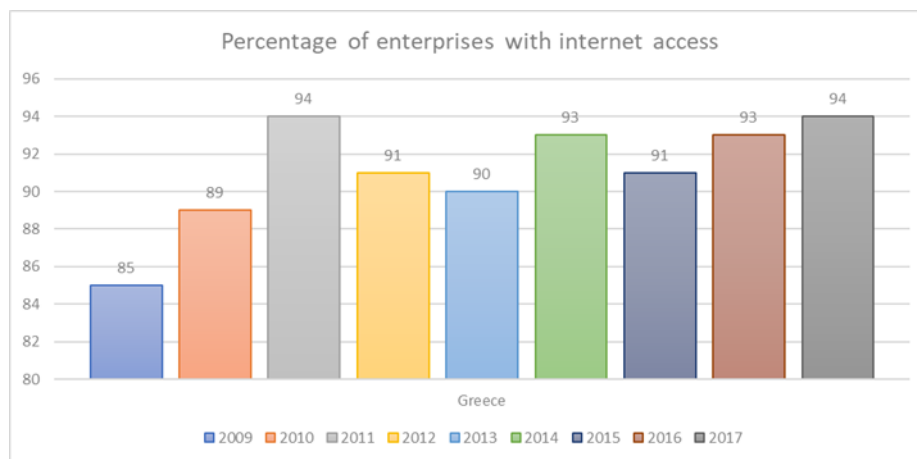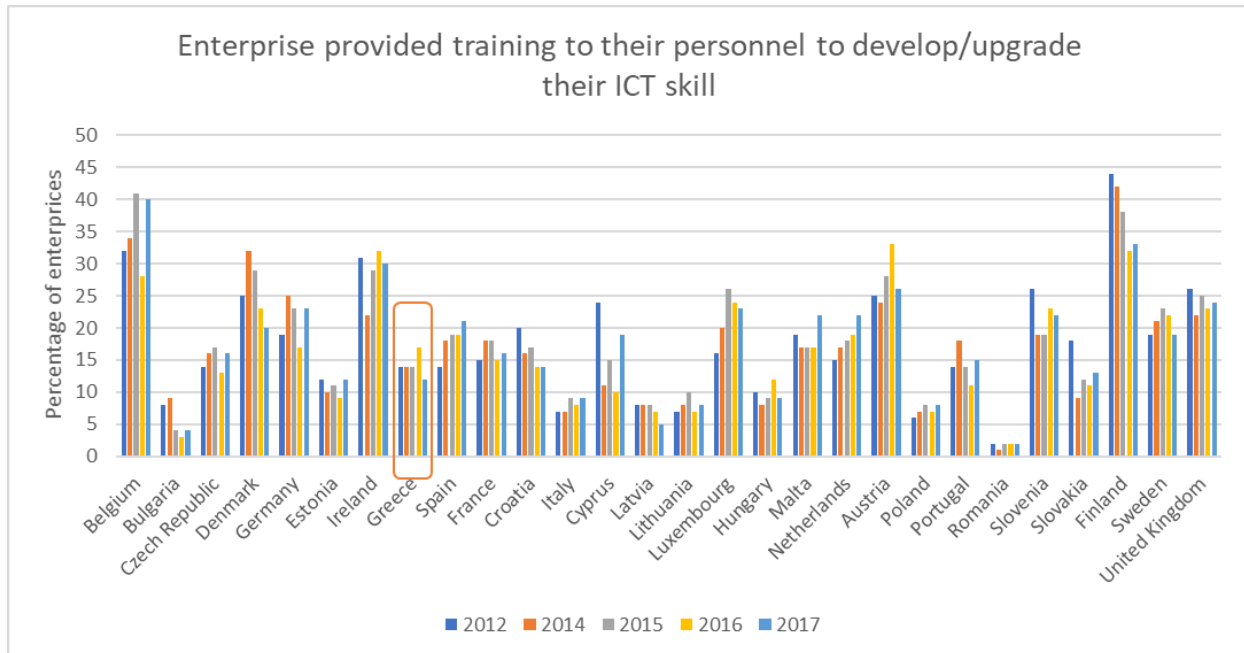

Figure 32 Percentage of Apparel manufacturers training their personnel (Source: Eurostat)
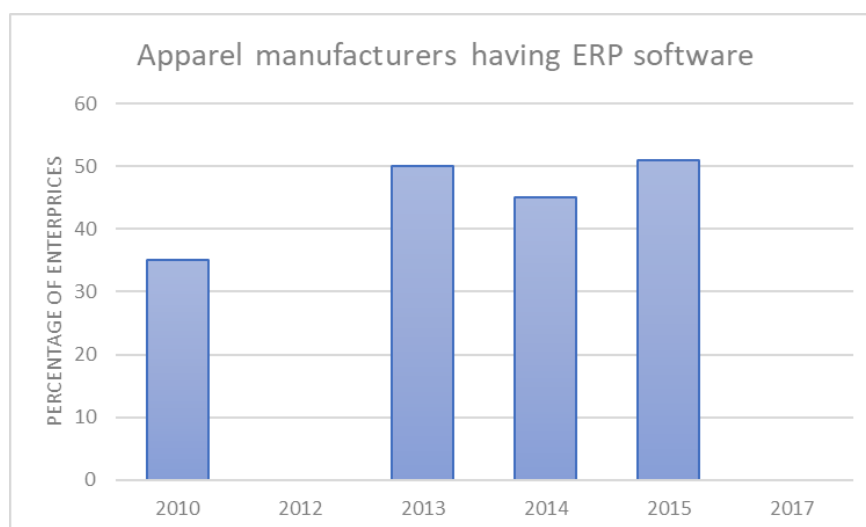
Figure 33 Percentage of apparel manufacturers having ERP software (source: Eurostat)
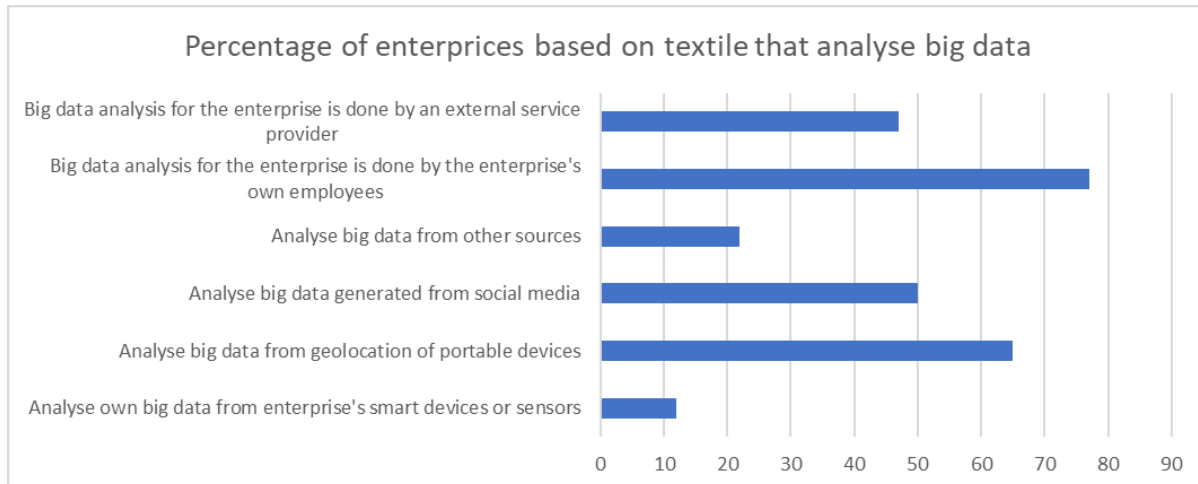
Figure 34 Percentage of enterprises based on textile using Big Data for 2016 (Source: Eurostat)

