INTERNET OF SMART CLOTHING: RECOGNIZING AND EXPLOITING THE OPPORTUNITIES INTRODUCED BY FASHION 4.0

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ABSTRACT

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Fashion industry has been influenced by recent technological revolution which has directed many organizations to encounter digitalization in almost every aspect of the business. The terms Fashion 4.0 and internet of smart clothing occurred because of digitalization and several market potentials has emerged due to the disruption introduced by the technologies related to these concepts. The thesis objective is to investigate how Fashion 4.0 and smart clothing are perceived, what market opportunities appears for the technologies and what understanding exists in recognizing and exploiting these potentials.

These issues were addressed and explored by analysing 11 clothing and apparel companies of Finland and for this purpose in-depth interview with entrepreneurs, top managers, and marketing specialist along with 4 experts from three educational and one fashion research institute were conducted. A qualitative approach in the form of thematic analysis was adopted to analyse the data accumulated through interviews.

The results suggests that the perception of Fashion 4.0 is understood as 'digitalization' of fashion industry and smart garment is perceived as a functional fashion apparel not as a luxury aesthetic clothing. The opportunities that emerged due to the disruption revolves around different industry level encompassing, manufacturing, supply chain, distribution, and retail whereas intelligent garments have numerous market potentials in health, sports, entertainment and workwear industry. Social capital, earlier knowledge about technology and market and actively scanning the environment acted as primary antecedent in identifying the opportunities whereas technological and financial capabilities are revealed important in exploiting the potentials.

This study benefits fashion entrepreneurs in discovering the unidentified potentials of smart clothing and technologies related to intelligent garments as well as offer actionable advice for mangers, designers and technology developers and finally several recommendations have been provided for future research.

Key words
Fashion 4.0, Smart Clothing, Digitalization, Opportunities, Recognition, Exploitation

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1 INTRODUCTION

1.1 Research overview and context

Technological advancement has been a significant phenomenon and its impact is inevitable in every sphere of life. Environment either social, political or economic is significantly influenced by novel innovations and technological advancement several times in history. Innovation of any sort brings transformations in industry structure as well as institutional practices (Hekkert et al., 2007). The innovation directed by technology, progress incrementally within a certain period of time or it sometimes begins abruptly. The current innovation process becomes obsolete by novel technological diffusion and innovations contribute into the firm's competitive advantage and assist in a performance increase (Ünaya & Zehir, 2012). Industry 4.0 is a term adopted to refer to such category of disruption that poses the capability to bring transformation in manufacturing, logistics and customer service and also is capable of introducing novel product or service (Bongomin et al., 2020; Vaidyaa, Ambadb & Bhosle, 2018; Bertola & Teunissen 2018)

Technology related to I4.0 to begin with, is bringing transformation in the fashion industry hence creating the idea of Fashion 4.0 by introducing smart wearables, smart textile or smart clotting (Dunne, 2010; Bertola & Teunissen 2018). The emergence of internet has directed the path to an interconnected and advanced communication system that has enabled organization to increase production efficiency, to reduce expenditure and to increase firm's performance (Hui, 2014). Since the business world is directed towards an interconnected and sophisticated communication and data sharing phase it will be inevitable for the organizations to ignore the disruptive technological changes and opportunities brought by digitalization (Bongomin et al., 2020).

In addition, innovative entrepreneurial firm or entrepreneurs seek for novel business potentials caused by any exogenous shock mostly by technological advancement (Rip & Kemp, 1997). The inherent nature of the individuals with entrepreneurship quality is to perceive any novel innovative concept developed through any market or technology transformation (Baron, 2006). This perception directs any entrepreneurs or entrepreneurial firms to be attentive to any potential benefits arises in the environment (Shane & Venkataraman, 2000). The recognition of

these market potentials poses a necessity for a continuous process of identification and evaluation and then further exploitation (García-Cabrera & García-Soto, 2009). The process of exploiting the opportunities begins as soon as the entrepreneurial firm receive clear understanding of optimum benefits brought by the technological change and appropriate knowledge about their capabilities (Choi & Shephard, 2003).

Moreover, Fashion 4.0 becomes a future reality that most of the business organizations in the fashion and apparel industry is experiencing (Bertola & Teunissen, 2018). Industry 4.0 ecosystem and technologies related to it are going to be the influencing factors in several areas and the innovations are compelling organizations to prepare for the upcoming transformation (Shrouf, Ordieres & Miragliotta, 2014). Internet of smart clothing (ISC) is one of the novel examples of the Fashion 4.0 technologies that have potential to introduce disruption hence introduce some opportunities (Bertola an& Teunissen, 2018; Fernández-Caramés & Fraga-Lamas, 2018). Apparently, organizations are required to obtain a refined understanding of the concept to receive the benefits brought by fashion 4.0 and ISC technologies.

Finnish clothing industry to mention, is considerably relevant as a context in this research. The clothing and apparel industry is inclined to mostly traditional business practices but market in Finland is providing a positive response towards any technological changes in present globalization era with advance of industrial Internet (Juahnko et al., 2015). The fashion and textile industry in Finland encompass several dimensions of clothing and apparel business such as textile manufacturing, clothing care, other industry level manufacturing and wholesale and retail markets (FIT Helsinki, 2017). The industry has been experiencing several periods of transformations and the Finnish firms have been adopting new strategies to confront the challenges the globalization is bringing forward. The industry also has encountered a rise of innovation in domestic textile technology and highly trained design experts ensuring enormous success and growth opportunities (Finnish textile & fashion, 2017).

In addition, the turnover of textile and fashion sectors according to FIT Helsinki (2017), was around £4.4 billion with about 22000 employees and 70% of those workforces are from wholesale and retail channels. The sectors are significantly influenced by the economic cycles and demand of domestic and imported products as well as consumers behaviour and the activities of fashion business environment (Finnish textile & fashion, 2017). At present, the industry is confronting a rising demand for sustainable and ethical products, recyclable products and an immense presence of online stores along with physical stores (Liukko, 2016; Koiviola, 2020). However, the industry also has encountered a sharp decline according to FIT Helsinki (2017) after the desolation of former Soviet Union in

1990's resulting significant decrease of foreign demands of Finnish products resulting transfer of production to low expenditure countries, reduced domestic work opportunities and decline of domestic business.

The fashion and textile industry in Finland apparently, have experienced positive return from decline period but the sector is still encountering several challenges (Ruokamo, 2017; Finnish textile & fashion 2017). Demand for sustainable fashion and reduction of industrial waste is two more challenging situation the industry is confronting recently (Finnish textile & fashion, 2015 & 2017). Certain phenomena according to Ruokamo, (2017) are modifying the future of textile and fashion industry specially in Finland and the first is the rising competition due to globalization and emergence of Asian manufacturers brands. Changing consumer behaviour and their inclination towards various online platforms is the second phenomena she has mentioned which is compelling the brands to consider cooperation with online retail stores. The third, according to her is the evolution of digital technologies and their implementation within the industry for new product development, dynamic pricing and demand forecasting ensuring sustainability and new venture creation.

In addition, the concept of circular economy is receiving significant attention and European Parliament Website (2021) mentioned it as a production and consumption model that encourage an extension of product life cycle and minimum wates by encouraging longer repairment, restoration, sharing, recycling and preservation of prevailing products and materials. Since the concept's action plan is adopted by European commission to ensure sustainability, waste reduction and efficient utilization of resources, most of industries in Europe is obliged to adhere this future change (Loonela & Stoycheva, 2020). Fashion and clothing industry as a consequence, is also compelled to adjust with the regulation introduced and Finnish textile industry is responding this phenomenon through introducing ideas on waste reduction, recycling and modified services (Finnish textile & fashion, 2017).

Moreover, Finnish fashion companies are collaborating with universities and research institutes to introduce novel solutions by combining technology in fabrics with the assistance of difference source of energies (Fablehti Website, 2021). Since the emergence on digital clothing, sustainability and gender and environmental issues are shaping the fashion, the fashion industry is turning towards a solution that will address those issues and at the same time will fulfil fashion requirements of the consumers (Vanska, Särmäkari & Turunen 2021). Thus, the changing environment and challenges are also introducing several opportunities which requires active attention or alertness from different organizations.

1.2 Research necessity, purpose and the structure

Literature on intelligent garments to mention, concentrated at the early age of the concept development on the work of Tao (2001) who defined the smart fabrics from the technological perspective. Majority period academics discussed on the technological aspect of product development (Duval et al., 2010) such as embedding technologies with the garments (Lam Po Tang & Stylios, 2005; Langenhove and Hertleer (2004) mostly sensors and actuators and other wearable computing devices (Mann 1996). Later researchers initiated more studies on the physiological aspect (Dunne, Ashdown & Smith 2005) and design research (Norman, 2004) to avoid the biasness towards technology (Suh, Carroll & Cassill, 2010). The studies on intelligent clothing that investigated both the design purpose and functional features have provided depth discussion about technical issues (Mahoney & Mahoney, 2010), functionality (McCann, Hurford, & Martin, 2005) aesthetics and lifestyle (Ariyatum et al., 2005).

In addition, in recent years much emphasis has been placed upon the application area such as medical (Scataglini, Andreoni & Gallant, 2015), health (Bergmann & McGregor, 2011; Mahmood & Lee 2020) and environmental situation (Rantanen et al., 2002). Several academics also has given attention on the end user requirements and design purpose providing much concentration on designer identified consumer needs in different context (McCann et al., 2005; Perry et al., 2017) as well as consumers attitudes and purchased intentions (Ko, Sung & Yun, 2009; Hwang, Chung & Sanders 2016). Apart from these, few research have been conducted on benefits and risks (Schaar & Ziefle, 2011) or the opportunities and challenges (Cherenack & Van Pieterson, 2012) or the barriers to the commercialization of intelligent garments (Dunne, 2010).

However, the understanding of smart fabrics until present period is not clearly defined although several researchers have conducted studies in different areas related to intelligent garments. The technological perspective is still dominant in the concept development process and majority period focused on the functionality and usability aspect ignoring the aesthetic requirements of the consumers (Perry et al., 2017). The number of research have been conducted on the perception of smart clothing and technologies related to it as a fashion product are also limited.

Correspondingly, the opportunity aspect has not been addressed sufficiently though few studies have been conducted on the general understanding of opportunities and risk of intelligent garments. As mentioned earlier, the few studies have been conducted on the health benefits (Bergmann & McGregor 2011; Mahmood & Lee 2020) or sport benefits (Ariyatum et al., 2005) but a detail study

of recognizing process of those benefits are limited. Also, the opportunities of smart clothing are discussed apparently as a functional technology invention but not as a fashion merchandise. Likewise, depth research in terms of identifying and evaluating them in the context of an individual entrepreneur or a company is scarce. Thus, this scarcity of studies in terms of individual and entrepreneurial context necessitates further thorough exploration on the topic specially opportunity recognition and evaluation aspect of smart garments and related technologies.

Fashion industry to mention has been influenced by the technological changes for adaptation (Bertola & Teunissen, 2018) and smart clothing is a prominent example of the advancement of digital technologies (Fernández-Caramés & Fraga-Lamas, 2018). Technological progression majority occasion introduces novel market opportunities in terms of new venture creation (Gilbert, 2003) and intelligent garments as a final fashion product possess numerous potentials in this instance (Fernández-Caramés & Fraga-Lamas, 2018; Bertola & Teunissen 2018; Gonku-Berk, 2019). For this reason, investing the insight of smart garment and technologies related to it from individual entrepreneurs or company perspective and an understanding of recognizing and evaluating the market potential introduced by it are important issues to conduct research on.

Therefore, the purpose of this research is to depict *how do Finnish clothing and apparel companies perceive the concept of Fashion 4.0 and Internet of Smart Clothing, what type of opportunities have emerged due to the disruption of the technologies related to fashion 4.0 and smart clothing and what understanding they have in recognizing and exploiting these opportunities brought by these technologies.* These initiatives allow the study to achieve insights about organization's cognitive understanding about any novel concepts brought by any technological change in the industry. Therefore, the thesis contains the potentials to contribute to the existing literature on the Fashion, technology and entrepreneurship study.

To serve the purpose, several fashion retail's perception is analysed to provide an understanding of the concept of Fashion 4.0 and internet of smart clothing and the business opportunities introduced by the technologies related with them. Thus, in dept interviews with owners of several start-ups, entrepreneurs, innovators, senior marketing, R&D and management officials and fashion designers from established brands along with expert individuals ranges from universities and other fashion institutes were conducted.

The structure of the study consists of several consecutive chapters. The introductory chapter presents the background of the study and explains potential gap surrounding the subject. It also explains the purpose by mentioning the research questions as well as the scope of the research. The literature chapter lays the foundation of theoretical background by reviewing the existing literature on fashion, technology, and entrepreneurship study. This section combines the literature

from fashion, technology, and entrepreneurship to create a comprehensive theme about different aspects related to smart clothing and its opportunities. A brief understanding about style, technology, and amalgamation of both in the context of apparel products have been discussed along with digital technology as a disruption as well as recognition and evaluation procedure of opportunities introduced by the digitalization. This section finishes with suggesting a synthesis of framework based on academic literature.

In addition, the methodology chapter is explaining the method of analysis, data collection process and presents the interviewed individuals. An inductive approach and a qualitative method have been adopted in this purpose. The research findings chapter presents the empirical discovery from the interview by organizing them in different categories with relevant quotes. The discussion section endeavours to provide answer for the research question in the context of the conceptual framework and discuss the important contribution of the study. Finally, the concluding chapter provides practical implication of the study as well as mentions the limitations and suggests ideas for future research.

2 FASHION AND TECHNOLOGY

2.1 Fashion, aesthetic and functionality

Fashion, which is completely interconnected with symbols, aesthetic, culture, and economics, is an influential aspect of everyday life (Kaiser, 1997). It is an expression of lifestyle, taste, social statues and community belongings through objects or clothes of any bodily ornamentation in an admirable way. (Pan et al. 2015). Bertola & Teunissen (2018) describe fashion, especially clothing, as a means to establish a social identity in the world for individuals by representing the 'self' in the form of visual and applied art. Projection of 'self' majority period through 'Dress' is often influenced by the fashion aesthetics and the fashion objects (Workman & Caldwell, 2007).

Fashion to mention, has a natural ability to influence individuals of different levels by stimulating social interaction through fashion objects (Chon, 2013). Sensory information is another important aspect through which individuals perceive fashion such as colour, fabric, pattern, shape and texture (Workman & Caldwell, 2007). Aesthetics rules as well as social and cultural rules actually dictate how this sensory information is interpreted in every individual context. These aesthetic rules in general are the design principles that change with fashion such as balance, scale and unity (Venkatesh et al., 2010; Workman & Caldwell, 2007). Therefore, the aesthetics values are demonstrated through different fashion experience and bodily embodiment of dress in different changing contexts (Chon, 2013).

Styles of fashion majority period are perceived through sensory experiences and visual forms of objects. These two traits construct the sense and idea of aesthetic that often are associated with harmony, order and beauty (Pan et al., 2015). Besides sensory involvement and graphical form of objects, elements of culture significantly influence the codes of design principles such as balance, emphasis and proportion. Hence, aesthetics of fashion progress through foundational disposition of those cultural elements and predominant induvial preferences (Venkatesh et al., 2010; Workman & Caldwell, 2007). Since fashion is a changing process which evolves through different periods, variation of different styles or a new style triggers the stages of evolution of fashion in various manners. As a result, in the process of creating new styles the aesthetic codes were frequently manipulated by the fashion designers in multiple periods (Workman & Caldwell, 2007).

In addition, the aesthetic view of fashion is often augmented by different form of fashion objects other than clothes, which usually compliments the 'clothing styles' such as ear ornaments, jewelleries and sunglasses (Rauschnabel et al., 2016). Apart from objects, aesthetic considerations such as colour fabrication, cut, proportion and details increase the possibility of the acceptance of the final product since these concerns contribute to psychological 'feel-good' factors of the final consumers. 'Form' often embraces these concerns along with cultural rules by respecting the cultural needs of the customers (McCann & Bryson, 2009, pp.45). Hence, a style that empowers an individual through desire fulfilment and social image creation has greater probability to be accepted by the consumers (Venkatesh & Meamber 2008; Venkatesh et al., 2010).

However, a strong attachment to aesthetic rules is not sufficient to produce a well-accepted style rather consumer's perceptions towards that particular design and acceptance of it. Therefore, fashion designers are often influenced by consumer preferences and consumer perception about fashion and aesthetics (Ariyatum et al., 2005). Perception of fashion comes to the consumer's mind in general as 'appearance´ or 'art'. The connection between art and aesthetics consequently creates interest in an individual's mind about fashion (Workman & Caldwell, 2007). Bodily appearance receives more privilege in terms of fashion wearability than the artistic meaning especially in case of clothing (Seymour 2008, pp.12-13).

Functionality is another significant characteristic of fashion product besides aesthetics that any individual considers. The connection of functionality with fashion is considerably adjacent also with individual identity. Therefore, comfortability, safety and unique ability to perform a specific task are essential since feelings and personal expression to the world are attached to clothes and clothing objects (Perovich et al. 2014). Protection and attraction are primarily associated with physical functionality whereas individual expression, social and economic status and political and religious association are affiliated with cultural functionality (Seymour 2008, pp.12-16).

In brief, functions embrace the standard requirements of the human physic and special demands of the final consumers (McCann & Bryson, 2009, pp.45). In the consumer needs model (Figure 1) Lamb & Kallal (1992) explains about different elements such as culture, aesthetic, functionality and expressiveness assist in identifying and fulfilling the consumer's requirements and the model also demonstrates that there exists an interrelationship between these elements.

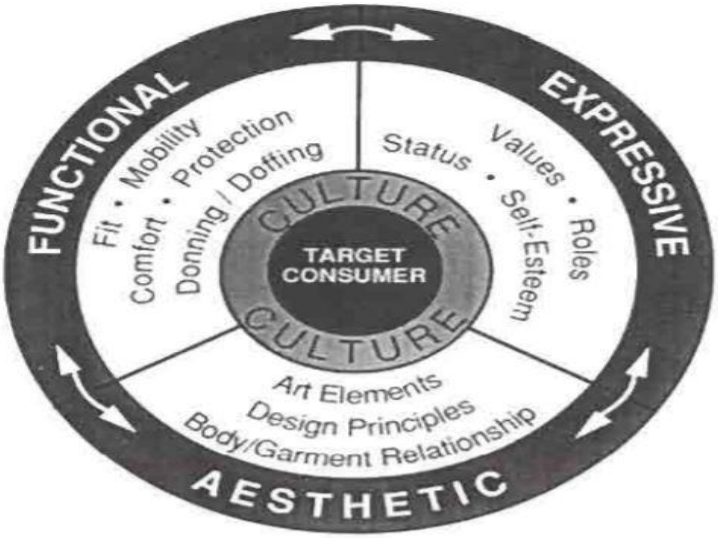

Figure 1: FEA consumer needs model (Adopted from Lamb & Kallak-1992)

As it appears from above that fashion, aesthetic rules and functionality on several occasions are influenced by culture and social elements as well as environmental changes such as market trends, changes in consumer preferences and technological advancement (Workman & Caldwell, 2007; Behr, 2018; Bertola & Teunissen, 2018). Technology in several aspects enhances the physical performance of the clothing and brings new definitions in fashion and clothing styles (Seymour 2008, pp.28-31). Thus, the paper will discuss the details about fashionable technology and fashion wearables afterwards.