Concluding, there are activities around sensing the new opportunities in the apparel manufacturing but of the uncertainty in the market demand, due to financial reasons, Greece is undergoing the digital transformation at a small pace. However, there are actions that drive the apparel manufacturing in the digital transformation. For instance, by training their employees around IT specializations and engage them in the transition process. Taking into consideration the data extracted from the interviews and the secondary data extracted from public databases, it is evident that in Greece the last 3 years there are actions to embrace the digital transformation.

6.3 Summary of the findings

The main drivers for digital transformation (see Figure 35) resulted from the aforementioned analysis are the need to meet production targets faster and accurate and thus firm's growth. Little less need is the need to use digital technologies in the manufacturing to improve the reputation of the firm and to communicate with the wholesalers and suppliers (textile firms). Moreover, sustainability is also the main driver for the respondent firms which also is for Levi Strauss & Co (see Section 6.1) was a motivating power to innovate.
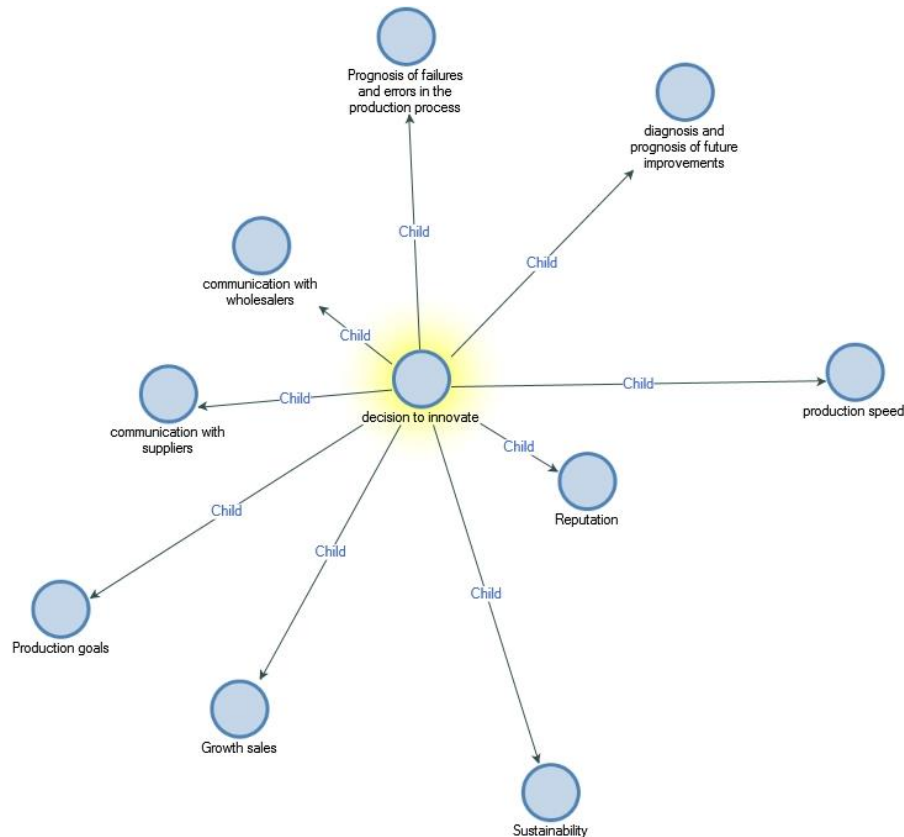
Figure 35 Drivers of digital transformation

From the analysis of the primary data, it is evident that most of the Greek apparel manufacturers are still in a transition phase. They invest in training their employees to acquire IT skills in order to engage them in the digital transformation. Most of the respondent companies, except the medium and the large one, they do not have an internal R&D department, but they appear to be more open-minded, having embraced the new innovative technologies and reshaped their business models. However, due to the financial situation, there is quite an uncertainty in the apparel industry, which is a considerable barrier to innovate. For that reason, the transformation to digitalization is going at a low pace.

The role of the Dynamic Capabilities in the digital transformation is crucial to first sense the benefits from the new technologies and then seize those opportunities and reconfigure the tangible and intangible assets so as to achieve a digital transformation. The respondent firms which vary from size and market share have the characteristics of the Dynamic Capabilities to support digital transformation, although they lack some aspects as described above. In comparison with the three giant apparel manufacturing firms that were described in section 6.1, the extent to which Greek manufacturers have undergone digital transformation is quite small but comparable. For instance, the respondent small-sized firms are lacking from a proper R&D department that will enable them to be the first to identify and shape the right mechanisms for their prosperity. However, they follow some R&D activities that facilitate the sensing of the opportunities. In addition, none of the respondents, even from the large firms did mention anything on the protection of their know-how. Limited awareness of the importance of the intellectual might be the reason.

Table 4 summarizes all the characteristics of the Dynamic Capabilities that have a significant role in the digital transformation of the apparel manufacturing in Greece.