2.1.1 Fashionology and smart wearable products

Wearables are novel examples of fashionology or fashionable technology and according to Seymour (2008, pp. 15) wearable technologies are enabling the functionality of fashionable wearables by combining wireless connectivity, electrical engineering, and physical computing. Rauschnabel et al. (2016) explains it as a term that refers to consumer's perception about portable equipment as an amalgamation of fashion and technology. Seymour (2008, pp. 12) provides a broader definition of the term especially fashionable technology as, 'Fashionable wearables are 'designed' garments, accessories, or jewellery that combine aesthetics and style with functional technology'. According to him, it is a connecting point where design, style, science, and technology all intersect together. Augmented reality (AR) smart glasses are the most different and obvious examples of this type of the latest technological development. Consumers growing interest in

wearable technologies like smart glasses is revealing the emergence of fashionologists who are inspired to experiment novel fashion and technology related objects (Rauschnabel et al., 2016).

Technological evaluation to mention, has inspired Fashionologist to adopt new portable technologies and this group acknowledges both the hi-tech device related aspect and sophisticated social engagement (Rauschnabel et al., 2016). Hi-tech characteristics of wearables basically are portable computing devices and embedded technologies (Yablonsky, 2016). According to Seymour (2008, pp.19-20), wearable devices are controllable by the users with incorporated personal space and are both functional and interactional in maximum period. He mentioned that integration of computing devices usually depends on the contextual usage and desired communication. Desired interaction as he also stated occurs typically between the fashionable portable devices and the outside environment. Therefore, in other words, embedded technologies such as microprocessors, interfaces, software, energies, sensors and actuators has enabled portable equipment to be more functional, comfortable and aesthetically acceptable (Wang et al., 2018).

As mentioned earlier, smart fabrics, smart clothing or smart garments are receiving significant attention as aesthetic wearables from not only fashonologist but also from common individuals (Connors, 2019). Smart clothing already is contributing to the periphery of sports, health and security through biga data and real time monitoring. Sensor technology, actuators and new garments material integrated with these technologies are improving the process of collecting more information about body position, muscle activities, blood pressure, heart rate and body acceleration (Borgers et al., 2008). Lumo's sports pants, Adidas's smart shirt for health monitoring and Sensora's socks with sensors are unique examples of usage of smart garments for health benefits (Behr, 2018).

In addition, garments integrated with wearables technology such as Levi's trucker jacket are allowing wearers to control the navigating system or receive calls from smartphones (Tillman 2019). Likewise, Twitter dress by CuteCircute and Hussain Chalayan's remote control dress are two innovative illustrations of smart fabrics as fashionable wearables (Behr, 2018). This paper henceforth, would further concentrate on the future prospect of smart wearables such as internet of smart clothing as an element of fashion 4.0 and the identification and evaluation process of these wearables as potential opportunities by the organizations throughout several periods of the firm's life.

2.1.2 Fashion 4.0

Fashion has been a central character in the industrial revolution cycle especially in the textile and garments industry in the eighteenth-century UK and early European industrialization (Matković, 2010). Fashion and apparel industry have significantly been influenced by the contemporary industrial revolution such as the knitwear frame in the early 18th century, water and steam powered technologies in the 19th century, advancement of electronic, and IT technology in the 20th century followed by the cyber and digital technology in the modern period. (Bertola & Teunissen, 2018; Matković, 2010). The electric powered infrastructure apparently has facilitated the transformation of the second industrial revolution from the first one which was motivated by the water and steam powered technologies. (Schwab, 2016). Innovation assisted the mechanization and transformation of the sewing and spinning procedure and apparel industry up until present time, is the significant responder to this industrial revolution by implementing mass market production models. (Bertola & Teunissen, 2018).

In addition, the conditions of the new market situation occurred after the second world war as a result of modern globalization (Bertola & Teunissen, 2018). Many countries moved their orientation towards design techniques and brand building whereas some countries in Europe and North America initiated the delocalization process by transferring the manufacturing infrastructure into countries in Asia and Latin America (Djelic, 1999). The initiation of the third industrial revolution occurred due to electronically controlled production and advancement of information technology (Schwab, 2016). This for instance, accelerated the globalization of fashion and the data were exchanged through computer aided design (CAD) and computer aided manufacturing (CAM) systems. Standard software language was applied to assist the CAD and CAM process which revolutionized the capability of changing products based on seasons or lifestyle progression (Christopher et al., 2004). As a result, customer's feedback along with the designer's idea have introduced a novel way of producing necessary designs and models that fulfils the requirements of the final consumers (Bertola & Teunissen, 2018).

Moreover, the recent phenomenon is that fashion companies are more responsive to technological innovation and globalization procedures in terms of mass dynamic production and transformation (Bertola & Teunissen, 2018). The third industrial revolution worked as a foundation for the digital or fourth industrial revolution which is a combination of several technologies that connect different elements of physical, digital, and biological spheres altogether (Schwab, 2016). Smart Product'-an amalgamation of 'fashion' and 'tech' probably an appropriate example how digital technology exposes a novel ecosystem of connected physical and digital dimensions in the fashion industry.

This Fashion 4.0 ecosystem which is constituted by companies, users and the interconnected social environment brings the potential value of 4.0 technologies

through exchanging information and co-creation (Bertola & Teunissen, 2018). However, According to Matković (2010), the dominance of fashion in certain periods of fashion history has influenced technology, especially design technology and invention of new machinery has also simultaneously influenced fashion and aesthetic designs. Figure 2 demonstrate the ecosystem that includes all the components and the principles within the fashion business

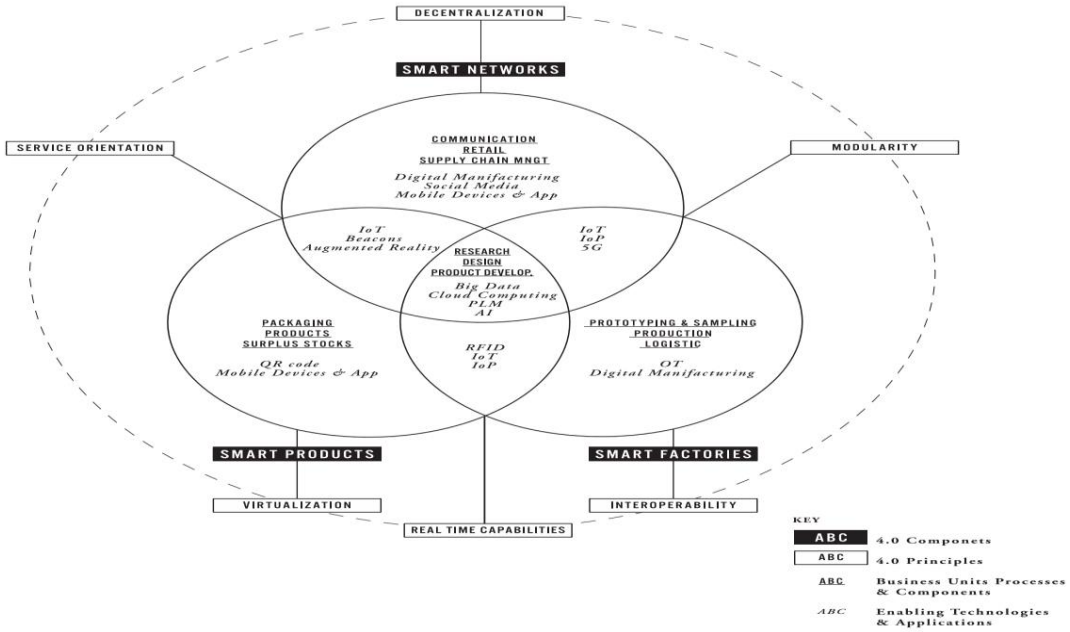

Figure 2: 4.0 Components and principles within fashion business (Adopted from Bertola & Teunissen,2018).

Many companies in the fashion industry apparently have started responding to the changes brought by technology and reaching towards the era of Fashion 4.0 (Bertola & Teunissen, 2018). Consequently, it is a trend that is continuing from third industrial period towards digitalization era which are presently influencing the production, operation, manufacturing, and supply chain process as well as logistics and product stocks through industry 4.0 (Grieco et al., 2017). Behr (2018) believes that digital technologies such as internet of things (IOT), 3D, virtual and augmented reality, 5G, big data analytics and RFID have triggered the transformation fashion and textile organizations are confronting. This transformation, according to him, is being recognized as Fashion 4.0 or digital revolution through industry 4.0 technologies in the aesthetics and textile industry. In this system, retail channels, products and final customers are able to communicate with each other and make efficient decisions (Bertola & Teunissen, 2018). Thus, digital technologies and innovation have introduced smart clothes which comprises sensor technology, smart fabrics and communication systems embedded into one intelligent fashion product (Behr,2018; Seymour, 2008, pp. 15-18).

As mentioned earlier, the fashion industry is approaching the 4th industrial revolution era and there is significant potential for the industry to be more consumers driven and more sustainable (Kabukcu, 2018). Industry 4.0 means digitization of production systems, fundamentally an architectural model that allows to collect and exchange data and information in any level of the organization (Bertola & Teunissen, 2018). The model was developed by German platform for I4.0 which is essentially combining the technologies related to 'smart manufacturing', 'smart networks' and 'smart products' (Platform, 2018; Görçün, 2018). The inherent concept of I4.0 is adopting digital technologies by the larger organization for conducting business and also gathering and sharing real time information about market and operations by creating connectivity between production facilities, equipment, supply chain, final product and consumers (Ardito et al., 2019).

In addition, the technologies related to these three concepts of Industry 4.0, in fact will potentially affect all areas of business units and processes when it is applied to the fashion industry (Shrouf et al., 2014). The model according to Bertola & Teunissen (2018), has components, business units and important procedures which enables 4.0 innovations to specify the relevance of a certain set of solutions. There are 6 design principles such as interoperability, virtualization, decentralization, modularity and service orientation, which convey a significant role in distinguishing those elements, operational units and procedures (Hermann, Pentek & Otto, 2015; Bertola & Teunissen, 2018). All these components, units and procedures along with a set of technologies allows the execution of Industry 4.0 ecosystem (Bertola & Teunissen, 2018). The technologies related to Industry 4.0 will be discussed and elaborated further in this paper.

2.1.3 Internet of Smart Clothing

The term smart clothing to begin with, means integrating digital and technical features into garments where the adornment still preserves the original protective and self-presentation functions (McCann & Bryson, 2009). According to Chae (2009), it is an innovative conceptual clothing which integrates information and digital technology to maintain different sensitive properties of garments. This definition is supported by Cho, Lee & Cho (2009), mentioning that it includes a digital procedure that communicates with the environment, conditions, and impetus of clothing wearers. Some authors mentioned smart clothing as smart textile or smart garments. For example, Langenhove & Hertleer (2004) mentioned them as 'smart textile' which is derived from intelligent and smart materials and Cherenack & Van Pieterson (2012) mentioning it as an electronic textile that can sense and respond to the environment like a wearable computer.

In addition, wearable computing processes are an essential element of the functionality of wearables products and smart wearables (Seymour, 2008). According to Fernández-Caramés & Fraga-Lamas (2018), International electronic commission (IEC) distinguishes four categories of wearables based on technology and human body proximity such as accessory wearables, textile wearables, patchable wearables and implantable wearables. They have mentioned that IEC has also classified them based on location or nearness of an organism such as wearables with close proximity, garments with electronics, wearables with on body attachment and inside body attachment. Figure 3 depicts the components of smart garments connected with communication network through internet. Nevertheless, smart clothes often include wearable computing, but it differentiates itself from the other wearables by mainly emphasizing the clothing features, by integrating electronics and by insisting on communication capabilities (Fernández-Caramés & Fraga-Lamas, 2018; Cho et al., 2009).

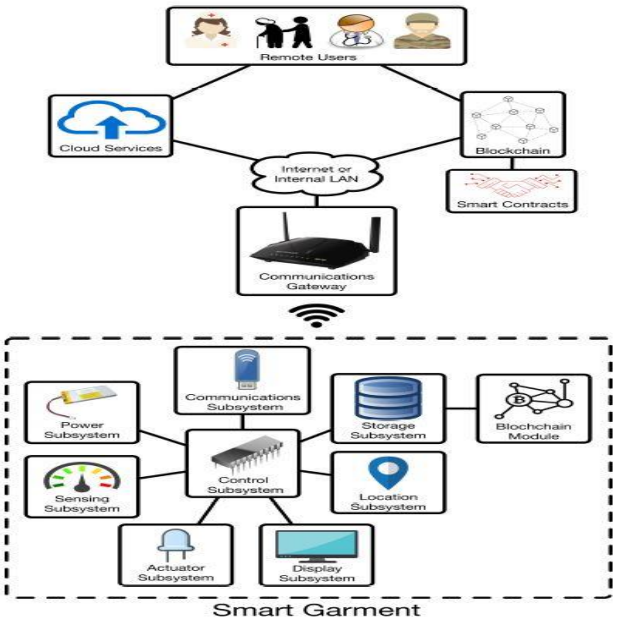

Figure 3: Generic architecture of IOT smart garments system (Adopted from Fernandez-Carames & Fragma-Lamas,2018).

Moreover, Tao (2001, pp.1-6) mentioned that smart textiles are of three categories such as passive smart or functional, active smart and very active smart. According to him sensors are utilized in all of these three categories of textiles for sensing the environment, reacting to them and to some extent adapting the behaviour. Passive textiles as the author mentioned, have sensors that are sensitive to environment whereas active textiles can deliver its response to the environment since it has actuator functions. On the other hand, very active textiles as Langenhove & Hertleer (2004) stated, are relatively advanced in adaptation based on the surroundings. The impetus and response according to them, can be of different

origin such as electrical, thermal, chemical or magnetic and other than these stimuluses, an actuator with a processing unit is another component necessary to receive the entire benefit of smart textile. They also have added that smart clothing contains five fundamental functions such as sensors, data processing, data networking, actuators and data arcade.

However, Cherenack & Van Pieterson, (2012) perceive that, electronic textiles don't include passive smart textiles since it contains traditional textiles and include materials where particular functions such as material, configuration, structure and finishing are added. According to them, design standards numerous period influence classifying the smart textiles and these standards establish the foundation of integrating different electric functions into textile architecture. The authors also added that smart textiles have some intrinsic quality or features that distinguish it from traditional textile and there were several stages in which smart textiles have been developed.

The evolution of smart clothing, to mention, started several decades ago. The concept came to existence in the early part of the 90's in Japan (Langenhove & Hertleer, 2004). The theory goes further back to the 1960's when a garment combined with a heating system with electric facility was presented but it was in the early 90's evolution of wearable computing assisted the integration of electrical functions within garments (Dunne, 2010). According to Suh et al. (2010) the first stage of development of smart clothing started with the idea of wearable computing followed by fashion and textile collaborating with technology to combine both electronics and fabrics in the second phase. In the third development period as they have mentioned, much concentration was placed upon the technical viability, comfortability and marketability of the clothing development whereas in the current period numerous fashion brands started adopting clothing with embedded technology.

In addition, according to Cherenack & Van Pieterson (2012) the first category of smart clothing had the purpose to construct a platform where fibers and yarns were possible to be utilized inside a garment with single functionality. They also added that in the second phase new methods of garments fabrication has been invested considering the fabric an important part of textile. The third category has been developed to 'fibertronics' to produce devices and logic circuits. These two technologies are integrated so that they will function below the device level and provide more electronic function to the fiber (Cherenack & Van Pieterson, 2012). Chunyan & Yue (2015) includes several technologies to define the technological clothing's such as 3D technology, electronic information technology, sensors, connectivity technology and communication technology and according to them these technologies play a significant role in developing the concept of intelligent garments

Moreover, the development of smart clothing has allowed the conversion of the high-tech industry and created a competitive environment by fulfilling the criteria of high added value technology (Fernández-Caramés & Fraga-Lamas, 2018). As a result, the transformation occurred from capability oriented towards information oriented, from quantity to quality and from single used product to multi used product and service. (Langenhove & Hertleer, 2004). Technological aspect of smart clothing according to Cho et al. (2009) is one important issue that is essential to receive the full benefits of smart garments. They have mentioned that the entire procedure of smart clothing is a combination of several basic elements such as interface, data organization, energy management and integrated circuit. According to them, these basic components exchange information, provide links between different components, process data, supply and preserve energy. The authors also added that it is necessary to integrate technical function in textiles so that functionality and textile features are retained.

Apart from the technological aspect of smart clothing, the human aspect is another condition that is essential to receive the benefits. According to Cho et al. (2009), this aspect emphasizes the integrated characteristics of both garments and the electronic devices. They have mentioned that electronic materials should be durable, efficient, usable and safe. They also stated that garments as a part of the clothing should be comfortable and fashionable as well. Fernández-Caramés and Fraga-Lamas (2018) agrees with the idea of ensuring the aesthetic part and usability mentioning that these two factors are important in designing smart clothing from the final consumer's viewpoint. They stated that customers search for something that fulfils the technical requirements to support the daily activity and also fulfil cultural requirements such as fashion.

Considering the durability, it is as Cho et al. (2009) mentioned, intelligent clothing as an important piece of garment that contains long lasting elements to ensure longevity by several periods of usage. Seymore (2008, pp.25) has similar understanding by mentioning that clothing and electronics has different lifecycle such as estimated lifespan for a battery is around 3 years and estimated lifespan for a piece of garments is around several usage before the disposition of the materials. Thus, it is essential to provide protection from any skin diseases as well as other types of risk related to skin (Cho et al., 2009).

Furthermore, ensuring longevity is required to resolve washability problems and electronic devices should be detachable or attached to soft cushions (Cho et al., 2009). Some fabrics are responsive to the electronic device even the laundering function proceeds and according to Cho et al. (2007) metal fabrics have been developed and integrated with polyurethane to ensure electronic durability. They discovered that the quality of the device did not falter after a few launderings when the fabric was connected to mp3 devices. Another important issue was the protection of physical, psychological, social and other types of dangers which

requires consideration of ensuring protection from electric current and electromagnetic waves (Cho et al., 2009).

Aside from above mentioned issues related to intelligent garments, fashion characteristic is another important aspect of smart clothing that some researchers believe to be essential for its commercialization. Cho et al. (2009) perceive that aesthetic should be considered along with other features of smart textile since clothing is also a fashion item. Consumers also desire to purchase clothing that can fulfil their need of the environment depending on culture, tradition or particular age group (Fernández-Caramés & Fraga-Lamas, 2018). The demand for the clothing to be fashionable apparently is increasing.