Dynamic Capabilities		Micro Sized	Small Sized	Medium Sized	Large Sized
Sense	Internal R&D / select new technologies	-	-	+	+
	Collaborations	+	+	-	-
	External R&D	+	+	-	+
	Identify market changes	+	+	+	+
Seize	Reshape BM	+	+	+	+
	Decision-making protocols	-	-	+	+
	Enterprise boundaries to manage complements and "control platforms"	-	+	-	-
	Loyalty & Commitment	+	+	+	+
Transform	Decentralization	+	+	+	+
	Governance	+	+	+	+
	Cospecialization	-	-	-	-
	Knowledge Management	+	+	+	+

Table 4 Summarize the Dynamic Capabilities of all the seven firms based on the company size

7. Conclusions

The aim of the study is to shed light on how Greek apparel firms are managing the digital transformation. Comparison between the existing evidence describing the role of Dynamic Capabilities in established apparel companies that have undergone digital transformation and findings from primary research on apparel companies in Greece was done to give the primary data more credibility/reliability. This study offers insights on companies from different sectors and sizes in Greece. To identify how apparel companies in Greece deal with digital transformation in the manufacturing process, qualitative research and a multiple case-study analysis were applied. A multiple case-study was constructed to give a detailed analysis of the issue of digital transformation and its correlations to the Dynamic Capabilities framework.

To identify the Dynamic Capabilities of the firms, an extensive literature review on the topic was conducted. The Dynamic Capability Concept consisting of three groups of organization and managerial activities (sense, seize and transform) was used to provide an extensive analysis of how firms are achieved change in the digital era. The Teece framework (2007) (see Figure 12) with the three groups was selected

to analyze the results from the interviews and give an in-depth insight into how firms deal with the subject. Moreover, secondary data was gathered from online databases and consultancy reports and was used to add additional emphasis on how Greek apparel manufacturers are handling the transformation to a digital era.

The answer to the research question is given based on the analysis of the primary data supplemented with the secondary data. The research question of the study is "*What is the role of the Dynamic Capabilities in the Digital Transformation of the apparel manufacturing in Greece?*".

The apparel manufacturing involves three main phases – design, production and distribution- all of which are facing huge changes due to the implementation of new digital technologies. The design phase is being transformed from paper-based techniques to an entirely digital one, using 3D fashion design software. In addition, the production phase is replacing the manual work with machinery using digital technologies to improve productivity and accuracy. Finally, in the distribution phase, warehouse operations and coordination of the entire process is being transformed to an automated process, enhancing the precision of the procedure and the productivity.

From the analysis, it is evident that apparel manufacturers in Greece are still in a transition phase. There is a limited awareness of the clothing market about the advantageous implementations of the digital technologies in the manufacturing. From the Eurostat data, it is evident that low market demand is one of the reasons companies are not considering innovating in that direction.

Considering the Eurostat data, Greek apparel manufacturers are aware of the benefits from some of the digital technologies, for instance Big Data. The percentage of the firms using Big Data reached 78% in 2016, which concludes that there is an awareness of some digital technologies. Knowledge around robotics, additive manufacturing, IoT, augmented reality and simulation are still in the primary phase. Most of the resources that respondent companies using to extract information an raise awareness on the topic are exhibitions and forums. Rarely firms have an internal R&D mechanism that will allow them a more comprehensive understanding of trend. However, R&D is not the only one aspect of Dynamic Capabilities that will facilitate the company to sense the trend, collaborations are another useful tool that contributes to effectively identify market opportunities and changes easier and faster. The role of a sensing capability consists of mostly collaborations with external partners and outsourcing R&D activities that help micro and small-sized firms to identify market opportunities. While for medium and large-sized firms, it is evident that the internal R&D mechanism and outsourcing activities facilitate the identification of the digital movement.

After sensing it is important for a firm to have the right mechanisms to seize those opportunities. Micro and small-sized companies consider that reshaping the business model will facilitate to capture value from the new technologies. Small-sized firms are using complementary support from external partners to identify and avoid bottleneck assets that may occur during the transition process. In addition, medium and large-sized firms not only reshape their strategy, but they also have standardized procedures in the decision making so as to avoid errors and biases during this phase. Moreover, taking into consideration the Eurostat data all firms, regardless of size, consider that engaging and motivating their employees will enable them to grasp the benefits from the new technologies more effectively. In conclusion, the role of

seizing capability is mainly supported by reshaping the business model and creating a motivation strategy for the employees to engage them in the process.

The successful recognition and adjustment of technological opportunities lead to a firm's development and profitability (Teece 2007). A key to maintain the competitive advantage is the ability to transform or reconfigure assets and structures. All the respondents mentioned the importance of engaging employees in the decision-making process. By doing this, firms are enabled to achieve better liability of managerial decisions so that the "recognition of opportunities and threats could proceed more thoroughly and expeditiously" (Teece 2007, p.1336). Another important aspect of a transformation capability that all the respondents mentioned is the knowledge. It is very important to enrich and develop personnel's skills and current company's knowledge resources to gain profit from the new technologies. In addition, incentives are shaped to the employees to empower the transition by improving their skills and rewarding them. In conclusion, the role of the transformation capability for apparel manufacturers in Greece mainly is supported by enhancing employees' knowledge to support the digitalization of the manufacturing and provide them incentives to motivate them to engage in the transition. Also, in conjunction with the Eurostat data, all firms invest in expanding their personnel to support the implementation of new technologies.. In addition, regarding the major problems that the apparel industry is facing (see Introduction), the findings lead to the conclusion that digital transformation is important to overcome the challenges of poor market research and an easier and more precise method to monitor competition. Based on the findings from secondary data, digital technologies are a way to develop original and novel creations, in a world that fashion industry is characterized by mass production

8. Discussion

8.1 Theoretical implications

The current study provides insights which contribute to the existing literature of firms' Dynamic Capabilities and the digital transformation of apparel manufacturing firms. In addition to firms' Dynamic Capabilities, the current analysis offers valuable insights into the applicability of the digital technologies in the apparel manufacturing and the degree in which Greek apparel manufacturers have been digitally transformed.

The analysis suggests that Dynamic Capabilities Framework (Teece 2007), represents how Dynamic Capabilities influence the digital transformation of the manufacturing process of firms examined. For the examination, micro to large-sized firms were tested to provide a holistic overview of the implementation of digital technologies in the manufacturing. Furthermore, the conclusion provided was that regardless of the size, Greek manufacturers have already implemented some digital technologies either in the pre-production and post-production or in the production process. However, due to lack of proper mechanisms and to financial reasons they are lacking to get full advantage of all the new digital technologies.