Many designers as mentioned earlier, are currently concentrating on the design techniques by bringing innovative features and integrating aesthetics elements in it (Bertola & Teunissen, 2018). The customer requirements for a clothing attire often depend upon the performance, artistic values and expressiveness of the product and Lamb & Kallal (1992) proposed a framework based on the requirements of customers for designers so that they receive some assistance about design criteria. Figure 4 exhibits the levels of involvement in the smart garments.

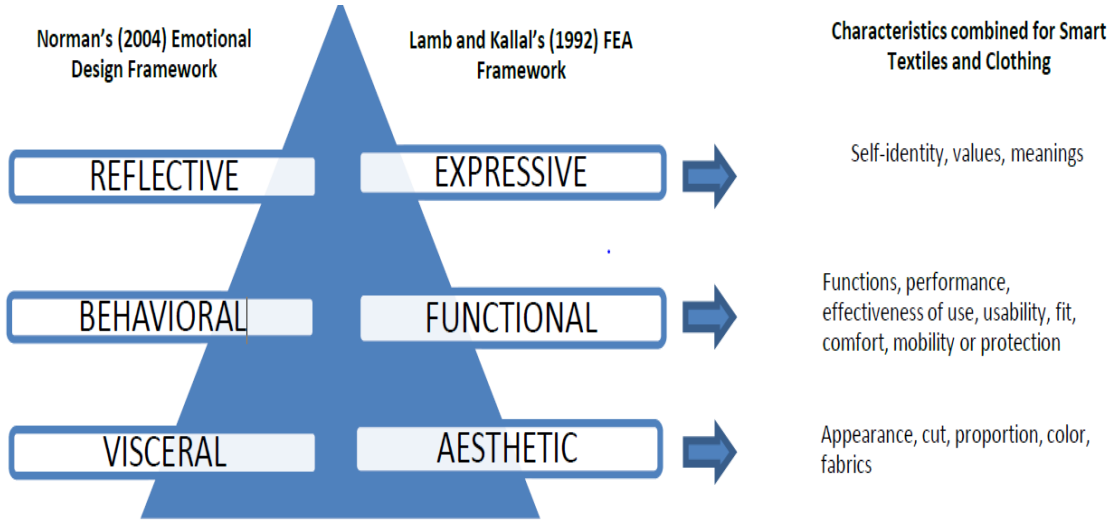

Figure 4: Three level of involvement for the design of smart clothing (Adopted from Lamb & Kallal,1992; Norman, 2004 and Gonku-Berk, 2019).

In the framework suggested by Lamb & Kallal (1992) concentrated on the three considerations of consumers for purchasing or selecting a certain apparel product such as artistic values, performance, and meaningful exposition. Aesthetics requirements according to them refers to the pattern, colour, texture, proportion, and pleasing design of the expected clothing materials whereas functionality con-

sideration revolves around the utility, comfortability, protective ability and fitting. Expressiveness as they mentioned is related to the customers symbolic aspects and communicative traits of the apparel as well as values and meanings of the desired clothing merchandise.

Similar understanding is provided by Norman (2004) mentioning that individuals interact and react to the design objects and the surrounding world in three interconnected level such as Visceral, behavioural, and reflective. Visceral design according to them, is related with appearance and aesthetic appeal of the object whereas behavioural level refers to the effectives, usability and performance of the designed object. Reflective design as they mentioned refers to the intellectual appeal and rationalization of the desired designed object. These two concepts can conveniently be applied to smart clothing (Gonku-Berk, 2019).

Correspondingly, the design research and processing majority period are associated with the development procedure of merchandise and any clothing product design process is in agreement with the engineer design procedure (Suh et al., 2010). The methodology for garments development usually follows the stages of idea creation, design clarification, prototype development and evaluation and finally production planning (Lamb & Kallal, 1992; Suh et al., 2010). The similar framework also applies for the functional clothing development procedure, but the consumer's requirements and preferences are also considered in the applied design process (McCann et al., 2005; Suh et al., 2010). The intelligent garment design procedure considers the embedding of technology into art and fashion. As a result, designers are compelled to accommodate the consumer's preferences starting from garment selection to product launching (Carroll & Kincade, 2007).

Similarly, the study of Ariyatum et al., (2005) and Perry et al. (2017) confirms the necessity of taking consumer's opinion into consideration revealing the consumers desire for an intelligent garment with aesthetic appeal. The research conducted by Ariyatum et al. (2005) reveals that consumers preference of smart fabrics that is physically appealing, emotionally fulfilling and matching with their lifestyle and simultaneously available with affordable economic value and comfortable to wear. Their findings also discovers that fashion designers emphasize the necessity of fashion whereas product developers insisted on the practical approach. However, both designers according to them are concerned about the social acceptance of smart garments and agreed on the commercialization of these products by combining fashion and technology together hence suggested a new design direction.

Likewise, Perry et al. (2017) study reveals something similar about aesthetic appeal of the intelligent garments mentioning that individuals who purchased and used the smart clothing prefers it as comfortable, stylish and with reasonable economic value. Designers on the other hand according to them, are on the opinion

that consumers require a clothing apparel with technological ease and aesthetic appeal appears as secondary. The design focus as Perry et al. (2017) mentioned, was more on the technical solutions and functionality rather than on hedonic value, fashion traits and seamless amalgamation.

2.1.4 Periphery of intelligent garments applications

In terms of applicability of the intelligent garments, there are few areas where the utilization of smart clothing has achieved success such as military, health, sports and entertainment where the growth rate differ based on each industry segments (Ariyatum & Holland, 2003; Suh et al., 2010). In the health sector, the application of garments with sensors and digital technology such as big data has accelerated the monitoring and collecting data of various levels for example heart rate, blood flow and temperature from patients especially older adults (Mahmood & Lee, 2020; Chen et al., 2016). Smart wearables are proving significantly beneficial for the people with Alzheimer disease, children with severe disability issues and impaired patients. The wearables technologies are assisting both health professionals and patient to communicate efficiently about their health concerns and solving their health issues (Mahoney & Mahoney, 2010).

Likewise, the military industry is successfully utilizing and receiving benefits of the wearable technologies in terms of ensuring safety and security of the soldiers, dealing with their health concerns in dire circumstances and developing an effective communication mechanism when they are in operations (Scataglini et al., 2016). Apart from safety and security, smart garments are also utilized to measure the performance of the Belgian soldier to monitor emotional factors such as stress, anxiety and also improving human function (Scataglini et al.,2016). The findings of Ariyatum et al. (2005) revealed that those intelligent fabrics poses massive potentials for this industry and are also an optimum 'fit' in terms of achieving a larger target market.

Apart from these two sectors, there is a significant potential for intelligent clothing in the periphery of entertainment and sports apparel as well as electronic industry (Suh et al., 2010). Study by Ariyatum et al. (2005) revealed that consumer prefers functionality mostly for intelligent garments as a sport product and also disclosed that their perceptions are different about an electronic item and a fashion merchandise. They also discovered that aesthetic aspects of the product 'good design' as well as 'matching lifestyle' likewise were considerable contributing factors. Designers both from fashion and product development confirms the notion of intelligent garments a perfect fit as a sport product.

Similar understanding is observed from Scataglini, Moorhead and Feletti (2020) on the potentials of smart garments which mentions that in extreme sport condition intelligent fabrics are an optimum solution for monitoring performance and psychological information of athletes to ensure safety as well improve quality of life by avoiding health injuries. In terms of entertainment field, the 'Hugshirt' by cutecircuit and 'heat up and glow' by Loomia are two novel examples of smart products in entertainment industry (Behr, 2018). Gaming industry are also a potential sector for complete utilization for the smart wearables and other digital technologies. (Soo, 2016).

Above discussion apparently illustrates that smart clothing is a sophisticated amalgamation of textile and technology which requires an ability to accomplish all consideration of consumers as a final fashion apparel. Sonderegger (2013) supports the perception about the sophistication of smart garments mentioning that it includes both the devices and the garments which combines the characteristics of clothing such as aesthetics, comfort and style as well as the traits of the technological devices such as usability and safety. By analyzing the models proposed by Lamb & Kallal (1992) and Norman (2004), Gonku-Berk (2019) concludes that combined characteristics of both the frameworks would facilitate a better understanding of smart clothing in terms of possessing the capability to offering a sustainable, transferable and customizable product for diverse customers. Therefore, smart fabrics or smart clothing is becoming an important outcome of Fashion 4.0 or will have a greater prospect in near future with high economic values (Behr, 2018; Langenhove & Hertleer, 2004).

2.2 Technological change

Technological change is the type of environmental change that will be concentrated in this paper especially in the context of fashion and aesthetics. Scholars of organizational and economic study to mention on several occasions, according to Ehrnberg (1995) strived to define technological discontinuities by adding different dimensions but the focus of analysis has been thorough multiple states of confusion. Tushman & Anderson (1986) stated that discontinuity in technology brings improvement in price performance but earlier scholars as Ehrnberg (1995) mentioned also have considered other dimensions such as changes in proficiency, changes in physical product or changes in procedures in the consideration to define discontinuity.

2.2.1 Types of change

According to Rip & Kemp (1997), mainstream economists presented technology as an exogenous variable and are connecting the production alteration with technological transformation when all other economic variables fail to describe the reasons for the alteration. They also mentioned that several economists on the other hand, endeavoured to present another idea to include innovation in a novel framework in later period. This framework, according to them, is recognized as an endogenous model, which depicts a connection between technological innovation with human capital input and research and development of the firms. Technology either is exogenous or endogenous has the ability to intensify the competition or make the current pattern obsolete by being discontinuous (Clarke, Weyant, & Edmonds 2008). Previous literature on diffusion of technology concentrates on two assumptions such as market-based assumption (Christensen & Rosenbloom, 1995) and competence-based assumption (Tushman & Anderson, 1986; Anderson & Tushman, 1990). Both of the assumption emphasized on incumbent firm's responds towards the changes brought by technology (Bergek et al., 2013).

Competence based assumption henceforth, concentrates on the ability of technological trajectories where it either enhances the competence of the incumbent firms or destroys the competence. (Tushman & Anderson, 1986; Anderson & Tushman, 1990). Emerging technologies that are different from dominant technologies several occasions require new sets of skills and knowledge to bring changes in the product development and production phase. As a result, this new knowledge and expertise threatens the existing performance set to become obsolete. In the product phase, the competence destroying discontinuity introduces novel product categories or creates a substitute for the existing one (Tushman & Anderson, 1986). Discontinuity that enhances the competence concentrates on the magnitude improvement in price or performance and is established on existing knowledge and expertise within a product class (Anderson & Tushman, 1990). Market based assumption on the other hand, concentrates on changes in value networks brought by innovation. Importance of performance curves and different categories of innovation such as sustaining or disruptive are discussed by the scholars of this supposition. (Bergek et al., 2013).

After considering all the different dimensions, Ehrnberg (1995) proposed a model to analyse the definition and in his model, he considered three perspectives that can provide a clear idea of technological discontinuity such as changes in price and performance, changes in product and processes and changes in technical competence and other resources. He concluded that technological discontinuity is defined as a variation in any of the dimensions and the nature of the change differs significantly. According to Hekkert et al. (2007), technological changes

comprise three stages such as invention, innovation and diffusion. They mentioned technological change as a dynamic process where different participants such as manufacturers, consumers, suppliers and policy makers assist in innovation transformation. They have stated that transformation of innovation requires an alternative framework in which evolution begins and proceeds.

As mentioned earlier, radical or incremental innovation are two types of change or categories of innovation that are discussed in the previous research significantly (Norman & Verganti, 2014). It appears that earlier academics have provided different connotations for these two terms such as discontinuous vs continuous, disruptive vs incremental, evolution vs revolution and continuous vs breakthrough (Ehrnberg, 1995). In addition, scholars have provided a notable amount of time on how to define these two categories of innovation and what procedures technology follows to be either incremental or disruptive (Norman & Verganti, 2014). According to Papp and Kurtz (2004) the term disruption of technology essentially illustrates the impact technology creates in the environment. They mentioned that the influence is noticeable due to radical innovation and successful firms' failure to adapt to the new technologies. Thus, the disruption as they stated essentially appears in the business model of the firms who encounter a downturn in the success due to the failure of the new technological adaptation.

In addition, the authentic nature of the destructive tendency of any technological change according to the earlier scholars, first was identified by Schumpter (1939) who explained that the entrepreneurs bring creative destruction through innovation (Utterback & Acee, 2005). The idea of creative destruction was the central theme of innovations in industries and development of technologies in recent literature (Bergek et al., 2013). Any novel innovation becomes disruptive by providing the smaller companies to challenge the established organizations with limited resources. Existing incumbents concentrate consistently on improving the present technologies they possess or improving the product or services for the significantly demanding customers by overlooking the requirements of certain segments (Bower & Christensen, 1995). The new entrants as a result, prove disruptive by serving the needs of those overlooked segments of the consumer market and achieve a stronghold in the market by delivering a low-priced product or services with more suitable functionality which can be observed from figure 5 (Christensen, Raynor & McDonald, 2015).

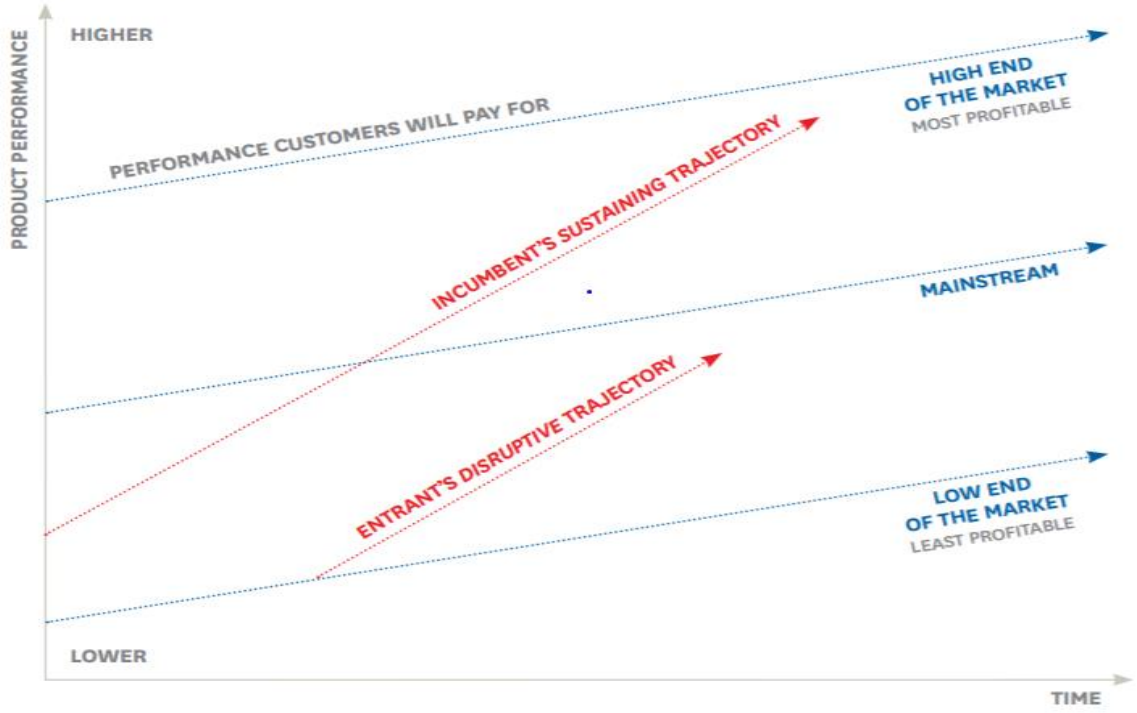

Figure 5: The disruption innovation model (Adopted from Christensen et al, 2015).

Moreover, Adner & Zemsky's (2005) findings demonstrated that there is a competition between new and established technology and advancement in technology is one of the reasons behind disruption to occur. They stated that the threat of technological trajectories is rising, equal to the number of new technology firms and is greater, if there is a significant price discrimination in different segments of the customers. According to them, performance oversupply isn't necessarily the major intrigue for the disruption but the market structure which they defined as how many firms are using the technology. Therefore, radical innovation introduces novel technology that allows designers to afford newness in the existing process and to provide a creative meaning to the product (Norman & Verganti, 2014).

Sustaining innovation on the other hand, concentrates on the existing technologies or competencies by enhancing or improving it in different periods of time. (Bergek et al., 2013). Incumbents that adopt the sustaining approaches of innovation produce products and services that are most suitable for the existing consumers. They preserve the sustainability by incrementally improving the present technology or product or services competence (Christensen et al., 2015). Established firms initiate sustaining innovation as a consequence of a design research strategy or through a mutual adaptation. The adaptation begins by the product developers and user community through a series of mutual attempts to bring an

arrangement between them (Bergek et al., 2013; Norman & Verganti, 2014). Products that achieve outstanding performance proceeds through continuous improvement towards lower cost and enhance effectiveness. Thus, sustaining innovation is significant though it is not as stimulating as disruptive innovation (Norman & Verganti, 2014).

Apparently, previous scholars like Verganti (2008) and Norman (2010) have attempted to provide a relationship between, design research, and meaning with these two dimensions of innovation. They mentioned that innovation is not only influenced by technology and changes in meaning but also by different levels of design research. They suggested that researchers should discover new interpretations of what a certain individual discovers meaningful (Norman & Verganti, 2014). Therefore, whatever connotation is provided, the categories of technological transformation are summarized into these two possibilities. They are either competence destroying or competence enhancing or either the innovation is sustaining or disruptive (Bergek et al., 2013).

However, recent scholars like Sood & Tellis (2005) mentioned that previous academics concentrated significantly on the effects of technological transformation rather than its attributes, which they discover problematic. Thus, they identified and defined the types of technological change into three categories such as platform, design and elements by emphasizing on the inherent characteristics of technology. In addition, Bergek et al. (2013) mentioned that incumbents possess the ability to integrate novel innovation into existing technologies. They have challenged the idea that established firms are under threat of new entrants at a period of discontinuity and stated that the concept has underestimated the incumbent's capability to perceive the potentials of novel technological innovation.

Similar findings are observed from Hill and Rothaermel (2003) study which mentions that incumbent firms confront the situation by adaptation strategy, performance improvement and exploitation of new innovation. Bergek et al. (2013) proposed the idea of creative accumulation where existing firms confront three challenges such as continuing the rapid evolution of existing technologies, expanding the present ones as well as acquiring new resources and assimilating the novel innovation with existing one to obtain superior performance solutions.