In terms of the Dynamic Capability Framework (Teece 2007) and the presented results, firms need to have mechanisms that will benefit the identification of opportunities and threats from digital technologies (Teece 2007). Greek apparel manufacturers have some of the necessary mechanisms that needed to identify and sense the opportunities from digital technologies and gain competitive advantage. However,

according to the responses there is a lack of specialized employees in R&D and IT that would facilitate companies to fully understand the benefits from the new technologies. On the other hand, Greek firms are engaging with external partners to get advices and consultations on the implementation of new technologies. Moreover, most of the respondents mentioned that although they are aware of the Industry 4.0, they are not yet fully alerted for all the digital technologies that can be implemented in the manufacturing. Therefore, Greek firms can sense the benefits but not yet in the whole, due to the limited awareness of the trend. Taking into consideration the seize capability, it is important to reshape business strategies and changes in the resource base of the firm to seize the sensed opportunities (Teece 2007; Reilly & Tushman 2007). Greek firms do not refuse to change its resource base, however due to the financial crisis, they are undergoing changes in a small pace. Based on the transformation capability, it is essential to reconfigure or transform tangible and intangible assets in order to ensure a continuous development and a competitive advantage (Teece 2007; Åberg et al. 2017). Greek apparel manufacturers are still in the transition phase, but according to their responses their current transforming capabilities can benefit the transition and ensured a competitive advantage.

8.2 Limitations to research

To ensure the viability of conducting this research in six months, the study focus was limited. An aspect that could consider a limitation is the small sample that used in the analysis part. In addition, due to the small primary data it could be the likelihood that the respondent's viewpoint is an imprecise reflection of the events. However, the use of secondary data benefitted the enhancement of the reliability and validity of the research.

To augment and extend this study's findings with large quantitative databases, the need for further examination is highlighted. Conducting this research again using quantitative data and adopting other qualitative methods and more comparable case studies would be valuable to provide a further overview of the digital transformation of apparel manufacturing. Nonetheless, it can be argued that this study is an initial attempt to investigate and examine the stage at which apparel manufacturing firms are experiencing digital transformation. There are limitations according to the small sample and there is limited viewpoint on the role of the Dynamic Capabilities in the digital transformation on large and medium-sized firms. Therefore, it would be interesting a similar investigation but specified for medium or large-sized firms. Moreover, it would be interesting to investigate in the future the extent to which apparel manufacturers have undergone digital transformation and providing qualitative and quantitative case studies.

8.3 Managerial implications

The conclusions of this research indicate that the Greek apparel manufacturing is now undergoing digital transformation in a slow pace but has potentials to develop and enhance its Dynamic Capabilities to further grasp the advantages from a holistic digital transformation in the future.

Firms are sensing the benefits that digital transformation offers but are lacking mechanisms that will facilitate the proper transition to the digital era. Specialized persons in R&D can influence the sense and the full understanding of the benefits that digital technologies offer. Moreover, having specialized employees can facilitate the proactive identification of problems, while also the methods that can be used

to overcome those challenges. It is very important for firms, to stay ahead of the new trend in order to survive. Digital technologies, such as robotics and additive manufacturing, are transforming the manufacturing in the apparel industry and firms have to be flexible and agile to adapt to the new era. Firms should create the necessary communications and infrastructures to successfully understand and manage data and real-time information that will benefit the construction of new business models and therefore the attainment of the competitive advantage.

However, Greece is now getting awareness of the digital transformation of the apparel manufacturing and has the potential to develop the needed capabilities. It is important to be fully informed about the benefits from digital technologies and the suitable areas of the application, to take a full advantage of it. By areas of applications, it is meant the perfect timing and place of the implementation in the manufacturing process. Moreover, it is crucial to have knowledge of the mechanisms that would benefit the smooth transformation process. Such mechanisms can be research and development but also future collaborations. Therefore, it is significant for a firm to acquire Dynamic Capabilities to better manage the digital transformation and gain competitive advantage.

References

Abd Jelil, R., 2018. Review of Artificial Intelligence Applications in Garment Manufacturing BT - Artificial Intelligence for Fashion Industry in the Big Data Era. In S. Thomassey & X. Zeng, eds. Singapore: Springer Singapore, pp. 97–123. Available at: https://doi.org/10.1007/978-981-13-0080-6_6.

Åberg, C., Kazemargi, N. & Bankewitz, M., 2017. Strategists on the Board in a Digital Era. *Business and Management Research*, 6(2), pp.40–51. Available at: http://www.sciedu.ca/journal/index.php/bmr/article/view/11552.

Adidas, 2017. Adidas Group Management Report 2017. *Adidas Group annual report*. Available at: https://report.adidas-group.com/media/pdf/EN/adidas_AR_2017_GroupMgmtReport_EN.pdf [Accessed August 1, 2018].

Ahmad, M., Papert, M. & Pflaum, A., 2018. Dynamic Capabilities related Implementation Skills for Internet of Things Solutions in the Digital Economy. In *51st Hawaii International Conference on System Sciences*. pp. 3996–4005.

Anand, G. & Ward, P.T., 2009. Fit, Flexibility and Performance in Manufacturing: Coping with Dynamic Environments. *Production and Operations Management*, 13(4), pp.369–385. Available at: http://doi.wiley.com/10.1111/j.1937-5956.2004.tb00224.x.

Armenakis, A.A. & Bedeian, A.G., 1999. Organizational change: a review of theory and research in the 1990s. *Journal of Management*, 25(3), pp.293–315. Available at: http://www.sciencedirect.com/science/article/pii/S0149206399000045.

Artschwager, A. et al., 2009. New Quality of Partnership in the Textile World – Concepts and Technologies. In L. Walter, G.-A. Kartsounis, & S. Carosio, eds. *Transforming Clothing Production into a Demand-driven, Knowledge-based, High-tech Industry: The Leapfrog Paradigm*. London: Springer London, pp. 141–200. Available at: https://doi.org/10.1007/978-1-84882-608-3_5.

Bahrin, M.A.K. et al., 2016. Industry 4.0: A review on industrial automation and robotic. *Research Gate*, 78(6–13), pp.137–143.

Berman, S.J., 2012. Digital transformation: opportunities to create new business models. *Strategy & Leadership*, 40(2), pp.16–24. Available at: http://www.emeraldinsight.com/doi/10.1108/10878571211209314.

Biggam, J., 2008. Succeeding with your Master's Dissertation: a step-by-step handbook. *Design and Technology Education: an International Journal*, 14, p.208. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Succeeding+with+your+Master?s+Dissertation:+a+step-by-step+handbook#0.

Bonfanti, A., Giudice, M. Del & Papa, A., 2018. Italian Craft Firms Between Digital Manufacturing , Open Innovation , and Servitization. , pp.136–149.