2.2.2 Evolution through changes and adoption of technology:

Technological evolution or revolution several occasions begins with innovations and the impact of different patterns of industrial innovation several occasions bring transformation in various phases of products, services or processes (Iansiti, 1995). Academics like Foster (1986) mentioned three concepts such as S-curve, discontinuity and attackers' advantage in understanding and explaining the

changes occurring in the business environment brought by technologies. According to him, S-curve shows the relationship between the endeavour of improving a product or process and the consequence of that effort provided. He also stated that understanding the phases and limits of s-curve is important since the discontinuity occurs as soon as the technology reaches its maturation. Any new innovation evolves as mentioned in the earlier research, through the s-shaped path by starting underneath the old technology and then reaching an intersection stage after which the old technology becomes obsolete, and the novel innovation directs the market (Sood & Tellis, 2005).

2.2.2.1. Technological evolution in transformation period

According to Foster (1986) as mentioned earlier, discontinuity several occasions replace the technology with a new one when the old one matures, and the entrants have an attacker advantage against the established incumbents in this situation. Earlier scholars concentrated on two aspects to explain the advantage of invaders as Christensen & Rosenbloom (1995) mentioned, such as the relationship between the established firm's or the new entrant's capabilities with the magnitude of technological changes and the dynamics and managerial procedures through which incumbents or new entrants confront the changing situation. Apart from these two factors, small firms concentrate on the value networks that were neglected by the larger incumbents and they undertake such procedure by addressing the requirement of consumers in different contexts (Christensen & Rosenbloom, 1995). This innovative strategy challenges established firms since the new incumbents improve the product performance which exceed the established market demands and as a result outperform the established firms in the context of disruptive innovation (Christensen et al., 2015).

Hence, the phenomenon of technological evolution begins in S-curve initially with a slow progress, followed by an accelerated growth and then culminates in a plateau (Foster, 1986; Sood & Tellis, 2005). The phenomenon of S-curve where the technological evolution begins, is presented as evolution in three stages such as preliminary stage, growth phase and maturity stage. The novel innovation proceeds underneath the previous technology in the introductory phase, intersecting it on the right summit in the growth stage and then becomes steady after achieving stability and maturity (Abernathy & Utterback, 1978; Foster, 1986). Kaplan & Tripsas (2008) describes the initial model that most of the earlier academics concentrated on, was the evolution cycle where the era of ferment follows after discontinuity. According to the model as they mentioned, the retention of a dominant design is initiated after the selection process of competing technologies and an incremental progress occurs at the period of convergence of dominant design which later is disrupted by another discontinuity.

Nevertheless, Sood & Tellis (2005) mentions in terms of performance increase technology do not follow the single S-curve rather the evolution proceeds from

no performance growth for a long period towards a largest performance bounce. According to them, the performance begins to improve as soon as the existing technology is intersected by the new technology, new performance procedure or by the competitor's technology. They stated that novel innovation does not have any strict regulation of appearing from below and might enter above the curve presenting the evolution predictable to some extent. They also found that technology itself and the rate of its transformation increases over time and both established incumbents and new entrants have the ability to introduce novel innovations.

Innovation or technological change to mention on+ several occasions predominantly occur in the product or process level since firms' endeavour to improve the performance for both (Tushman & Anderson, 1986). Product's development on technical aspects and its introduction in the market on several occasions appear as major determinants of innovation to appear on the scene (Gort & Klepper, 1982). This process of development according to Abernathy and Utterback (1978) contains three phases and they introduced it as a product cycle model that concentrates on a single cycle of technological change. They mentioned that in the preliminary stage the improvement is fluid where the rate of product innovation is greater than the rate of process innovation and then in the following stage of introductory phase, the rate of process innovation becomes higher than the rate of product development. They also stated that in these two phases majority discontinuity or radical changes appear. In the final phase, majority incremental changes occur in a stage where both the product and process innovation stabilize slowly and arrive in a balanced state (Abernathy & Utterback, 1978).

In addition, Anderson & Tushman (1991) mentions that any transformation in technology continues through a cyclical process and any discontinuity might direct an industry to experience a novel product or a process innovation. These changes as mentioned earlier either are competence destroying or competence enhancing. Technological trajectories that are competence destroying are recognized as disruptive whereas competence-enhancing trajectories are identified as incremental (Tushman & Anderson, 1986). New incumbents are renowned for proceeding to the market with radical innovation by threatening the competence of existing firms or bringing novel innovation in product performance. Incremental change on the other hand, are well recognized for being embraced by the existing organizations for enhancing the present skills and performance (Anderson & Tushman, 1990).

Moreover, Size of the organization as Fritsch & Meschede (2001) mentioned also determines the innovation approach firms assess to proceed further. They stated that larger firms usually invest significantly on process innovation whereas smaller firms concentrate on more novel product or service ideas. According to their findings, product innovation is more a suitable option for new entrants than process innovation. Arrival of technology or pace of transition, according to

Sood & Tellis (2005) also has a significant role on firms' attitude towards technological changes and represents the rate at which innovation is introduced in the market. A sharp and successive movement in performance or a continual movement several occasions increase the pace of technology. This frequent change occurs due to the rapid development of technology in different areas (Sood & Tellis, 2005).

Furthermore, the source of the technological changes from which it appears is another important aspect for the incumbents to consider. The sources can be either internal or external to the organization or several occasions it is outsourced or there is no investment on the technology (Archibugi & Planta, 1996; Leonard, 1998, p. 51). An organization considers outsourcing a technology when it has high familiarity but low strategic importance (Leonard, 1998, p. 51). According to Clarke et al. (2008) R&D is one of the major sources of changes to occur along with learning by doing and spillover. Technologies with high familiarity in this situation have larger strategic importance for the firm and are optimum candidates for internal R&D (Leonard, 1998, p. 51). The research and development majority period are funded by the organization itself, but several occasions are funded by public organizations (Clarke et al., 2008). Larger organizations invest significantly in their research and development sector due to the drive for problem solving innovation (Coccia, 2017).

Correspondingly, as Clarke et al. (2008) have mentioned, organizations several occasions invent radical solutions to increase product performance by learning by doing. According to them, it is one of the important sources of technological change that initiates through repetitive activities. Other than these two, spillover as the authors have mentioned is another important source in which any technological transformation occurs, and the change occurs through transfer of knowledge (knowledge spillover) or transfer of economic benefits (rent spillover).

Apart from the size and source, the measurement of technological evolution is another important aspect that incumbents consider receiving a comprehensible concept about the impact that discontinuity would generate (Popp, 2005). According to Archibugi & Planta (1996), the major reasons for the assessments of evolution are reaching an understanding about the resource management related with innovation, initiating and managing correct strategy for the resource's allocation process and selection of areas in which economic returns will occur through innovation. Classical academics such as Basberg (1987) and Archibugi & Planta (1996) mentioned patents and surveys as an effective approach to measure any technological innovation. Basberg (1987) stated that patent statistics is a convincing indicator of technological transformation and according to Archibugi & Planta (1996) organization obtain understanding of the innovation progress through surveys of innovations and firm's innovative efforts.

Popp (2005) on the other hand, stated that organization several periods obtains uncomplicated data from the research and development (R&D) and from diffusion studies of certain technologies. He states that larger organizations preserve information of technological change through continual progress of R&D activities and diffusion since it is a gradual process. Therefore, innovation that counts those results from R&D activities and the total factor productivity are two methods of measuring the rate of technological progress. There is a high correlation between the rate of product or process innovation to the contribution of university research and government laboratories (Klevorick et al., 1995). However, Popp (2005) also has similar understanding about patent data like Basberg (1987) and Archibugi & Planta (1996). He believes that unlike R&D, patent data provides detailed information about the inventor and inventions. He also added that patent data also provides understanding about different categories of R&D and its activities. Thus, patent proves as a convenient method of measuring both innovative activity and output.

2.2.2.2. Adoption response towards changes

Technological transformation compels organizations to introduce adaptive strategies to ensure their existence in the market (Aggarwal, Posen and Workiewicz, 2016). Majority literature on strategic management concentrated on the adoption process of technology by the larger organizations that is how firms struggle and survive for their existence in a changing environment (Chakravarthy, 1982). The strategies several occasions are influenced by organizations perception, importance and familiarities about the technology itself (Leonard, 1998, p. 51). Perception as a term informs about the organizations understanding towards certain technological evolution such as technology as an opportunity or technology as a risk or a threat (Nelkin, 1989). Companies' response towards technology is positive and proactive approaches are adopted when they perceive potential benefits in the environmental change whereas organizations adopt conservative approach when they recognize the change as a potential threat (Chakravarthy, 1982; Preez & Pistorius, 1999).

In addition, technological importance to organizations depends on the degree of meaning a novel innovation provides as an opportunity (Teece, 2012). Kaplan & Tripsas (2008) findings demonstrated that the collective frame improvement and technological meaning are influenced by the interaction occurring between producers, users and institutions. Sensemaking usually begins in the exploration and exploitation phase and the process majority period depends on the socio-cultural situation of the organization and the technology (Henfridsson, 1999). It is a procedure of retrospective development that rationalizes peoples conduct, in other words a creation of cognitive elements through which technology is interpreted and perceived (Henfridsson, 1999; Weick, Sutcliffe & Obstfeld, 2005). Companies decide the adoption strategy after assessing the technology through opportunity

sensemaking procedure mostly in the exploitation phase since at this period ambiguity about new innovation becomes smaller and the technological characteristics become explicit gradually (Henfridsson, 1999; Teece, 2012).

Moreover, familiarity with certain innovation and scientific know-how also influence the decision-making procedure of any organization towards that technology (Zunino, Suarez & Grodal, 2019). The existing knowledge and capabilities along with the capabilities gap identified by the company, influence the sourcing of technology as well as the adoption strategy (Dewar & Dutton 1986; Leonard, 1998, p. 48-50). Kahl & Grodal's (2016) have similar understanding about familiarity, but he mentioned creativity as a crucial element also since according to his study companies were less successful who just emphasize only familiarity.

Furthermore, Optimal timing is another factor which also influences the organizational decision of embedding certain innovation with an existing one. Majority Firms confront uncertain situations about the improvement of new technology and the degree of arrival (Farzina, Huisman & Kortb, 1998) and factors such as cost reduction, market competition intensity and number of new substitute technology influence firm's decisions of switching to novel innovation and adoption strategy (Milliou &Petrakis 2011). Also, Brashear-Alejandro, & Kang (2016) proposes a framework that demonstrates four more factors that work as an antecedent for technology adaptations such as technological attributes, outside influence, internal influences within the firm and inter-organizational correlation. Their research demonstrates the importance of interfirm relationships and discovers three significant aspects of relationship such as power, trust and justice influence the adoption of technologies.

The strategic response of a firm towards environmental changes to mention varies on the absorptive capacity (Nicholas-Nixon, 1995) and a state of adoption (Chakravarthy, 1982). The absorptive capacity provides firms to assess and assimilate the outsourced knowledge. It is the outcome of a firm's technological capabilities which enables organizations to respond to technological changes through both external and internal knowledge (Nicholas-Nixon, 1995). Technological sourcing both internal and external, influences the outcome of firm's activities through multifaceted approach (Nicholas-Nixon & Woo 2003). Apart from this, firms' strategic responses are also influenced by the state of adaptation, organization and material capacities and thus three types of adaptive fits are recognized such as Stable, Unstable and Neutral (Chakravarthy, 1982). Three categories of adaptation are also identified depending on the flexibility and responsiveness towards the environment change such as defensive, reactive and proactive (Miles et al., 1978; Chakravarthy, 1982).

Organizations in general, provide reactive responses to disruption in stable equilibrium state, consider a bureaucratic management approach and possess suffi-

cient material capacity. The reactive firms initiate adoption only after the influence becomes apparent and endeavour to improve the situation (Miles et al., 1978; Chakravarthy, 1982). On the contrary, in an unstable state, organization practices mechanistic arrangement and response defensive since it is susceptible to the change (Chakravarthy, 1982). Inability to respond to its markets transition is one fundamental shortcomings of defender organizations (Miles et al., 1978). Correspondingly, Proactive strategy is considered in the state of neutrality and companies consider the organic arrangement through which firms become more flexible and effective towards environmental transition (Miles et al., 1978; Chakravarthy, 1982). The major reason for an organization to confront failure in response to technological discontinuity is the rigidity and not integrating external technology sourcing to internal knowledge (Nicholas-Nixon, 1995).

Moreover, According to Damanpour (2001), the adoption of product innovation is greater than the process innovation since the product innovation is protected by the patents. The authors mentioned that patent security is ineffective for process innovation and more effective for product innovation because of technology utilization. Kraft (1990) mentioned in his study about a positive relation between the transformation of both product and process transformation where product innovation has a significant impact on process innovation but there is no evidence of the alternative impact. In their study on banks adaptation pattern on innovation, Damanpour (2001) have found something similar to Kraft (1990) and mentioned that production innovation majority period leads to process innovation and successful banks always endeavour to adopt both innovation with perfect synchronization. Thus, deciding an appropriate fit and appropriate pattern of adoption is crucial for a firm to confront any potential technological trajectories (Chakravarthy, 1982; Damanpour, 2001).

2.2.3 Technology behind fashion 4.0 and smart clothing

The broad spectrum of fashion as mentioned earlier also has been influenced by the rapid innovation and technological advancement for a long period (Matković, 2010). Fashion 4.0 as an ecosystem is influenced by industry 4.0 technologies which revolves around several exponential disruptive technologies (Bertola & Teunissen, 2018; Bongomin et al., 2020). The I4.0 ecosystem consists of three essential spheres such as smart factories, smart networks and smart products (Platform, 2018; Bertola & Teunissen, 2018). Internet of things (IOT), big data, cloud computing, digital manufacturing, augmented and virtual reality (AR, VR) are major exponential disruptive technologies of I4.0 and applications that have been implemented in the fashion industry in recent period specially sensors technologies and RFID (Vaidyaa et al., 2018; Bertola & Teunissen, 2018; Bongomin et al., 2020). A brief about the three spheres of I4.0, the technologies and their impact

will be discussed further except the smart products sphere which has already been discussed earlier in detail.

2.2.3.1. Smart factories

The industry 4.0 or fourth industrial revolution concept has been introduced by Schwab (2016) and according to him, smart factories will create a flexible and cooperative manufacturing system that will enable physical and virtual objects connected with each other globally. Smart Factories are one of the key components of Industry 4.0 along with the Cyber physical system (CPS) and Internet of Things (IOT) (Hermann et al., 2015) and are challenging the traditional manufacturing system by introducing changes and incorporating the requirements of smart systems (Mabkhot et al., 2018). In the smart factories, IOT and CPS coordinate through effective communication and networking to assist individuals and machineries to execute the assigned tasks as well as increase traceability and visibility through IOT enabled platforms (Hermann et al., 2015; Y Zhong et al., 2017). The traceability and visibility platform assist achieving real time production and increasing the efficiency of smart manufacturing through radio frequency identification (RFID) (Y Zhong et al., 2017).

In the fashion industry, the 6 design principles mentioned earlier are significantly influenced by the IOT and CPS. Interoperability and virtualization are two of the principles enabling the connectivity between individuals, organizations and CPS through IOT and internet of service (IOS) (Hermann et al., 2015) but according to Bertola & Teunissen (2018) companies in the fashion industry still are not able to establish a digital infrastructure that assists this communication or connectivity the IOT or Internet of people (IOP) is delivering though they are welcoming in incorporating these novel technologies. The authors mentioned that there is no transparent replication available to detect some criticalities through real-time control and system check.

2.2.3.2. Smart connectivity

Networking is an essential part of the I4.0 ecosystem where information and data are transmitted to and received from every component of a smart factory as well as smart products that are connected to each other (Ardito et al., 2019). Supply chain and retail channels are significant components of this phase of smart networking (Bertola & Teunissen, 2018). Exchanging information is crucial to all the supply chain, retail networks and all components of production facilities and one method to improve is by adopting new digital technologies for data through digitization and digitalization (Braglia et al., 2020). Digitization assists in establishing networking ecosystems that include different associates of the supply chain raw materials and includes technologies such as advanced analytics, smart pro-

curement, integrated planning and execution system as well as other digital technologies such as augmented reality, cloud technology, big data and IOT (Schrauf & Berttram, 2016).

2.2.3.3. Smart product

Intelligent product is another aspect of industry 4.0 that assists in creating a smart environment (Bertola & Teunissen, 2018). Smart products consist of several intelligent technologies such as sensors, actuators, computational elements and other interconnected technologies that are seamlessly embedded into everyday products to assist the smart ecosystem (Mühlhäuser, 2008). There are several definitions provided by different authors describing the connotation under the name of 'intelligent product' or 'smart product' but Gutiérrez et al. (2013) described these as separate terms and placed under one umbrella such as the concept of 'smart thing'. Smart clothing and smart textiles are two examples of smart fashion products that have been discussed earlier already.

2.2.3.4. IOT and IIOT

Internet of things is an ecosystem that interconnects a network of machines and devices globally and allows them to interact with each other (Balaji & Roy, 2017). It is also perceived as the internet of everything meaning that IOT will not only observe, perceive and comprehend' but also will possess the ability to absorb, anticipate and recognize everything of its surrounding environment (Madakam, Ramaswamy & Tripathi, 2015). This disruptive paradigm has the potential to bring changes in the business processes, strategies and competencies (Lee & Lee, 2015). Describing the concept briefly, the technology uses sensors and actuators to interlink devices and humans in a physical environment (Saarikko et al., 2017). Companies can achieve different benefits through IOT such as process optimization, sophisticated self-driven systems and decision analytics (Balaji & Roy, 2017). Industrial Internet of Things (IIOT) is the application of IOT at industry level. Boyes et al. (2018) defines Industrial Internet of things (IIOT) as a networking system where smart particles, virtual and physical resources, information technologies and cloud computing platforms work collectively.

2.2.3.5. Big data analytics

Big data, according to the HACE theorem, begins as a data of massive quantity with decentralized control from diverse and autonomous sources that explore complicated, meaningful and evolving relationships among a data set (Wu et al., 2014). Boyd & Crawford (2012) have added that to achieve a transparent and effective decision, organizations several occasions utilize big data to explore purposeful and perceivable patterns from data generated or data supported activities. The procedure of storing, analysing and visualizing massive amounts of data

to observe and identify that meaningful pattern is recognized as big data analytics (Sagiroglu & Sinanc, 2013). IOT will assist big data by proving better predictive analytics to reduce inventory volume, connecting consumers and maintaining the manufacturing closely to consumers (Schrauf & Berttram, 2016).

2.2.3.6. Artificial intelligence (AI)

Artificial Intelligence (AI) on the other hand, is an area of computer science that explores human intelligence and attempts to reconstruct that intelligence into machines. The original purpose of the recreation of human intelligence is to enable machines to perform complicated human functions such as reasoning, creative thinking, social intelligence, recalling memory, perception and learning (Lu et al., 2018). It also encompasses rigid and non- rigid objects with assistance of IOT, 2D and 3D technologies and sensor technologies such as GPS, RFID, touch and speech recognition and tracking (Bradley et al., 2009). In addition, iconic gestures are enabled for the consumers by the technology that combines AR, virtual space and hand tracking face recognition (Papahristou et al., (2017).