Book, W.J. et al., 2010. AUTOMATED GARMENT MANUFACTURING SYSTEM USING NOVEL SENSING AND ACTUATION. *Proceedings of 2010 ISFA*, pp.1–10.

Bovey, W.H. & Hede, A., 2001. Resistance to organizational change: the role of cognitive and affective processes. *Leadership & Organization Development Journal*, 22(8), pp.372–382. Available at: http://www.emeraldinsight.com/doi/10.1108/01437730110410099.

Bruce, M., Daly, L. & Towers, N., 2004. Lean or agile: A solution for supply chain management in the textiles and clothing industry? *International Journal of Operations & Production Management*,

24(2), pp.151–170. Available at: http://www.emeraldinsight.com/doi/10.1108/01443570410514867.

Bryman, A., 2012. Social research methods Bryman. *OXFORD University Press*, p.766.

Byrne, C., 2000. CLOTHING INDUSTRY R & TD IN THE 1980s. *Europe*.

Chin, M., 2018. adidas SPEEDFACTORY Wins 2018 German Innovation Award. *Hypebeast*. Available at: https://hypebeast.com/2018/4/adidas-speedfactory-wins-german-innovation-award-2018 [Accessed July 30, 2018].

Cognizant, 2017. How Digital is Reinventing Levi Strauss & Co.'s IT Business Model. , 10(1), pp.1–5.

Colovic, G., 2014a. The Garment Industry Problems. *Journal of Textile Science & Engineering*, 04(06), p.1000168. Available at: http://omicsgroup.org/journals/the-garment-industry-problems-2165-8064.1000168.php?aid=31230.

Colovic, G., 2014b. The Garment Industry Problems. *Journal of Textile Science & Engineering*, 04(05), p.1000168. Available at: http://omicsgroup.org/journals/the-garment-industry-problems-2165-8064.1000168.php?aid=31230.

DevicePlus, 2018. SewBot Is Revolutionizing the Clothing Manufacturing Industry. Available at: http://www.deviceplus.com/connect/sewbot-in-the-clothing-manufacturing-industry/ [Accessed April 26, 2018].

Ebner, G. et al., 2013. Operational Excellence through Digital in Manufacturing Industries. *Capgemini Consulting Group*, pp.1–15.

Endres, H., 2017. *Adaptability Through Dynamic Capabilities: How Management Can Recognize Opportunities and Threats By Herbert Endres*, Springer Gabler.

European Commission, 2017. *Germany: Industrie 4.0*, Available at: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie 4.0.pdf.

Eurostat, 2018. SMALL AND MEDIUM-SIZED ENTERPRISES (SMES). *Eurostat*. Available at: http://ec.europa.eu/eurostat/web/structural-business-statistics/structural-business-statistics/sme.

Gabriel, M. & Pessl, E., 2016. Industry 4.0 and Sustainability Impacts: Critical Discussion of Sustainability Aspects With a Special Focus on Future of Work and Ecological Consequences. *Annals of the Faculty of Engineering Hunedoara*, 14(2), p.131.

Gereffi, G. & Korzeniewicz, M., 1994. Commodity chains and Global capitalism. , pp.94–122.

Gill, P. et al., 2008. Methods of data collection in qualitative research: Interviews and focus groups. *British Dental Journal*, 204(6), pp.291–295.

Golafshani, N., 2003. Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report*, 8(4), pp.597–607. Available at: http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf.

Green, D., 2018. Adidas just opened a futuristic new factory — and it will dramatically change how shoes are sold. *Business Insider*. Available at: https://www.businessinsider.nl/adidas-high-tech-speedfactory-begins-production-2018-4/?international=true&r=US [Accessed July 30, 2018].

Green, D., 2017. Nike and Adidas are making huge investments that should terrify Under Armour. *Business Insider*. Available at: https://www.businessinsider.nl/morgan-stanley-note-on-adidas-nike-2017-6/?international=true&r=US [Accessed August 1, 2018].

Hallgren, M. & Olhager, J., 2009. Lean and agile manufacturing: external and internal drivers and

performance outcomes. *International Journal of Operations & Production Management*, 29(10), pp.976–999. Available at: http://www.emeraldinsight.com/doi/10.1108/01443570910993456.

Hanelt, A. et al., 2015. Digital Transformation of Primarily Physical Industries – Exploring the Impact of Digital Trends on Business Models of Automobile Manufacturers. *12th International Conference on Wirtschaftsinformatik*, (October), pp.1313–1327.

Ibarra, D., Ganzarain, J. & Igartua, J.I., 2018. Business model innovation through Industry 4.0: A review. *Procedia Manufacturing*, 22, pp.4–10. Available at: http://linkinghub.elsevier.com/retrieve/pii/S2351978918302968.

Iscoop, 2017. Industry 4.0: the fourth industrial revolution – guide to Industrie 4.0. Available at: https://www.i-scoop.eu/industry-4-0/ [Accessed March 5, 2018].

Jain, S. et al., 2017. Big data in fashion industry. *IOP Conference Series: Materials Science and Engineering*, 254(15), pp.13–19.

Jayatilake, H. & Rupasinghe, T.D., 2016. Implementing Industry 4.0 in the apparel industry; A study to design a customized smart apparel production plant. *Research Gate*, (February), pp.1–3.

Jayatilake, H.S.B. & Withanaarachchi, A.., 2016. Industry 4.0 In The Apparel-Manufacturing Sector: Opportunities For Sri Lanka. In *1st Interdisciplinary Conference of Management Researchers, At Sabaragamuwa University of Sri Lanka*. pp. 1–10. Available at: ssrn: https://ssrn.com/abstract=2881329.

Kadir, B.A., 2017. The nine pillars of Industry 4.0. Available at: https://www.4thpost.com/single-post/2017/07/23/The-nine-pillars-of-Industry-40 [Accessed March 5, 2018].

Kang, H.S. et al., 2016. Smart manufacturing: Past research, present findings, and future directions. *International Journal of Precision Engineering and Manufacturing - Green Technology*, 3(1), pp.111–128.

Khan, M., 2017. Greece's manufacturing sector is growing again (a bit). *Financial Times*. Available at: https://www.ft.com/content/d035c499-8e47-3f61-82da-d72389d74c0a.

Kiel, D., Müller, J.M., et al., 2017. *Sustainable Industrial Value Creation: Benefits and Challenges of Industry 4.0*, Available at: http://www.worldscientific.com/doi/abs/10.1142/S1363919617400151.