2.2.3.7. Augmented and Virtual reality (AR and VR)

Augmented reality is an amalgamation of the physical and digital world where different elements are introduced and are enhanced through computer generated input where the inputs encompass sounds, videos, graphics and GPS (Pesce, 2020). Virtual objects are embedded into an actual scene into a video image or head mounted display (HMD) and accurate computation of camera stance is required to achieve precise alignment between the virtual object and actual objects (Bradley et al., 2009). Virtual reality on the other hand, a technology that creates a simulated environment that allows vision, hearing, touch and smell with a head mounted display (Bardi, 2020). The technology through simulation enables users to be present inside an experience and interacts with the 3D world without leaving the present location (Strohanova, 2019). Sensors, 3D graphics and algorithms are applied in both the AR and VR but in virtual reality the environment responds to users' vision and is artificially constructed through images and sounds whereas in the augmented reality the images and videos are superimposed (Bardi, 2020).

2.2.3.8. RFID and NFC

The radio frequency identification technology detects people or objects through radio signals (Azevedo and Carvalho 2012). This method embedded wireless technology through which networking ability of electronic intelligence connected with visible items are improved (Modrak et al., 2010). Any human contact is not required in RFID and are composed of elements such as readers, readers security program, tags and softwires (Hingley et al., 2007). Suppliers embed the tags to

different logistics entities such as cartons, cases and palettes as well as some individual items (Loebbecke, Palmer & Huyskens 2006). As a result, product is traced with the assistance of RFID chips embedded within it as soon as consumers touch or select the product (Papahristou et al., 2017)

Near field technology (NFC) on the other hand, is a near parameter radio communication technology that facilitates the application of mobile usage of a significant number of individuals by bringing two compatible devices of NFC together about four centimetres (Park, 2018; Coskun et al., 2013). The application of mobile has become more secure, convenient and fashionable as a physical instrument due to the development of both RFID and NFC (Coskun et al., 2013). Any device that has incorporated NFC, is able to read any NFC tags and this integration has enabled consumers to receive any information about the product instantly (Park, 2018).

2.2.3.9. 3D technologies and additive manufacturing

3D technologies have been implemented in the automobile and military industry for decades and have significant prospects in the fashion retail and other retail industries (Arribus & Alfaro, 2018). The adoption of the technology mostly is observed in the larger retail chains and the familiar technologies that are integrated are 3D printing, additive manufacturing, 3D virtual visualization and 3D manufacturing (Papahristou et al., 2017; Arribus & Alfaro, 2018) In the fashion industry, the implementation of the technology as Arribus & Alfaro (2018) have mentioned, is relatively new compare to other industry but it has introduced transformation and disruption in the product development and design phase. They also have stated that 3D printing, and additive manufacturing are mostly applied to the different areas of production manufacturing and design phase and designers have achieved significant freedom in designing.

2.2.3. 10. Sensors and actuators

Sensor technology has been adopted in several industries to receive electric information from the physical object and recently it has been integrated into the fashion industry through smart textile or smart fabric manufacturing and smart clothing (Castano & Flatau, 2014). Sensors a device as Kenny (2005, pp 1-15) mentioned, converts physical phenomenon to electronic signals by being a part of the interface whereas actuators do the exact opposite. According to him, sensor technology establishes functional relationships, ensures sensitivity and maintains accuracy. In terms of smart fabrics and smart clothing, sensor technology is a well-integrated one and creation of sensing functionality is possible through an internal and external modification of textile and an integration to fabric platform (Fernández-Caramés & Fraga-Lamas, 2018; Castano & Flatau, 2014).

In addition, there are possibilities according to Castano & Flatau (2014), to measure energy, compulsion, chemicals, humidity and temperature and customization of all the elements connected to fabric technologies are possible. They have also mentioned that the technologies are less robust than the standard electronics and their findings foretell that it is possible to achieve an absolute system of smart fabrics by integrating distinct categories of functional textile elements. Contemporary researchers according to Chin, Callaghan, & Allouch (2019) reveal something similar mentioning that minimal expenditure sensors are feasible to be integrated into smart textile and smart clothing and the technology is able to monitor human movements. In the fashion and apparel industry, the sensors are connected through wireless and other technologies RFID and NFC, AutoID sensors to IOT ecosystem (Gokalp, Gokalp & Eren 2018).

Apart from above mentioned technologies, OR code, IOP, Beacons, cloud computing, cyber physical system (CPS) and PLM are also well renowned technologies that are integrated and applied in the several fields of fashion industry (Bertola & Teunissen, 2018). The impact of all these technologies on fashion design, products and the fashion industry will be discussed further.

2.2.4 Technology influence on fashion and the industry

Technology and fashion are closely connected even though they appear as distant from each other (Seymour, 2018). Fashion signifies changes and the complicated process of aesthetic transformation is quite often influenced by changes in environment such as economic and market transitions and changes in consumer preferences. (Bertola & Teunissen, 2018). Technology also on most occasions brings changes through development and influences the surrounding environment. As a result, the fashion clothing and apparel industry were significantly responsive to the changes brought by contemporary advancement of machineries (Bertola & Teunissen, 2018; Behr, 2018).

2.2.4.1 Impact on design techniques, aesthetics and functionality

Historically, the foundational standard for fashion was mostly driven by design perspective where connected resources from different areas assisted the creation of many new organizations. (Bertola & Teunissen, 2018). Technology has a significant impact on these designs driven business models since it is recognized that technology influences the industrial design with all its possibilities. For example, in the first few decades of the eighteenth century several distinct techniques had evolved through different fashion changing trends. Techniques such

as producing knitwear on a frame was introduced because of contemporary technological advancement even though these fashion trends did not encourage dramatic technological development (Matković, 2010). Significant transformation had occurred in the history of textile when the smooth production of readymade garments and precise 'cut' for the 'shape' became possible and prior to the 19th century most of the ready-made garments were loose fitting (Godley, 1997). Wide knitting frame and 'Cut up fabric system of production' are two good examples of how technological innovation has enabled fashion and technology impact on each other (Matković, 2010).

Techniques for designs to mention, are developed based on attributes of designs, which are visible or perceptible. According to Eisenman (2013), design attributes such as colour, shape and texture are visible and associated with the functional, aesthetic and sensory information. Researchers discover several factors that influences the designers in designing procedure such as aesthetic, history, culture, psychology and markets and these factors inspires designers to introduce novel and efficient design techniques (Au, Taylor & Newton, 2004). Design procedure driven by consumer's aesthetic preferences will assist exploiting niche market and would develop and produce attractive products with harmony of both form and function (McCann & Bryson 2009, pp.45).

In addition, digital innovation technology such as RFID, virtual prototyping and automated manufacturing have introduced innovation in design procedure, have improved the quality of functionality of products and have accelerated production speed (Bertola & Teunissen, 2018). For instance, the designer Hussein Chalayan´s revolutionary idea of garments is a novel example of innovative design techniques where electrical circuit, wireless technology and automated commands are embedded together onto the surface of human physics. The remote-control dress which allows changing 'shape' and 'fit' while wearing has established a dialogue between human body and environment by marrying fashion with technology (Quinn, 2002; Behr, 2018). His pioneering concept not only presented a unique aesthetic perspective but also introduced an augmentation of clothing performance in terms of looking and to-be-looked-ness. (Bertola & Teunissen, 2018).

Moreover, design printing and 3D technology has introduced a new dimension in design methods eventually influencing aesthetics and functionality (Vanderploeg et al., 2017). Many companies are experimenting with electric technology and feedback systems into garments such as Loomia's 'heat up and glow' products and CuteCircute's twitter product's (changes colour after receiving a tweet) adding new elements in performance of the wearables. Besides, the wearer of HugShirt introduced by CuteCircute is able to experience a sense of embrace from another person wearing the shirt (Behr, 2018). Furthermore, 3D designs that are providing more freedom to designers by enhancing the creativity beyond the

traditional method, are assisting in recovering every design change, recording every possible design for future reference and are accommodating design and aesthetic details in product decision through 3D virtual prototyping (Arribas & Alfaro, 2018).

Furthermore, IOT technology has enabled communication technology into smart fabrics. Evolution in fabrics through smart textile has introduced garments that enable real time monitoring of human physic and muscle activity. As a result, athletes are capable of monitoring the overall physical activity and of improving performance (Kuzemchak, 2018; Behr, 2018). Nadi X smart yoga leggings are one good example of embedding technology into fabrics. The tech-enabled yoga pants are sensing the body movement and providing guidance throughout the session. Also, Nova jacket by Twinery MAS that combined fashion and safety together through lighting technology is another novel example (Kuzemchak, 2018). Thus, Leading organizations through IOT investment are able to bring transformation in the product development process and to assume the future trends and colour transformation in design by smart analytics and algorithms (Papahristou et al., 2017).

Apparel and the sports industry apparently are the larger receiver of these technologies and are producing smart wearable that enhance the performance of the product and athletes all together (Behr, 2018; Kuzemchak, 2018). Fashion industry and technological changes have a mutual response to the transformation they bring which also influence consumer's perspective about aesthetic and technology. Growing interest in wearable products as a result have generated a novel entrance for fashionable technology products hence smart clothing (Lambert, 2019).

2.2.4.2 Impact on fashion clothing and apparel industry

As mentioned earlier, the clothing and apparel industry are one of the central characters of embracing new technologies since the beginning of industrial revolution (Godley, 1997; Bertola & Teunissen, 2018). All phases of the fashion and apparel industry have been influenced by technological innovation and transformation starting from manufacturing to final consumers (Bertola & Teunissen, 2018). For example, ready-made garments have become more precise according to precise shape and cut requirement (Matković, 2010) and consumers through VR are able to select and order products based on their requirements (Bradley et al., 009). Contemporary fashion has been highly affected by the machinery innovations and interaction between customers and companies have been transitioned into a new phase (Bertola & Teunissen, 2018). As a result, the new market environment has worked as a motivation factor for digitizing and digitalizing the industry in the field of manufacturing, supply chain, logistics, inventory and retail management (Arribas & Alfaro, 2018).

2.2.4.2.1 Production and manufacturing

Production of fashionable objects and their usage have been through many stages of alteration due to technological advancement (Bertola & Teunissen, 2018). Fashion industry historically maintained the traditional practice of production and manufacturing but was forced to adopt the new innovations and technologies due globalization trends (Arribas & Alfaro, 2018). In the fashion industry, smart factories accommodate prototyping, simple gathering, prediction and logistics. Technologies such as additive manufacturing, 3D technologies, digital printing have already been implemented such as Nike and Adidas are adopting 3D printing and electronic knitting (Bertola & Teunissen, 2018).

In addition, the adoption of the PLM system and shop floor control system (SFC) has been accelerated by emergence of IOT in the fashion industry to achieve real time data collection and monitoring (Papahristou et al., 2017;). Product and design development have also been accelerated through using consumer data analytics by merchandisers and designers which results in an increased ROI (Papahristou et al., 2017; Porter & Heppelmann, 2015). However, according to Arribus & Alfaro (2018) fashion industry is still in exploratory phase in terms to 3D printing and AR even though several organizations have implemented the PLM software and technological advances are still expected in the manufacturing field (Arribas & Alfaro, 2018).

2.2.4.2.2 Supply chain and logistics

The technologies related to I4.0 to mention, has enabled digitization of the value chain from downward to upward operation of business as well as both horizontally and vertically (Ardito et al., 2019). Digitization would convert all the functional areas of the horizontal sphere and the entire value chain of the vertical sphere encompassing product development, purchasing, manufacturing, distribution and customer services (Schrauf & Berttram, 2016). Data set that is required for this digitalization according to Braglia et al., (2020), includes historical data and real time data about customers feedback, inventory capacity, returns of product and delivery times. They also have stated that at present rapid sharing of information and substantial incorporation of supply chain is possible through digital data. In addition, Big data and AI have facilitated certain organizations in fashion industry to establish supply chains with more flexibility and higher acceleration (Marr, 2018). IOT also along with other digital technologies will enable the fashion supply chain to be part of an absolute ecosystem and ensure complete transparency at every stage which can be observed from figure 6 (Schrauf & Berttram, 2016).

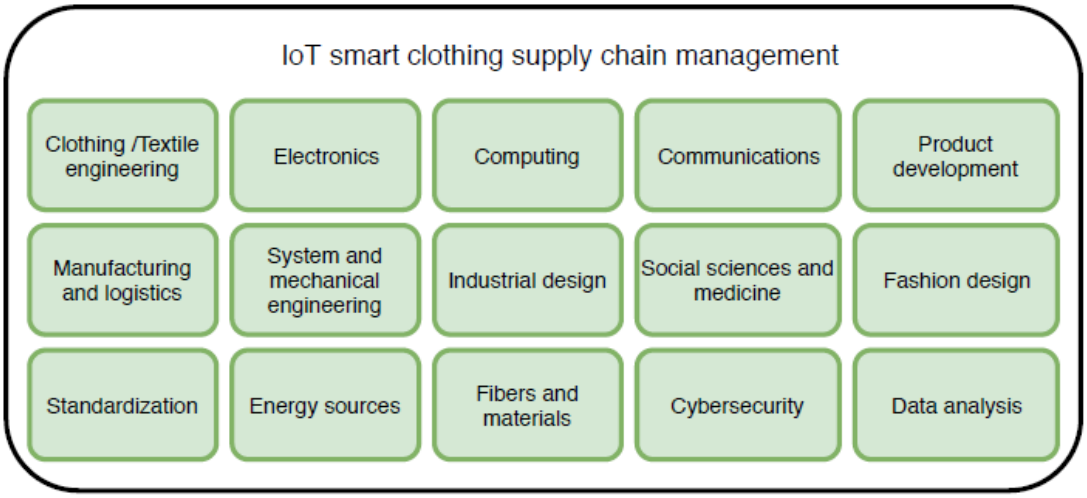

Figure 6: Discipline involved in IOT supply chain management (Adopted from Fernández-Caramés & Fraga-Lamas, 2018).

2.2.4.2.3 Inventory and retail management

Along with supply chain, fashion retail channels are adopting a framework that connects consumers through a network of integrated intelligent objects or devices to provide better service and real time information (Roy et al., 2018). Therefore, in the digital ecosystem, all the data will be available real time and enterprise will collaborate with the customer and suppliers to better manage the production, operation, supply chain and marketing function (Ardito et al., 2019; Schrauf & Berttram, 2016). In addition, merchandisers and designers are using social media and mobile apps to collect the consumer data on recent purchasing behaviour and trends with the assistance of big data analytics and IOT (Silva et al., 2019). This has accelerated the inventory process and reduced the time in inventory and has increased profitability (Marr, 2018).

2.2.4.2.4 Communication and networking

Smart connectivity in the fashion industry according to Bertola & Teunissen (2018) concentrated for a longer period to establish a stronger network globally through its operation but emphasized less in vertical integration of value chain. They mentioned that if the challenges of embodying the two key principles of the I4.0 such as modularity and decentralization are solved then the consequence of such transformation would decentralize different units in smart factories by keeping them connected and allowing more flexibility in functioning. A novel solution set such as RFID and advanced product lifecycle management (PLM) is

already assisting horizontal integration in this advanced supply chain management (SCM) model and these two-solution set would support the model to connect the entire value chain from suppliers to retail or communication channels (Braglia et al., 2020; Bertola & Teunissen, 2018). As a result, real time data exchange will empower the entire system to adapt manufacturing cycle (both small and larger scale) and market changes and production issues by ensuring transparency (Bertola & Teunissen, 2018).

Apparently, all the technology related to Industry 4.0 in the fashion industry is introducing potential disruption by challenging the traditional fashion practice (Bertola & Teunissen, 2018; Bongomin et al., 2020). Several new market possibilities and opportunities have occurred due to technological innovation (Bertola & Teunissen, 2018; Fernández-Caramés & Fraga-Lamas, 2018). The identification, evaluation and exploitation of these advantages introduced by innovation related to fashion 4.0 and the internet of smart clothing will be discussed further.

2.3 Business opportunity recognition and exploitation

2.3.1 Opportunity identification and assessment

Technology creates disruption, which brings challenges and brings opportunities for further business growth. Entrepreneurs leverage these challenges to introduce creative innovation (Spencer, Kirchhoff and White, 2008). They consider challenges as opportunities and opportunity recognition is a significant part of the entrepreneurship process (Nicolau et al., 2009). Therefore, researchers for several periods are searching for a definite explanation for what constitutes an opportunity, the source of its origin and 'why' and 'how' it is discovered by certain individuals and not everyone (McMullen, 2007; Shane & Venkataraman, 2000). Theoretical uncertainty in defining the concept and difficulty in constituting an appropriate methodology according to Lim & Xavier (2015) was a significant issue for the academics for several years and different individuals have different meanings and have described the concept in different manners.

2.3.1.1. Opportunity or entrepreneurial opportunity

In entrepreneurship study to mention, economic theory is the influential conceptual perspective and the two economic frameworks that exist in entrepreneurship literature are neoclassical equilibrium theory and Austrian theory (Wang, Ellinger & Jim Wu, 2013). The academics of neoclassical school actually denied the concept of individuals as entrepreneurs and their ability to perceive those possibilities (Kirzner, 1997). According to neoclassical economists, the market contains maximizing agents whose collective decision affects market prices and every individual has the ability to recognize opportunities at any point in time (Lim & Xavier, 2015). The concept is recognized as equilibrium theory that emphasizes on the information of the market than the attributes of individuals to decide who becomes an entrepreneur. Thus, this approach proposed that the knowledge about the future possibilities is not restricted and equally apparent to the entire market population (Shane, 2000; Lim & Xavier, 2015).

On the other hand, Austrian school view differs in several aspects. The scholars of Austrian approaches assume that the theoretical underpinning provided by the equilibrium theory does not satisfy the appropriate comprehension of market processes (Shane, 2000). According to Austrian economists, the market contains individuals who possess idiosyncratic information through which they identify particular opportunities that are not apparent to others. Contrary to the ideas of neoclassical economists, the academics of Austrian schools suggest that asym-

metry of information exists in the market, and it is information about opportunities that determines an individual as an entrepreneur, not the characteristics of that individual. They believe that the entire procedure of recognizing opportunity depends on other elements as well, apart from people's intention and capability to take action (Kirzner, 1997; Shane, 2000).

Moreover Schumpeter (1934), one of the influential academics of this school, presented entrepreneurs as market pioneers who instigates creative disruptions in the market (Spencer et al., 2008). The entrepreneurs deliver creative novel products and services to transform the demand and supply of the market (Shane &Venkataraman, 2000). Entrepreneurial innovation increases the process of creative destruction in an existing business environment by concentrating on performance rather than price. Larger organizations begin encountering a decline in market share and dominance in the market. Individuals as a result, acquire the dominance position and promote equal distribution of wealth through inventive disruption (Spencer et al., 2008). Thus, in brief, entrepreneurs not only introduce novel product or process innovation but also new market potentials or new customer requirements (Wang et al., 2013).