Kiel, D., Arnold, C. & Voigt, K.I., 2017. The influence of the Industrial Internet of Things on business models of established manufacturing companies – A business level perspective. *Technovation*, 68(October), pp.4–19. Available at: http://dx.doi.org/10.1016/j.technovation.2017.09.003.

Kumar, S., 2005. Supply Chain Strategies in the Apparel Industry : The Case of Victoria ' s Secret Supply Chain Strategies in the Apparel Industry : The Case of Victoria ' s Secret Master of Engineering in Logistics.

Landherr, M., Schneider, U. & Bauernhansl, T., 2016. The Application Center Industrie 4.0 - Industry-driven Manufacturing, Research and Development. *Procedia CIRP*, 57, pp.26–31. Available at: http://dx.doi.org/10.1016/j.procir.2016.11.006.

Lasi, H. et al., 2014. Industry 4.0. *Business and Information Systems Engineering*, 6(4), pp.239–242.

Liere-Netheler, K., Packmohr, S. & Vogelsang, K., 2018. Drivers of Digital Transformation in Manufacturing. , pp.3926–3935.

Loetscher, S. et al., 2017. Changing fashion The clothing and textile industry at the brink of radical transformation.

Louise, J., 2015. The Adidas "Speed Factory" Aims To Bring Local Customization To Manufacturing. *Fast Company*. Available at: https://www.fastcompany.com/3054380/the-adidas-speed-factory-aims-to-bring-local-customization-to-manufacturing.

LS & Co. Unzipped Staff, 2018a. PROJECT F.L.X.: A SIMPLE SIDE-BY-SIDE PROCESS GUIDE. *Levi Strauss & Co*. Available at: http://www.levistrauss.com/unzipped-blog/2018/02/28/project-f-l-x-simple-step-step-guide/ [Accessed August 2, 2018].

LS & Co. Unzipped Staff, 2018b. PROJECT F.L.X. REDEFINES THE FUTURE OF HOW JEANS ARE DESIGNED, MADE AND SOLD. *Levi Strauss & Co*. Available at: http://www.levistrauss.com/unzipped-blog/2018/02/27/project-f-l-x-redefines-future-jeans-designed-made-sold/ [Accessed August 2, 2018].

Maijanen, P. & Ritala, P., 2017. Managing digital transformation : Cross-level analysis of dynamic capabilities in a media company. In *EMMA 2017 Conference 10-12 May, Ghent, Belgium*. pp. 1–19.

McKinsey, 2017. The State of Fashion. *Business of Fashion and McKinsey & Company*, 63(12), pp.42–43.

Meister, J., 2014. A New Way Of Working And Learning: Adidas Style. *Forbes*. Available at: https://www.forbes.com/sites/jeannemeister/2014/07/21/a-new-way-of-working-and-learning-adidas-style/#52f7c5612adc [Accessed August 1, 2018].

Müller, J.M., Kiel, D. & Voigt, K.-I., 2018. What Drives the Implementation of Industry 4.0? The Role of Opportunities and Challenges in the Context of Sustainability. *Sustainability*, 10(1), p.247. Available at: http://www.mdpi.com/2071-1050/10/1/247.

Neves, P. & Caetano, A., 2006. Social Exchange Processes in Organizational Change: The Roles of Trust and Control. *Journal of Change Management*, 6(4), pp.351–364. Available at: http://www.tandfonline.com/doi/abs/10.1080/14697010601054008.

Newell, S. & Marabelli, M., 2015. Strategic opportunities (and challenges) of algorithmic decision-making: A call for action on the long-term societal effects of "datification." *Journal of Strategic Information Systems*, 24(1), pp.3–14.

Newman, D., 2017. Top 5 Digital Transformation Trends In Manufacturing. *Forbes*. Available at: https://www.forbes.com/sites/danielnewman/2017/08/08/top-5-digital-transformation-trends-in-manufacturing/#607c168f249f [Accessed February 12, 2018].

Nike, 2015. NIKE'S MANUFACTURING REVOLUTION ACCELERATED BY NEW PARTNERSHIP WITH FLEX. *Nike news*. Available at: https://news.nike.com/news/nike-s-manufacturing-revolution-accelerated-by-new-partnership-with-flex [Accessed August 1, 2018].

Nike, 2018. WHAT IS NIKE FLYPRINT? Available at: https://news.nike.com/news/nike-flyprint-3d-printed-textile [Accessed August 1, 2018].

OECD, 2018. Enterprises by business size. *OECD publishing*. Available at: https://data.oecd.org/entrepreneur/enterprises-by-business-size.htm [Accessed August 14, 2018].

Oks, S.J., Fritzsche, A. & Möslein, K.M., 2017. An Application Map for Industrial Cyber-Physical Systems. In S. Jeschke et al., eds. *Industrial Internet of Things: Cybermanufacturing Systems*. Cham: Springer International Publishing, pp. 21–46. Available at: https://doi.org/10.1007/978-3-319-42559-7_2.

Paritala, P.K., Manchikatla, S. & Yarlagadda, P.K.D.V., 2017. Digital Manufacturing- Applications Past, Current, and Future Trends. *Procedia Engineering*, 174, pp.982–991. Available at: http://dx.doi.org/10.1016/j.proeng.2017.01.250.

Parviainen, P. et al., 2017. Tackling the digitalization challenge: how to benefit from digitalization in practice. *International Journal of Information Systems and Project Management*, 5(1), pp.63–77. Available at: http://www.sciencesphere.org/ijispm/archive/ijispm-0501.pdf#page=67.

Pattanachai, K., 2016. Guideline for Garments Manufacturing Process. Available at: https://www.linkedin.com/pulse/guideline-garments-manufacturing-process-pattanachai-kaewkanha/.

Pazireh, E., Sadeghi, A.H. & Shokohyar, S., 2017. Analyzing the enhancement of production efficiency using FMEA through simulation-based optimization technique: A case study in apparel manufacturing. *Cogent Engineering*, 4(1), pp.1–12. Available at: http://dx.doi.org/10.1080/23311916.2017.1284373.

Perella, M., 2015. New fabrics make recycling possible, but are they suitable for high street? *The Guardian*. Available at: https://www.theguardian.com/sustainable-business/sustainable-fashion-blog/2015/jan/22/fabric-recycling-closed-loop-process-high-street-fashion.

Porter, M.E. & Heppelmann, J.E., 2014. How Smart, Connected Product Are Transforming Competition. *Harvard Business Review*, (November), pp.64–89.