In addition, the scholars of Austrian school of thoughts inserted significant emphasis on asymmetry of information and they proposed that the option of becoming an entrepreneur is to identify and exploit the market, by being positively exposed to any individual if they are aware of potential opportunities (Lim & Xavier, 2015). One of the pioneers of this idea was Kirzner (1997) who believes there is a disequilibrium in the market and entrepreneurs bring equilibrium by being alert to the undervalued information and by utilizing that information. His theory explains that entrepreneurs utilize that information to fulfil the requirements of the sellers and the consumers. Thus, Schumpeterian entrepreneurs create new possibilities and new markets through 'technological innovation push' whereas Kirznerian entrepreneurs discover them in existing environments in other words through a 'market pull' (Spencer et al., 2008; Siegel & Renko, 2012).

Nevertheless, the academics have shared a mutual understanding about entrepreneurial opportunity even though they have different approaches in defining the idea (Lim & Xavier, 2015). According to Venkataraman (1997), the concept of *opportunity* comprises a collection of ideas, doctrines and actions that certain individuals possess to create a potential goods and services for future markets. He also mentioned that entrepreneurs endeavour to create novel products and services that are absent in current market situations by searching the possibilities. According to Baron (2006) the concept encompasses three important issues such as capability to generate profit potentials, novelty and societies moral and legislative acceptance of a new product or service. Therefore, the question arises how these opportunities are recognized, are evaluated and then are exploited. These

issues have become an essential part of entrepreneurship study for academics for several decades (Mason & Harvey, 2013).

2.3.1.2. Recognition and evaluation procedure

Identification of opportunities have become an interesting theme and there are differences of opinion and contrasting views on whether opportunities are discovered or created (Alvarez & Barney, 2007; Mason & Harvey, 2013). The supporter of discovery theory known as positivist believes that entrepreneurs discover opportunities caused by exogenous changes that create competitive imperfection. The changes such as technological, political and regulatory, social and demographic might disrupt the competitive market equilibrium and entrepreneurs discover market prospects from those changes (Shane, 2000). As mentioned earlier, Krizner (1997) was of the understanding that entrepreneurs endeavour observing the transition of economic curves rather than transiting the curves through actively venturing novel opportunities (Spencer et al., 2008).

In contrast other academics known as constructionists, perceive those individuals with entrepreneurship ability, create new possibilities through social interaction and endogenously constructs opportunities though the exploitation process of action, reaction and enactment (Alvarez & Barney, 2007). Schumpeter (1934) is well renowned for this idea and mentioned entrepreneurs as creative innovators who bring destructions in the market by creating novel ideas, processes and combinations (Spencer et al., 2008). Thus, George et al. (2016) based on previous research, divides opportunities into 3 different categories such as identification type, discovery type and creation type. According to them, these different categories of opportunities function under different laws and organizations are required to balance more than one growth mode for each type of opportunity.

Academics have also spent a significant amount of time on the sources, the process and the influencing factors of the opportunity identification process (Veilleux et al., 2018). Previous scholars from different backgrounds such as psychology, sociology, economics and management have presented different models of opportunity recognition procedure (Wang et al., 2013; García-Cabrera & García-Soto, 2009; Ardichvili, Cardozo & Ray, 2003). For instance, psychological approach concentrated on the individual traits and cognitive functions whereas sociological approach emphasized on the environmental factors affecting entrepreneurial decisions (Wang et al., 2013; García-Cabrera & García-Soto, 2009). Existing researchers in terms of psychological approach, according to Siegel & Renko (2012), concentrated on two approaches of identification of opportunities. They mentioned that one group of researchers concentrated on the 'black box' or the cognitive approach of the entrepreneurs and another group of academics emphasized on the determinants or antecedents that influence the 'black box' of the recognition process.

The procedure of the opportunity identification process, which is demonstrated by figure 7 to mention, begins with one of the three sub processes such as the perception phase followed by the other two such as the discovery phase and the business creation phase (Ardichvili et al., 2003). According to García-Cabrera & García-Soto (2009), a cognitive procedure assisting in recognition of opportunity differentiates the identification stage from the exploitation phase. They mentioned that the ideas are being materialized in the exploitation phase where the resources and capacities of new firms influence the economic and technical feasibility of the novel idea. The sub processes as Ardichvili et al., (2003) mentioned, are under constant evaluation in the different stages of the recognition process and after continuous evaluation the business is finally developed. They also mentioned that the development procedure is iterative and cyclical in which few more opportunities are recognized or are rejected.

Figure 7: Opportunity Recognition process (Adopted from Ardichvili et al., 2003 and García-Cabrera & García-Soto, 2009).

Perception to begin with, is the first of the three subprocesses that represents an entrepreneur's ability to recognize the new market requirements or the underemployed resources (Ardichvili et al., 2003). Some individuals have the capability to perceive these underemployed resources by being sensitive to them and are able to allocate them more efficiently (García-Cabrera & García-Soto, 2009). *Discovery* is another sub-process that represents the ability to observe the exogenous shock in the market (Alvarez & Barney, 2007). Individuals with entrepreneurial ability in this phase analyse the possible noble fit by considering the resources availability and product or service innovation capability (García-Cabrera & García-Soto, 2009). Organizational learning specially the behavioural and cognitive learning impact significantly on the analytical process of these individuals. Thus, in this phase the best combination evolves that eventually meets the market requirements (Lumpkin & Lichtenstein, 2005).

In addition, The *Business invention* phase is the situation where the optimal solutions are identified to satisfy the market requirements and the solution encompasses resources of different combinations to provide more value than the current value offerings (García-Cabrera & García-Soto, 2009). The solution according to Ardichvili et al. (2003) not only provides the optimal combination of resources but also restructures the present business model through radical innovation. The entrepreneur's assessments of each possible outcome are present in every phase of the recognition process and individuals continue this evaluation process informally and formally (Ardichvili et al., 2003; García-Cabrera & García-Soto, 2009). The informal assessment begins with consulting friends and acquaintances to ensure the appropriateness of the identified solution which leads to more formal evaluation conducted by market and financial feasibility study (Corbett, 2005). The continuous assessment procedure enables entrepreneurs to develop and implement or reject the business concept and also explains the reason behind why the unmet market requirements and realized underemployed resources is greater than the number of established successful businesses (Ardichvili et al., 2003; García-Cabrera & García-Soto, 2009).

2.3.1.3. Determinants of opportunity recognition process

As mentioned earlier, some researchers concentrated on the antecedents that influence the decision-making process of opportunity recognition to provide insight on why some individuals discover or create opportunities. In doing so, several earlier and contemporary researchers have emphasized on several factors for example Baron (2006) introduced a conceptual framework connecting environmental changes such as technology, demography and policies and regulations to the opportunity identification process along with previous knowledge, active search and social networks. He presented the connection through cognition where individuals recognize some patterns in search for opportunities that arise from the changes happening in the environment.

Therefore, based on previous research George et al. (2016) summarized those into six prominent factors such as the previous knowledge and experience of entrepreneurs (Shane & Venkataraman, 2000; Shane, 2000), the social networks (Ozgen & Baron, 2007; García-Cabrera & García-Soto, 2009), entrepreneurial alertness (Kirzner, 1997; Ardichvili et al., 2003), personality traits (Baron, 2006; Zahra et al. 2005), systematic search or accidental discovery (Fiet et al., 2005; Chandra et al. 2009) and the external environmental conditions (Schumpeter 1934; Shane & Venkataraman, 2000). These factors possess a significant impact on the entrepreneurial decision making and thus will be elaborated further.

2.3.1.3.1. Prior knowledge and experience

The significance of previous knowledge in the opportunity discovery process has been massively discussed among the contemporary scholars (George et al., 2016). Previous knowledge about market and technology exemplifies the cognitive insights that entrepreneurs utilize to recognize opportunities (Shane & Venkataraman, 2000; Shane, 2000). The framework introduced by Baron (2006) reveals that prior experience assists in recognizing patterns from the new information introduced by any external changes and social connection assists in reframing the cognitive understanding of the opportunities through discussion with associates. Earlier knowledge and experience, especially technological expertise is significant in recognizing the market potentials in hi-tech organization (Park, 2005). These knowledges can be achieved in a tacit form and in an explicit form and market or technological experience assist in achieving the tacit knowledge whereas individuals achieve explicit knowledge through formal education (Shane, 2000; Shane & Venkataraman, 2000). A convergence between knowledge of special interest and knowledge of industry is significant for a successful recognition of market potentials (Ardichvili et al., 2003).

In addition, to achieve the knowledge both Lumpkin & Lichtenstein (2005) and Corbett (2005) emphasized on the importance of organizational learning and individual experiential learning. According to Corbett (2005), by adopting different methods of learning, individuals transform previous knowledge and experience into novel insights and understanding. The effectiveness of distinct styles of learning as he mentioned, differs depending on the different phases of the recognition process. Lumpkin & Lichtenstein (2005) stated that in organizational level entrepreneurs convert the information into knowledge through cognition, adapt and transform through behavioural process and then reframe current assumption through learning by action.

Moreover, Shane (2000) proposed three dimensions of prior knowledge such as knowledge about the market, knowledge about the different methods of the market and knowledge of the consumer's requirements. Through these understanding of the market and customer requirements individuals with entrepreneurship capability identify opportunities, that are hidden in the environment or introduced by any technological innovation to create successful ventures (Ardichvili et al., 2003). This understanding is supported by Siegel & Renko (2012) mentioning that ideocentric knowledge about markets and industry and new information about science and technological transformation poses a significant value in recognizing opportunities. In their findings, they revealed that higher levels of knowledge about technology, market and customer's necessity directs individuals towards the larger number of opportunity identification and higher absorptive capacity. These knowledges can be external or internal and Foss, Lyngsie & Zahra (2013) in their analysis reveals that organizations exploit more strategic opportunities if they have access to more external knowledge sources.

2.3.1.3.2. Cognitive traits

Academics discussed certain characteristics of individuals that assist in discovering opportunities in creating new firms and these characteristics belongs to the realm of psychology such as optimism, creativity, self-efficacy, necessity for independence and achievement, risk assumption tendency and locus of control (Ardichvili et al., 2003; Baron, 2006; Nicolaou et al., 2009; García-Cabrera & García-Soto, 2009; George et al., 2016). Self-efficacy is a belief of individuals that motivates them to achieve certain goals (Krueger, 1998). Wang et al. (2013) discovered a strong relationship with self-efficacy and opportunity recognition and mentioned that higher the self-efficacy the larger the possibility to discover more opportunities. Apart from self-efficacy and open mindedness, creativity and intelligence are also essential in recognizing different market potentials (Ardichvili et al., 2003; Baron, 2006; Nicolaou et al., 2009). It is Schumpeter (1934) who introduced the idea of creativity and explained that individuals with these characteristics introduce novel innovation hence create new ventures.

Along with creativity, optimism as Ardichvili et al. (2003) mentioned also has a significant impact on discovering certain market benefits and higher the level of optimism the greater the motivation to search for different market potentials. According to them, all characteristics of personality other than these two traits have weak relationships with opportunity recognition. In addition, Shane et al. (2010) believes that imagination, curiosity and open mindedness have positive relationships with creativity and discovered that higher the tendency to openness toward innovations greater the possibility of individuals to identify opportunities.

2.3.1.3.3. The social capital

Information and resources that are required for the opportunity recognition process are achieved through social capital by the entrepreneurs (Ardichvili et al., 2003; Baron, 2006; Shane & Venkataraman, 2000; Shane, 2000; Jenssen, 2001). Social networks assist entrepreneurs in integrating into the environment which encompasses all their connected individual acquaintances and through these networks they acquire necessary knowledge, experience and new information (Baron, 2006). According to Ardichvili et al. (2003) a comprehensive social network with optimum utilization ensures the success of opportunity identification and this network encompasses four elements such as weak ties, associations, action set and internal connections. Kontinen & Ojala (2011) illustrated network ties as formal, informal and ties with family. García-Cabrera & García-Soto (2009) discovered trade exhibition as a novel example of formal ties for the small tech firms for new information whereas Ozgen & Baron (2007) emphasized on mentors and professional forum participation for opportunity recognition.

In addition, Granovetter (1973) introduced the idea of 'weak ties' where individuals possess more casual acquaintances which assist them to achieve eccentric information about new potentials (Shane & Venkataraman, 2000; Ardichvili et al., 2003; García-Cabrera & García-Soto, 2009). Arenius & De Clercq (2005) supports the view of weak ties and stated that maintaining casual relationships with a variety of individuals from different backgrounds provide possibilities to achieve unknown information and knowledge that assist in determining the perception of opportunities. On the other hand, Hite (2005) mentioned that individuals maintain relational embeddedness such as family or friendly ties and new firms' strategic decisions several occasions are influenced by these interactive ties. He argued that to ensure growth and establish a stronghold, entrepreneurial firms should maintain these 'strong ties'. His findings demonstrates that the relational embeddedness develops through a dynamic evolutionary process by leveraging certain issues such as personal relationships, dyadic economic relationships and social capital.

Mobilization of resources is also influenced by the types of networks an entrepreneur possesses (Hite, 2005; García-Cabrera & García-Soto, 2009). Individuals who have a higher number of strong ties achieve more resources and opportunities (Hite, 2005). Small firms with limited resources achieve new pathways through social networks that facilitate in accessing external resources and creation of new ventures (Jack & Anderson, 2002; García-Cabrera & García-Soto, 2009). According to Jenssen (2001), both the strong and weak ties have significant influence on opportunity recognition when resource variables are introduced and also work as a significant medium for resources.

2.3.1.3.4. Environmental condition

Academics of entrepreneurial study are not able to neglect the influence of the external environment even though significant concentration has been placed on individual traits (Wang et al. 2013). Considering the sociological perspective, scholars have provided frameworks to analyze the impact of environment on the recognition procedure (García-Cabrera & García-Soto, 2009). Wang et al. (2013) proposed that there is a strong positive relationship between external environment and the identification process. Several environmental factors such as growth of economy, cultural norms and values, geographic location and social and political factors have notable influence on the decision-making process of identifying new market potentials (Schumpeter, 1934; Mitchell et al., 2000; Mueller & Thomas, 2000). Different elements such as technological change, political and regulatory change and demographic conditions according to economists create new information that an ordinary individual ignores (Stevenson & Gumpert 1985; Shane & Venkataraman 2000; García-Cabrera & García-Soto, 2009).

In addition, economic factors like national growth, changes in trends, changes in consumers preference and evolving organizational practice set forth novel pathways to introduce innovation hence new venture creation (George et al., 2016). The recognition of opportunity according to Casson & Wadeson (2007) became feasible by any changes in the economic situation, and they mentioned that stability in economic situations creates a positive atmosphere for entrepreneurs. Muller & Pénin (2005) mentioned that the previous scholar emphasized on the importance of innovation for sustaining continuous economic growth. As mentioned earlier, social factors such as changes in trends and consumer preferences and political factors such as governmental regulations and policy changes influence opportunity identification procedures. Individuals continue the process of innovation and creation of new business potential in any given situation (Tominc & Rebernik 2007).

Furthermore, Cultural influence is also an important element that is considered to be crucial and entrepreneurs with unique and positive cultural knowledge possess greater possibility to discover innovative solutions (George et al., 2016). Based on the research on different countries in North America, Asia and Europe, Mitchell et al., (2002) discovered that national culture influences entrepreneurial cognition and traits such as willingness, arrangement and ability differ based on the national archetypes. According to Mueller & Thomas (2000), entrepreneurial values are stronger in individualistic culture because of independent action and greater locus of control. They also mentioned that the degree of innovativeness is higher as well in the individualistic culture than the collectivist and high uncertainty avoidance culture if it is combined with locus of control. However, in their findings they stated that there is no association with creativity or innovativeness with particular culture or country and creativity is a universal trait and contains no cultural influences.

2.3.1.3.5. Entrepreneurial alertness

Significant emphasis has been placed on alertness by the academics of entrepreneurial study. Kirzner (1997) first introduces the idea which denotes the process through which an individual is sensitive to changes, overlooked possibilities, incidents and patterns of behaviour in the surrounding environment (Baron, 2006; Lim & Xavier, 2015; George et al., 2016). Entrepreneurs are sensitive to unanswered problems and requirements of the market and novel combination of resources (Lim & Xavier, 2015). Thus, this responsive tendency towards market potential depicts him as a passive agent who recognizes the opportunity in any given situation (García-Cabrera & García-Soto, 2009).

According to Lim & Xavier (2015) the notion of being sensitive also depends on the level of intelligence and cognitive skills any individual poses. Based on a research on technology firms, García-Cabrera & García-Soto, (2009) discover that

alertness as a cognitive quality not only describes individuals' primary perception about business opportunity and but also assist in developing technological awareness which includes systematic and accidental search. They also have mentioned that a methodical system information alertness which seizes any market transformation or high-tech trends assist in materializing the technological alertness. According to Ardichvili et al. (2003), successful opportunity identification and development is connected to higher entrepreneurial foresight.

In addition, Tang, Kacmar & Busenitz (2012) represents alertness with three complementary dimensions such as active and passive scanning of environment and information search, alert association and information connection and evaluation and judgement of existence of profitable market potentials. These different dimensions provide a foundation of identifying new business concepts to individuals by complimenting them. Prior knowledge and propensity to new market potentials are associated with systematic and non-systematic scanning and these two traits enable individuals to examine any innovative concepts (Tang, Kacmar & Busenitz 2012; Lim & Xavier, 2015). In this process of scanning, entrepreneurs adopt unconventional approaches to evaluation and obtain and extend their domain relevant information (Busenitz, 1996).

The other dimension as Tang, Kacmar & Busenitz (2012) mentioned is associated with information connection and concentrates on achieving novel information, creativity and making extension in logic. As a result, according to them, entrepreneurs are able to establish unique connections by considering different possibilities. Evaluation and judgement dimension enable individuals to assess, and filter wanted and unwanted information and verify its impact on business opportunities (Tang, Kacmar & Busenitz 2012; Lim & Xavier 2015).

2.3.1.3.6. Active or Passive Search

Significant number of academics of entrepreneurship literature insisted on the systematic search for available opportunities (Ardichvili et al., 2003). Entrepreneurs require information to discover and exploit opportunity and any uncertainty or inadequate information is detrimental to the search process (Fiet et al., 2005; George et al., 2016). The discovery of opportunities is a perfect combination of previous knowledge and new venture creation, and the social capital and earlier experience becomes the source of the prior knowledge (Baron, 2006).

According to Fiet (2007), entrepreneurs have more possibilities to develop new venture ideas through a methodical search process and they have discovered ideas which will provide greater potential for wealth creation rather than just only scanning the market. Thus, Fiet (2007) has a similar view as Baron (2006) about the strategic fit between earlier knowledge and experience with the search for new venture creation ideas and has indicated the weakness of entrepreneurial

alertness. He mentioned that entrepreneurs' aspiration for systematically searching opportunities is not possible because of the negative possibility of receiving guidance for the discovery process.