Prasanta, S., 2013. garment manufacturing process flow chart. Available at: http://www.onlineclothingstudy.com/2013/05/garment-manufacturing-process-flow-chart.html.

Radziwon, A. et al., 2014. The smart factory: Exploring adaptive and flexible manufacturing solutions. *Procedia Engineering*, 69, pp.1184–1190. Available at: http://dx.doi.org/10.1016/j.proeng.2014.03.108.

Reilly, C.O. & Tushman, M.L., 2007. Ambidexterity as a Dynamic Capability: Resolving the Innovator's Dilemma. *Journal of Management*, 1904(1963), pp.185–206. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=978493.

Reuters staff, 2015. Adidas buys fitness tracking app maker Runtastic. *Reuters*. Available at: https://www.reuters.com/article/us-runtastic-m-a-adidas/adidas-buys-fitness-tracking-app-maker-runtastic-idUSKCN0QA20620150805 [Accessed August 1, 2018].

Richter, S., Trier, M. & Richter, A., 2017. Value co-creation in the digital factory – The empowered role of shop floor workers. *Australasian Conference on Information Systems 2017*, (November). Available at: https://www.acis2017.org/wp-content/uploads/2017/11/ACIS2017_paper_144_FULL.pdf.

Rindfleisch, A. & Sachdev, V., 2017. Perspective The Digital Revolution, 3D Printing, and Innovation as Data. , 34(5), pp.681–690.

Roger, L., 2017. Digital transformation - the ultimate challenge for the fashion industry. Available at: https://www2.deloitte.com/ch/en/pages/consumer-industrial-products/articles/ultimate-challenge-fashion-industry-digital-age.html [Accessed August 1, 2018].

Rüßmann, M. et al., 2015. Industry 4.0. The Future of Productivity and Growth in Manufacturing. *Boston Consulting*, (April), pp.1–14.

Saldana, J., 2014. *The Coding Manual for Qualitative Researchers*, SAGE Publications.

Sarjana, S., 2015. Dynamic capabilities in manufacturing: the main role of manufacturing capability, knowledge re-sources and environmental turbulence to improve enterprise performance. *Journal of Entrepreneurship, Business and Economics*, 3(2), pp.41–64.

Savastano, M., Amendola, C. & Fabrizio, D.A., 2018. How Digital Transformation is Reshaping the

Manufacturing Industry Value Chain: The New Digital Manufacturing Ecosystem Applied to a Case Study from the Food Industry. In R. Lamboglia et al., eds. *Network, Smart and Open. Lecture Notes in Information Systems and Organisation*. Springer, Cham, pp. 127–142.

Schallmo, D.R.A. & Williams, C.A., 2018. *Digital Transformation Now! Guiding the successful Digitalization of you Business Model*, Ulm, Germany: Springer B.

Schwab, K., 2015. The Fourth Industrial Revolution What It Means and How to Respond. Available at: https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution [Accessed February 26, 2018].

Sentryo, 2017. THE 4 INDUSTRIAL REVOLUTIONS. Available at: https://www.sentryo.net/the-4-industrial-revolutions/ [Accessed February 20, 2018].

Smit, J. et al., 2016. Industry 4.0. *European Parliament*, (February), pp.1–10. Available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf.

Suyati, 2016. The role of cloud computing in apparel industry. Available at: https://suyati.com/blog/cloud-computing-new-trend-apparel-industry/ [Accessed March 13, 2018].

Tannou, M. & Westerman, G., 2013. Nike: From Separate Digital Initiatives to Firm-Level Transformation.

Teece, D., Peteraf, M.A. & Leih, S., 2016. Dynamic Capabilities and Organizational Agility: Risk, Uncertainty, and Strategy in the Innovation Economy. *California Management Review*, 58(4), pp.13–36. Available at: http://www.ucpress.edu/journals.php?p=reprints.

Teece, D.J., 2017a. Business models and dynamic capabilities. *Long Range Planning*, 51(1), pp.40–49. Available at: https://doi.org/10.1016/j.lrp.2017.06.007.

Teece, D.J., 2012. Dynamic Capabilities: Routines versus Entrepreneurial Action. *Journal of Management Studies*, 49(8), pp.1395–1401.

Teece, D.J., 2017b. *Dynamic Capabilities and (Digital) Platform Lifecycles*, Available at: http://www.emeraldinsight.com/doi/10.1108/S0742-332220170000037008.

Teece, D.J., 2007. Performance and microfoundations of (sustainable) enterprise peformance explicating dynamic capabilities. *Strategic Management Journal*, 28(13), pp.1319–1350. Available at: http://www.jstor.org/stable/20141992%0Ahttp://about.jstor.org/terms.

Teece, D.J. & Linden, G., 2017. Business models, value capture, and the digital enterprise. *Journal of Organization Design*, 6(1), p.8. Available at: http://jorgdesign.springeropen.com/articles/10.1186/s41469-017-0018-x.

The Economist, 2012. The third industrial revolution. Available at: http://www.economist.com/node/21553017 [Accessed February 13, 2018].

Ustundag, A. & Cevikcan, E., 2018. *Industry 4.0: Managing The Digital Transformation*, Available at: http://link.springer.com/10.1007/978-3-319-57870-5%0Ahttp://www.springer.com/series/7113.

Vaidya, S., Ambad, P. & Bhosle, S., 2018. Industry 4.0 – A Glimpse. *Procedia Manufacturing*, 20, pp.233–238. Available at: http://linkinghub.elsevier.com/retrieve/pii/S2351978918300672.

Walter, L., Kartsounis, G.A. & Carosio, S., 2009. *The European Textile and Clothing Industry in the Global Environment – Reality and Challenges* L. Walter, G. A. Kartsounis, & S. Carosio, eds.,

Wang, S. et al., 2016. Implementing Smart Factory of Industrie 4.0: An Outlook. *International Journal of Distributed Sensor Networks*, 2016, pp.1–10.

Wang, Y., Kung, L.A. & Byrd, T.A., 2018. Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change*, 126, pp.3–13. Available at: https://doi.org/10.1016/j.techfore.2015.12.019.

Weber, P.S. & Weber, J.E., 2001. Changes in employee perceptions during organizational change. *Leadership & Organization Development Journal*, 22(6), pp.291–300. Available at: http://www.emeraldinsight.com/doi/10.1108/01437730110403222.

Westerman, G. et al., 2011. Digital Transformation: A Road-Map for Billion-Dollar Organizations. *MIT Center for Digital Business and Capgemini Consulting*, pp.1–68.