Some Academics on the other hand challenged the idea of strategic fit and supported the concept of continual scanning hence creating a dichotomy about the opportunity recognition process (George et al., 2016). Scanning of the market according to Kirzner (1997) provides entrepreneurs an ability to sense the future potentials through exogenous shock. This concept is supported by Ardichvili et al., (2003) mentioning that individuals do not search for information rather recognize the value of it after acquiring it. According to them, when entrepreneurs are in a passive mood they are inclined towards an accidental discovery and higher entrepreneurial alertness is a significant determinant of the discovery process. However, Murphy (2011) endeavoured to create a bridge between two opposite views mentioning that the two perspectives do not contradict each other always and suggested that through a multidimensional framework, entrepreneurs have the possibility to identify opportunity in situations with high and low on both dimensions.

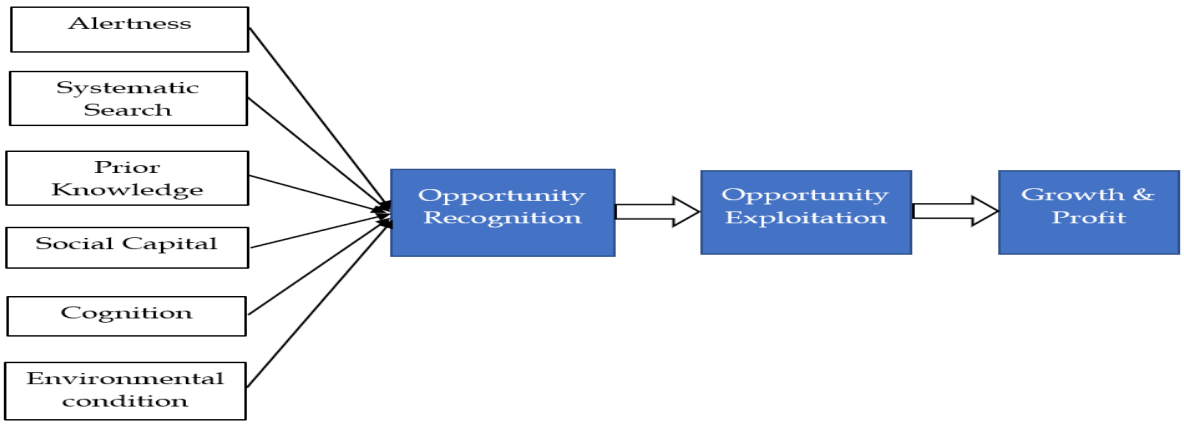

Figure 8: Factors influencing the OR process (Adapted from Ardichvili et al., 2003; Baron 2006; García-Cabrera & García-Soto, 2009; George et al., 2016).

The above-mentioned factors that are visible in figure 8, actively influence the entrepreneurial decision-making process and recognition process of opportunity. These determinants pose equal importance on the discovery and identification model However, Ardichvili et al., 2003, Baron, 2006 and García-Cabrera & García-Soto, 2009) demonstrated alertness as an individual quality and differentiated it from the active search. They believe that all the above-mentioned factors first

impact on alertness in the process of recognizing opportunity. According to Ardichvili et al. (2003), the development process begins with the maximum level of alertness and other determinants establish an association with it in the procedure.

2.3.2 Opportunity exploitation and resource capabilities

The exploitation phase begins after the opportunities are perceived and realized and entrepreneurs after considering some factors, decide or reject to exploit further (García-Cabrera & García-Soto, 2009). Some academics are on the perception that the same antecedents of the recognition process to a certain degree are also responsible for the decision-making process of exploiting opportunities especially the factors such as previous knowledge and social networks (Kuckertz et al., 2017; Fuentes, 2010). However, Kuckertz et al. (2017) views the recognition process is distinct from the exploitation process and introduced two sets of measuring methods. According to Choi & Shephard (2003), decision to exploit often is influenced by the resources and the capabilities of the firm.

The role of capabilities poses a significant weight in terms of opportunity exploitation and firms based on technological or managerial capabilities decide for further exploitation of perceived potentials (Teece, 2012). Capabilities of a firms means to acquire a set of skills, complementary resources and routine that provide the foundation for a competitive capacity (Katkalo et al., 2010). The term emphasizes the appropriate significance of strategic management in assimilating, establishing and reconfiguring firms internal and external skills, knowledge and resources in response to changing environments as well as evolution of these capabilities within time (Teece et al., 1997). Dynamic capabilities are important in the sense that it allows organizations through a routine behaviour to adapt to change and to acquire competitive advantage through effective use of resources (Eisenhardt & Martin, 2000).

In addition, Dynamic capability literature concentrated on the dynamic environmental change and extended the sphere of resource-based view. Resources based view establishes its attention towards the resources of organization in the form of managerial, physical, or human capital (Eisenhardt & Martin, 2000). Opportunities need resources in order to be exploited (Alvarez & Busenitz, 2001) and according to Haynie et al. (2009) two ways a resource is recognized such as existing resources which are utilized to exploit opportunities and future resources that are required for the future exploitation.

Based on the resource-based view, Choi & Shephard (2003) analysis proposed three important antecedents of entrepreneurial decisions of exploiting the perceived opportunities such as perceived knowledge of customer demand, opti-

mum technological capability, managerial capability and support from the stakeholders. Kuckertz et al. (2017) poses similar views on the characteristics of opportunity exploitation and emphasizes more on human and financial capital, development of novel products and creating new ventures. Lack of any of these factors would direct towards delaying or rejection of the exploitation of the opportunity perceived (Wood & Pearson, 2009).

The uncertainty of demand to mention, becomes an important factor in deciding exploitation of an opportunity (Choi, Lévesque & Shepherd, 2008). The value proposition for any new product invention requires it to be based on real demand of customers rather than assumption on the future demand. The foundation of the demand is established upon the customers familiarity with the product and its value proposition and customers often are dubious about the value proposition (Meyer & Utterback, 1995). Thus, Choi & Shephard (2003) proposed that it is a necessity for entrepreneurs to have *appropriate knowledge about customers uncertainty and about product or service capability* to fulfill their requirements before the full-scale exploitation of new product or service opportunities.

Technological capability is another important aspect that also influences the decision-making process of exploitation. A resource's comparative advantage according to resource-based view depends on the internal and external factors of the firm and the success depends on the full-scale development of the technology (Barney, 2001). The optimum level of technology along with strategic flexibility would introduce products with quality such as reliability, durability and efficiency expectations such as per unit expenditure (Meyer & Utterback, 1995). The entrepreneurs confront less risk and uncertainty when the technology at its optimum efficiency. Thus, optimum improvement of technology is positively related with full scale exploitation (Choi & Shephard, 2003).

In addition, along with technological ability organizations *managerial capability* also drives an entrepreneurial firm to exploit the perceived potential. The administrative ability encompasses an organization's skill, knowledge and experience to manage critical and complex tasks in every area of business and according to resources-based view, this ability is crucial for managing the firm's resources (Barney, 2001). For exploitation, an entrepreneur needs to manage complex and difficult tasks such as production, logistics and serving the customers which require efficient resource utilization (Barney, 2001; Choi & Sheppard, 2003). According to the study conducted by Chou & Zolkiewski (2010) technological capacity of an organization and capability to manage other resources determines the uncomplicated entrance of technological transformation. The authors mentioned that it is important for an organization to possess the ability to manage the other organizational resources, discharge some and reintegrate them later in a new cycle when necessary. Therefore, there is a positive relationship between the exploitation and realized managerial ability of the organization (Choi & Sheppard, 2003).

Moreover, *Financial capability* assist in acquiring technology and future resources and in administering present resources and human capital (Kuckertz et al., 2017). Identifying and obtaining financial resources is one of the critical factors of opportunity exploitation (Gumel, 2018). Ogina (2014, pp. 40-43) have similar view on monetary capabilities of an organization mentioning that economic possessions successfully contribute to the exploitation of existing market potentials.

Besides the administrative and monetary abilities, efficient *management team associates, employees* and other *stakeholders* are also important in exploiting an opportunity. Exploitation requires time, finance and expertise which comes from stakeholder support and stakeholder support as human capital is very crucial (Choi & Sheppard, 2003; Bayon et al., 2016). Management teams with human capital output in the form of formal education enhance the possibility for entrepreneurs to exploit different market potentials. Thus, support from stakeholders has strong correlation with exploitation decisions (Choi & Sheppard, 2003). Uncertainty of any of the above-mentioned capabilities would lead to reject or to delay the decision-making process of not only exploitation but also recognition process at the first hand (Choi et al., 2008; Wood & Pearson, 2009). Thus, the evaluation processes several occasions doesn't finish in the recognition but also extends to the exploitation phase (García-Cabrera & García-Soto, 2009).

2.3.3 Opportunities brought by Fashion 4.0 and ISC technologies:

Opportunity as mentioned earlier can arise from any changing situation which introduces now product or services with higher selling return than the production expenditure and new organizational methods (García-Cabrera & García-Soto (2009). Clarke et al., 2006) mentions technological opportunities which are the potential for technological revolution has the possibility to be exploited by industry activities. Their findings reveal that technological trajectory have the tendency to respond towards market forces however novel technologies and markets appears due to the new and unpredictable technological opportunities introduced by the disruption.

In addition, Disruption brings several potential benefits for the organization when it occurs, for example, it increases net growth through a new market or customer segment, it compels organization to adopt a new business model and it creates a positive influence on the consumers mind (Gilbert, 2003). Similarly, Industry 4.0 technology as a disruptive technology is bringing transformation in the fashion industry hence introducing several benefits and advantages (Bertola & Teunissen, 2018). These benefits encompass all the areas of production and manufacturing, supply chain and logistics and end product level (Papahristou et

al., 2017). Some opportunities brought by technologies related to Fashion 4.0 and the Internet of smart clothing are discussed further.

One of the benefits of I4.0 technology is that it has enabled *designers to enhance their creativity* by providing more liberation in design methods through 3D technologies such as printing, knitting and virtual prototyping and hence expanding the boundaries of traditional design methods (Arribas & Alfaro, 2018). These 3D technologies assisted designers in recording changes made in the design process in an archive and has also enabled to easily outsource the design process by collecting information through big data analytics by engaging in the design process (Vanderploeg, Lee & Mamp, 2017). Designers are also able to predict accurately about the design and its effectiveness with the assistance of AI assisted design systems which also reduces the repetitive tasks and amplifies their creativity (Papahristou et al., 2017).

Customization of products is another advantage brought by these technologies such as personalized blazer, shirt and sweaters with the assistance of 3D printing and knitting (Arribas & Alfaro, 2018). With the assistance of big data, AI and android application customers' lifestyles and activity is being monitored in Googles and based on the data, dresses with customized design are delivered by H&Ms digital fashion house (Marr, 2018). In addition, in the design level, most of the technologies are enhancing the *functionality of the product along with aesthetics* (Lam Po Tang & Stylios, 2005). Smart mirror and Magic mirror are one good example where fashion consumers are able to observe aesthetic transformation of their body in terms of 'looking good' and to experience the accessories and outfits through the appearance presentation without any fashion expertise (Kim & Cheeyong, 2015). Also, by adding LED lights, sensors, and solar cells which are stylish when embedded with cloths, the smart wearables are providing functional benefits of experiencing emanating lights and aroma along with increased comfortability, durability and sensitivity (Bertola & Teunissen, 2018; O'Brien, 2014).

In addition, I4.0 technology has altered the manner in which consumers experience their product or services at present and has introduced other benefits such, as *sensory product or service experience* through AR and VR (Bonetti et. al., 2017). One example is that a company named Tory Burch has altered the traditional customer experience through big data analytics, AR and VR by turning the runway show to a retail platform (Silva et al., 2019). Fundawear, is another good example of this experience which is an underwear product with sensor technology by an Australian company in cooperation with Durax providing customers a feeling of touch (O'Brien, 2014). Thus, the customer's encounter a sensory level of experience and receive more transparent information (Bertola & Teunissen, 2018).

Moreover, to provide satisfactory value proposition technology has been implemented by the retail fashion to examine consumers intention of purchasing a product, their willingness to pay and their evaluations of product values (Sohn et al., 2020). Retail organizations are providing transparent information about product location, usage and inventory through RFID, wi-fi analytics and beacon analysis. AI initiatives have also been launched for in-store monitoring, fraud detection and customer behaviour classification (Sohn et al., 2020). In addition, the method of communication will be transformed by IOT when it is combined by AR or VR and customers will receive better product or service experience (Papahristou et al., 2017). As a result, *optimum level of value* can be provided for the customer along with higher level of satisfactory product experience.

Furthermore, Digitalization has impacted *sales and profitability* in a significant manner by creating *potential new markets*. Sales have accelerated due to the application of Industry 4.0 in the neuromas field of many industries which eventually has increased the revenue. According to Geissbauer et al., (2014), industries in Europe receive more than £110 billion of additional revenue annually from digitized products and services. The similar scenario is observed in the fashion industry such as a British online retail ASOS has increased its profit utilizing big data to predict trends and provides consumers their required product and services. Topshop, another retail brand is accessing free blogs and social media channel to acquire numerous data in its predictive analytics to identify emerging trends (Brownlow et al., 2015). In addition, H&M is receiving advantage of both big data and AI to obtain increased sales and profitability (Marr, 2018).

Apart from these, *Production speed* has improved due to digitalization such as adoption of 3D technologies, robotics and additive manufacturing (Arribas & Alfaro, 2018). Merchandisers and designers are using social media and mobile apps to collect the consumer data on recent purchasing behaviour and trends by utilizing big data analytics and IOT (Kumar Reddy & Rajeshwari, 2016). With the assistance of 3D design and printing lead time and iteration of product samples has been reduced. This has accelerated the inventory process and *reduced the time and expenditure* in production and in inventory process (Arribas & Alfaro, 2018).

Fashion and other retails corporations are also major incorporators of this technology along with RFID and NFC that are allowing them to confront the challenges of inventory and logistics (Kumar Reddy & Rajeshwari, 2016). Fashion industry has special requirements for these two technologies especially after being integrated into IOT because of the complex logistics system and the necessity to transfer the design from table to the store shelves (Azevedo & Carvalho, 2012). Both Big data and analytics in the fashion industry, are assisting organizations in terms of identifying new market opportunities, estimating, and enhancing cross-selling, analysing trends and providing new benefits for designers (Papahristou et al., 2017). Thus, these technologies are providing companies some *competitive*

edge in the business environment with increasing efficiency (Boström & Micheletti, 2016).

Ensuring sustainability through reducing material waste, efficient utilization of energy and improvement of social environment is possible through industry 4.0 technologies (Ghobakloo, 2019). Sustainability refers to the preservation and appropriate utilization of global resources for the benefits of present human generation without destroying the similar opportunities for future generation (Cronin, 2011). Thorisdottir & Johannsdottir (2019) mentions pressure from market, innovation, value creation and functionality are several driving forces of sustainability among many others in fashion industry. According to them, innovation is one of the significant factors to ensure sustainability and competitive advantage can be achieved through new technology or new consumer trends.

Sustainability issues to mention, are discussed under majority period under three important periphery such as environmental, social and economic (Cohen & Munoz, 2017). According to Ghobakloo (2019), business model innovation and manufacturing proficiency is recognized as economic sustainability functions which are a consequence of industry 4.0 and this economic sustainability establishes the pathway for the socio environmental sustainability functions. They also stated that potentials of sustainability offered by digital revolution require appropriate understanding and guarantee that intended sustainability functions are delivered by industry 4.0 proportionately and reasonably.

In addition, different sustainability functions generate opportunities for entrepreneurs to introduce ideas and innovations which is able to enhance and maintain the wellbeing of the socio environmental surroundings (Cohen & Munoz, 2017). Sustainable entrepreneurship as Sarma et al., (2022) has mentioned, searches for possible solutions for degradation of environment, concentrates on the prosperity of the future generation and endeavours in natural life conservation and community sustenance. Entrepreneurs understanding about surrounding market which also includes information about sustainability issues along with technological knowledge, assist him to identify the opportunities that will fulfil the ecological requirements (Choongo et al., 2016). Industry 4.0 provides in this situation sufficient means to achieve sustainability objective (Ghobakloo, 2019) and exploit and explore the sustainable opportunities which essentially will increase organisational performance (Maletič et al., 2016).

Apart from sustainability issues, the market size for wearable devices along with smart clothing are also important which is increasing significantly specially in health and defence industry (Fernández-Caramés & Fraga-Lamas, 2018) According to Hanuska et al. (2016) the market size for both the wearables and smart clothing has doubled from the year 2015-2020 and the global market value for smart fabrics are expected to be increased to 4.08 billion USD from 1.72 billion USD according to Research & Markets (2021) as mentioned in Market Watch

(2021) with the Compounded annual growth rate (CAGR) of 19.01% over the forecasted year of 2018-2023. These reports provide evidence for the companies for a potential market growth for the companies specially in fashion Industry. Thus, combining wearable technology with clothing leads many different avenues for several business expansion opportunities.

2.4 Conceptual framework:

This section summarizes the literature review introduced before which serves as the foundation for the theoretical understanding of the phenomena of I4.0 related to fashion and clothing apparel as well as recognition and exploitation of opportunities brought by the technologies. Several key models that have been developed are also presented and a framework has been developed bashed on those models to present a precise understanding of the amalgamation of fashion and technology 4.0 into garments and opportunity recognition process. This study is one of few attempts to the authors best knowledge, that has been initiated to discover the current perception of fashion 4.0 and smart clothing specially as a fashion merchandise as well as the identification process of different market potentials introduce the technology 4.0. A summary of the literature with visualization of a conceptual framework is presented to address the issues raised through research questions.

Fashion 4.0 is a concept that evolved due to the technological phenomenon of industry 4.0 which endeavours to integrate technology with aesthetic merchandise. Clothing and apparel industry at present are confronting this phenomenon and are compelled to respond to the changes introduced by these technologies as well as the potentials (Bertola & Teunissen, 2018). Aesthetic and functionality are the two essential elements that are attached to the understanding of the traditional fashion clothing and apparel but due to technological advancement, embedding electronics into clothing to enhance those two elements is inevitable (Workman & Caldwell, 2007; Venkatesh et al., 2010). Thus, technology is creating a novel space in the fashion clothing creation along with those two traditional elements.