Wiener, A., 2017. Inside Adidas' Robot Powered, on-demand sneaker factory. Available at: https://www.wired.com/story/inside-speedfactory-adidas-robot-powered-sneaker-factory/ [Accessed March 7, 2018].

Yap, Y.L. & Yeong, W.Y., 2014. Additive manufacture of fashion and jewellery products: A mini review: This paper provides an insight into the future of 3D printing industries for fashion and jewellery products. *Virtual and Physical Prototyping*, 9(3), pp.195–201.

Yeow, A., Soh, C. & Hansen, R., 2017. Journal of Strategic Information Systems Aligning with new digital strategy : A dynamic capabilities approach. *Journal of Strategic Information Systems*, (September), pp.0–1. Available at: http://dx.doi.org/10.1016/j.jsis.2017.09.001.

Appendix A: Interview structure

Introduction

Thank you for taking the time for this interview. My name is Areti Kaplanidou and I am a master student at Utrecht University. My supervisor Dr. Annika Lorenz and I are currently investigating firms undergoing digital transformation processes. Particularly, my thesis focuses on the digital transformation of the manufacturing process in the apparel industry. Digital transformation is described by a fundamental transformation of the entire business/manufacturing process through the implementation of digital technologies. These technologies are e.g.: Big Data analytics, autonomous robots, additive manufacturing, simulation, system integration, cloud, internet of things and cybersecurity. These technologies have begun revolutionizing the way business in the fashion industry operates.

The aim of the research and research question

Considering increasing consumer's demands there is a growing need for apparel firms to strengthen their competitive advantage. Digitalization in the manufacturing process enables better monitoring of the processes and therefore enhances efficiency, quality, transparency and flexibility. Therefore, in this interview, I'd like to discuss with you whether your company has considered implementing any digital technologies into the manufacturing process and how your company uses its dynamic capabilities to adapt to the new digital era.

Interview process

The interview starts with some preliminary questions about your company, followed by some questions about whether your company has implemented digital technologies and why, and finally how your firm uses its dynamic capabilities to adjust to the fast-changing environment. The interview follows a semi-structured approach with open-ended questions. Please answer freely and add experiences and thoughts you have spontaneously.

Confidentially, privacy and anonymity

The analysis of the data is done confidentially and anonymously and will only be published in an anonymous form. In order to study the interview results, the interview is recorded, transcribed and temporarily saved for scientific purposes. The recordings are just used for this purpose and the research results will be provided to you after finalizing them. With your participation you consent to these conditions.

Case	
Position	

1. Introduction

1.1 What is your position and role in the company?

1.2 Please, could you tell me how long have you been in the company? S

1.3 When has the company been founded?

1.4 How many people are currently working for the company?

1.5 What is the average manufacturing lead time?

1.6 How much it spends on R&D?

1.7 What were the revenues in the past year?

1.8 Are you aware of this new technological trend (Industry 4.0, digital transformation and digital technologies)?

1.9 Which smart technologies of the following are you using in your manufacturing process? Are you planning to establish other technologies as well? If so, which ones?

2. The company has implemented digital technologies

2.1 Are you aware of the benefits that digital technologies offer? And if so, what are they?

2.2 Do you believe that the company can sense the benefits that digital technologies offer? Did the company ever invest in research and development before implementing the digital technologies in the manufacturing process?

2.3 Can you describe the transition process (process/ transition time/resources/organizational changes)?

2.4 Which advantages of this implementation did you see so far?

2.5 Did you face any challenges during the digital transformation?

2.6 If so, please name them and describe how did you overcome them?

2.7 Apart from the above, did you face any resistance from your workforce? If so, how did you overcome it?

2.8 Does the company provide any workshops or trainings to their employees? If so, what kind of trainings?

2.9 Have you hired employees with new skills (such as IT, R&D) to support the switch to smart technologies?

2.10   Do you believe that the implementation of the digital technologies has changed company's position in the competitive market?

2.11   Are you thinking of investing in more of the digital technologies that are mentioned in the beginning after this interview? If so, can you name them and describe the reason for investing?

2.12 **What is the reason and the weight of importance each reason for investing in the implementation of digital technologies in the production process?**

(scale 0 (Not important) to 5 (very important))

Reasons	0 to 5
Communication with customers	
Communication with consumers	
Communication with suppliers	
Meet production goals	
Increase production speed	
Diagnosis and prognosis of possible changes in the future	
Sustainability	
Prognosis of failures/error in the production process	
Growth sales	
Reputation	

The company has not implemented digital technologies

2.13 **Are you aware of the benefits that digital technologies offer? And if so, what are they?**

2.14 **Do you believe that the company can sense the benefits that digital technologies offer? Did the company ever invest in research and development before implementing the digital technologies in the manufacturing/warehousing process?**

2.15 **(Hypothetically) In case you decide to implement some of the technologies, can you describe the transition process (process/ transition time/resources/organizational changes)?**

2.16 **What was the main reasons of not implementing the digital technologies so far in your production/warehousing process?**

- o **unawareness**

- o **financial reasons**

- o **not enough employees**

- o **culture**

- o **other?**

    _____

2.17   **Did you face any challenges before deciding to implement digital technologies in your production/warehousing process?**

2.18   **If so, please name them and describe how did you overcome them?**

2.19   **Apart from the above, did you face any resistance from your workforce? If so, how did you overcome it?**

2.20   **Does the company want to implement some of these digital technologies in their manufacturing/warehousing process in the future? If so, have they redesign their resource base of the company, so as to raise awareness over the digital technologies? (i.e. hire staff with IT skills, R&D)**

2.21   **Have the company hired employees with new skills (such as IT, R&D) to support the switch to smart technologies?**

2.22   **Does the company provide any workshops or trainings to their employees? If so, what kind of trainings?**

2.23   **Do you think that your current manufacturing process is good enough compared with what your competitors are doing? Are you aware what your competitors are using in their manufacturing process?**

2.24   **Were there any changes in the production line in order to be more competitive?**

2.25   **Are you thinking of investing in some of the digital technologies that are mentioned in the beginning after this interview? If so, can you name them and describe the reason for investing?**

2.26   **What are the reason and the weight of importance each reason for investing in the implementation of digital technologies in the production process?**

(scale 0 (Not important) to 5 (very important))

Reasons	0 to 5
Communication with customers	
Communication with consumers	
Communication with suppliers	
Meet production goals	
Increase production speed	
Diagnosis and prognosis of possible changes in the future	
Sustainability	
Prognosis of failures/error in the production process	
Growth sales	
Reputation	