Perception of style firstly, is majority period is influenced by cultural and social elements since it is a means through which individuals express their self-identity. Fashion elements attached to clothing's are perceived through personal sensory experience and is dictated by aesthetic rules. These artistic values along with aesthetics elements of garments evolved through different period of clothing development and designers takes these reasons into their consideration along with evolving consumer's needs (McCann & Bryson, 2009, pp. 45; Ariyatum et al., 2005). Clothing performance secondly, is another crucial element that is adjacent with the fashion understanding of any bodily embodiment. This essential component of dressing ensures the comfortability, protection, task performance and bodily attraction to confirm the expression of induvial 'self'. Advancement in technology throughout the different period, has strengthened the interrelation

between fashion elements and functionality with expressiveness as well as with digital technology in recent period by embedding electronics with fashion apparel (Bertola & Teunissen, 2018). Thus, emergence of fashion wearables and smart clothing as fashion apparels have become an eminent phenomenon.

The understanding of Fashion 4.0 encompasses the periphery of networking, manufacturing, and logistics and retail through digitalization. Smart product is one of the components of this ecosystem which includes all varieties of wearables including intelligent garments (Bertola & Teunissen, 2018). Wearables are embedding electronics with the fashionable objects or garments through wireless connectivity and physical computing to enhance the functionality and aesthetic appeal of the developed merchandise (Fernández-Caramés & Fraga-Lamas, 2018). Smart clothing as a fashion garment is receiving significant attention from product developers, designers as well as consumers for its enhanced capabilities. Cho et al. 2007; 2009)

At the initial stages of the product development, intelligent clothing's were perceived as a functional merchandise that accomplishes certain requirements such as health and protection but due to technological advancement the demand for the fashion elements attach to it is increasing (Suh et al., 2010). Designers are now considering integrating the technical elements with aesthetic essentials by embedding technology with clothing apparel (Ariyatum et al., 2005; Perry et al., 2017). Sports industry is considered as an optimum periphery for the application of technology embedded smart garments where both functional and fashion requirements are realized apart from health and armed industry. However, the intelligent garment as a technology embed fashion product is still not considered an item that poses significant commercial potential due to a gap exist between designers' perception of customers understanding of smart garments with actual consumers perception and requirements (Ariyatum et al., 2005).

Technological advancement specially 4.0 phenomenon has cleared the path of intelligent garment by introducing novel technologies into clothing apparel which has directed fashion industry on the verge of transformation. Disruptive situation occurs due to any transformation appears in the environment which organizations either to adapt or to seek for potential market opportunities (Clarke et al., 2008). Diffusion of technology either appears in the product sphere through product innovation or appears in the production level through process innovation and either enhances the competence or destroys it (Anderson & Tushman, 1986; Anderson & Tushman, 1991). The technological trajectories become radical when any novel innovation threatens the previous technology, or an existing technology is being introduced in a new environment. Majority period,

small incumbents introduced novel product or innovation to challenge the existing technological capability of establish firms (Christensen et al., 2015; Christensen & Rosenbloom, 1995). Size, technological knowledge, degree of transformation and the source of the transformations are important issues that any incumbent considers for an innovative approach. Disruption has a tendency to increase the net growth through new market segment, directs organizations to adopt a new business model and changes consumers perceptions (Christensen et al., 2015).

Several technologies such as 3D technologies, IOT, RFID, 5g, AI&VI, AR&VR and sensor technologies to mention, have introduced novel approach in production process and design approach in fashion industry and to certain degree has introduced disruption in the clothing manufacturing, logistic and supply chain and also in product level (Vaidyaa et al., 2018; Bertola & Teunissen, 2018; Bongomin et al. 2020). The performance of products is enhanced by novel innovation as well as artistic values by these technologies which ultimately directing towards a novel technology embed fashion merchandise. The technology related to Industry 4.0 has introduced many potentials for business such as efficiency and acceleration in production, saving expenditure, increased sales and profitability through new customer segments and ensuring sustainability (Bertola & Teunissen 2018; Fernández-Caramés & Fraga-Lamas (2018). Therefore, organizations are able to receive these benefits by adopting and utilizing the technologies presented by Industry 4.0 phenomenon.

Recognition of those opportunities is significant for organizations to respond to changes brought by the digital technology in fashion industry. Diffusion of technology introduces exogenous shock in the environment and individuals with creative and innovative capability discovers those shocks through active observation (Spencer et al., 2008). They several occasions take advantage of this unexpected market situation and introduce novel business concepts. People with their entrepreneurial ability number of occasions also create 'exogenous shock' in the market (Lim & Xavier, 2015).

The process of identification begins with individuals preconceive understanding of the business environment, technological advancement and own personal capabilities. These understanding in the form knowledge and experience directs them to observe and identify the hidden market potentials (García-Cabrera & García-Soto, 2009; Ardichvilia et al., 2003) Social associates or acquaintances numerous occasions are an optimal source of collecting information of a disruption or the changing business environment. The evaluation process in this phase is iterative since entrepreneurs assess their options and possibilities before deciding for a new venture creation (García-Cabrera & García-Soto, 2009).

Exploration begins after the business potentials are identified with certainty and in this phase resource availability and current capabilities are considered for the

feasibility of the venture creation. Individuals in this situation, still relies on the previous knowledge about technology, market and consumer's requirements and networks to continue the exploitation process (Kuckertz et al., 2017; Fuentes, 2010). Existing resource capabilities as well as technological knowhow assist in the further exploitation decision. Presence of sufficient material and economic resources plays a significant role in the decision-making process along with substantial improvising and execution competences. The management associates in the form of human capital as well as appropriate knowledge about consumers uncertainty and knowledge strengthen the exploitation process (Choi & Shephard, 2003; Kuckertz et al., 2017). Uncertainty of any of those resources and capabilities would direct towards the rejection or further exploitation of the identified business potentials for introducing a new business.

The figure 9 bellow illustrates the understanding of the internet of smart clothing as a consequence of Fashion 4.0 technologies which brings disruption in the traditional practices of fashion industry hence creating opportunities to be identified and to be exploited for a novel venture creation. The figure demonstrates that smart clothing is a consequence of industry 4.0 technology in fashion context where garment aesthetics and functionality are significantly impacted by the technological advancement. There is an interrelationship between these three elements of fashion 4.0 where technology assists in improving style and performance of the final product simultaneously aesthetic and functionality also assists technology to improve or on several occasion introduce novel innovation.

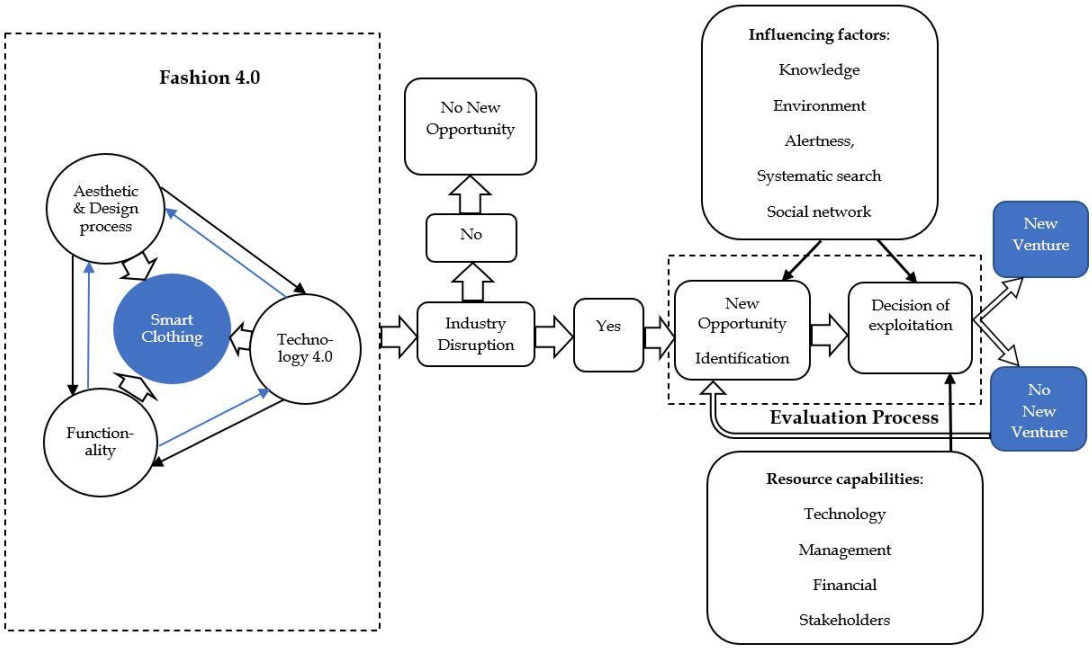

Figure 9: Intelligent garment and the recognition process of opportunities brought by the technology related to it (Own illustration based on Figure 1, 2 3, 4, 7 & 8)

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In addition, Industry 4.0 technologies are introducing transformation in the fashion industry in the several level and creating new business benefits. The disruption majority period appears through innovation both in the product and process level hence creates novel market potentials. Individuals with entrepreneurial ability identify those hidden novel opportunities for new market ventures otherwise they endeavour to discover existing unidentified business benefits already introduced by technology increment.

The recognition procedure of the new market potentials begins with observing the changes introduced by any diffusion in the environment and the process is influenced by any individual's social connectivity, preconceive understanding of the environment and technological improvement, ability of being alert and intention of continuous search for new opportunities. These issues act as determinants in identifying the new market potentials and directs individuals or organizations to exploit further. The exploitation decision is often established based on the cautious consideration of the available resources and the capabilities such as technological, monetary and managerial. Inadequacy of any of these resources or capabilities would direct individuals to discontinue the exploitation whereas sufficiency of those resources and capabilities would assist in new venture creation.

Moreover, Organizations or entrepreneurs several period in their discontinued period of further exploitation endeavour to improve the capabilities and accumulate or acquire more resources. After satisfactory accumulation they reconsider the new venture creation decision otherwise they continue searching for existing opportunities or observe the new market potentials that their current resource capabilities support to receive. Therefore, evaluation procedure is iterative in nature and several occasions continue until this phase to confirm the certainty of the recognized potential for a novel business creation.

3 METHODOLOGY

3.1 Methods of data collection

The research aspires to achieve an in depth understanding of how companies in Finland understand Fashion 4.0 and smart clothing concept, what opportunities have occurred due to the disruption introduced by the technology and what understanding companies have towards recognizing and exploiting the opportunities. Serving this aim requires a novel method named qualitative approach which has been a most accepted methods in business and market study (Carson et al., 2001). The primary objective of this approach is to identify the practice and perception of individuals associated with an organization and to receive an understanding in the wider phenomena around the topic (Carson et al., 2001, pp. 61-66; Creswell, 2007, pp. 36-39). This research also has similar intention to achieve understanding of the phenomenon of fashion 4.0 and smart clothing as well as the identification and exploitation of market potentials introduced by the technology related to it. This intention is served by studying the perspective of individuals of entrepreneurial experience and specialist from different educational background.

In addition, qualitative approach also intends to discover practical solutions besides providing novel scientific knowledge and yields descriptive data that attempt to respond to the research question that seeks the answer to the questions 'what' 'how' and 'why' (Flick 2007; Eriksson & Kovalainen, 2008, pp. 39-41). For these reasons, in-depth interviews were conducted to collect primary data for this research that ranges from company decisions makers to specialist to experts from universities. Producing empirical materials for the research in question is the fundamental purpose of the qualitative interviews and the interviewer concentrates on the issues related to the research topic and the questions of their study (Eriksson & Kovalainen, 2008, pp. 78). As limited study has been conducted on the understanding of the opportunity recognition and exploitation of smart clothing and technologies related to fashion 4.0 and smart garments, conducting interviews has allowed this present research to achieve comprehensive and depth insight on the perspective of different company personnel and of experts from educational and research institutions.

Moreover, formulating a proper question set that will not be equal to the research questions and also will create material relevant to the study is a challenge related

to qualitative approach (Glesne, 1999, p. 69 as mentioned in Eriksson & Kovalainen, 2008, pp. 79). There is a necessity for interview question to provide materials that answers the research question by answering the material (Eriksson &Kovalainen, 2008, pp. 79). Thus, this study has taken the necessity into consideration and endeavoured to formulate a 'good' set of interview questions that will produce sufficient material related to the understanding of smart clothing and their opportunity recognition and exploitation.

The interview model to mention, used in this study, are the guided, semi-structured interviews and a subjectivist approach was also adopted which deals with individual's insights, perception and conceptions (Eriksson & Kovalainen, 2008, pp. 79-80). One of the advantages of this form of interviews, is that a researcher is able to use an outline of questions simultaneously have some freedom to stretch the order and exact wording of questions (Eriksson & Kovalainen, 2008, pp. 79-80). Another benefit of semi-structured interview is that the interviewer has the possibility to produce more organized and comprehensive materials instantaneously maintaining an informal and conversational tone in the interview (Eriksson & Kovalainen, 2008, pp. 82). The researcher has the space to include more questions or exclude the unnecessary ones depending on the flow of conversation to explore the research topic more in depth (Saunders et al., 2009, p. 320).

For this reason, a framework of open-ended questions was included in the interview process which allowed sufficient space for asking more relevant questions depending on the responds of the participants. This method has allowed the respondents to provide an overview of their perception, conception and insight of Fashion 4.0, smart clothing technologies and identification and exploitation process of opportunities introduced by the technologies.

Unlike structured interview, semi-structured interviews necessitate including all the topics from the outlines which is a challenge and researchers at the same time are encouraged to ensure respondents provide in-depth answers (Eriksson & Kovalainen, 2008, pp. 82). Participants also need to be provided sufficient liberty to express information they consider important, and the analysis and the comparison appear more challenging due to the wide nature of the interviews where respondent's own interpretation of the questions are distinct from each other (Eriksson and Kovalainen, 2008, pp. 82). However, this form of interview is suitable for this research since it allowed to acquire different opinions and viewpoints about the emerging understanding of fashion 4.0 technologies and smart clothing and the recognition and exploitation procedure of the market potentials the technologies are delivering.

3.2 Data collection

For the purpose of this research, the data was collected by attempting to seek for a list of companies related to fashion industry. The initial idea was to collect information about the viewpoint of fashion 4.0 and smart clothing technologies and opportunity identification and exploitation of these technologies. The accumulation of information was intended from various organizations of fashion and apparel industry of Finland who have already initiated the exploitation decision and who are still observing the market potentials to be emerged. The companies were approached majority period through LinkedIn, through mail correspondence and some occasion through the recommendation of previous interviewers. In this scenario, an email was delivered to the new contacts refereeing the other contacts as a mutual acquaintance.

In addition, around, 30-40 companies were approached, and the companies were selected based on their engagement, relativeness and potential engagement with the technologies related to Fashion 4.0 and smart clothing. For this reason, a brief study about the organization was conducted by studying the webpage and some news articles to accumulate some relevant information and to accelerate the selection process further. Primary data was accumulated through in-depth interviews totalling 15 altogether with the company owner, company representatives, a marketing expert and a sustainability expert as well as four experts from a renowned research institute and three educational institutes in Finland to add variety in the data accumulated.

Majority company representatives to mention, are active members of the organizations, associated to the top management team and several of them possess entrepreneurship quality or actively engaged in entrepreneurial activities. This issue was important in the study scenario due to the necessity of the participants knowledge about the technology, industry and ability to observe and identify emerging market potentials. Positions of interview participants includes Inventor and Founder of a clothing start-up, Chief Executive Officer, Chief Operating Officer, Founder and Manging Director of start-ups and Entrepreneurs. Additionally, to company representatives two interview was conducted with a Director of Research and Development and Social Media Analyst as experts from two renowned Finnish clothing companies.

These interviews to mention, were arranged to achieve a better understanding of fashion and technology amalgamation as well as the business opportunities which is emerging in Finland due to that reason as well as to discuss the issues addressed in company interview in more detail. The overview of the company participants, the dates and companies are available in Table 1.

Table 1 Overview of the company participants and interview details.

Interview	Company	Designation	Number of employees	Date
1	1	Inventor & Former CEO	5-10	17.03.2020
2	1	CEO	5-10	01.04.2020
3	1	Digital Marketing Specialist	5-10	12.03.2020
4	2	Partner, Concept design and R&D	2-10	19.03.2020
5	3	Founder, Managing Director	2-10	09.04.2020
6	4	COO	11-50	23.04.2020
7	5	Director of R&D and Sustainability	201-500	15.04.2020
8	6	Entrepreneur, CEO	11-50	07.02.2021
9	7	CEO	11-50	30.06.2020
10	8	R&D Innovation manager	200-500	09.12.2020
11	9	Fashion & Sustainability consultant	189	15.05.20221

In addition to company representatives and experts, four expert interviews were conducted to gain more comprehensive insight on the conception of Fashion 4.0 and smart clothing technologies and realization and exploitation of the future potentials of these technologies. The participants such as a researcher, two lecturers and an expert of Fashion 4.0 concept were selected and are from a renowned research institute and three education institute in Finland. An overview of these participants is provided in Table 2.

Table 2 Overview of the expert participants and interview details.

Interview	Expert	Institution	Designation	Date
12	1	Aalto University	Functional Clothing Lecturer	13.06.2020
13	2	Metropolia University of	Lecturer on fashion Design	08.12.2020

		Applied Science		
14	3	VTT Technical research Centre of Finland	Senior Researcher	01.02.2021
15	4	Aalto University	Doctoral candidate (expert in Fashion 4.0)	28.05.2021

Moreover, the interview conducting procedure continued for a long period of time than the actual planned period since the process occupies a greater amount of time to seek, select, approach and receive a reply from companies and organizations intended. The progress was further delayed due to the emergence of the pandemic situation at the beginning of 2020. Majority company interviews were cancelled as the pandemic condition became intense. As result, receiving a reply from companies after approaching was time consuming and tedious. As the pandemic situation started becoming normal, the searching process initiated again in summer 2020 and the process of arranging interviews accelerated and by May 2021 all the interviews were conducted. The positive side of the lengthy period was that it allowed sufficient interval between the interviews to reflect upon their contents and adapting the interview questions based on experience gained.

Furthermore, the interview questions were reviewed and refined after first few interviews of the interview process to accumulate most relevant and related information that is able to provide sufficient materials to answer the research questions. Majority interviews were conducted via zoom and skype which lasted around 50-60 minutes each. A framework of in-depth question was used in a semi-structured model where the interview structure consisted of four fundamental segments. The first section concentrated on the company respondent's and expert's opinion on fashion 4.0 technologies and smart clothing concept, impact of technology on aesthetics and functionality in company context and the benefits the company will receive.

The second segment of the questions list dealt with issues related to fashion 4.0 technologies as disruptive and reason for the disruption. The third portion of the set of questions lists covered queries related to the opportunities and the identification and exploitation of the market potentials the technology is introducing. The final section dealt with threat, perceived challenges and risks of technologies related to Fashion 4.0 and intelligent garments. The standard interview questions are be added in the Appendix B.

Likewise, the formulation and order of the questions varied to certain extant depending on the flow of the conversation and issues raised by the participant. As

a result, the different category of questions was mixed throughout the interview to maintain the course of conversation and some freedom was provided for participants to concentrate on the aspects they considered significant. One of the consequences of this approach is that participants already answer some questions before hand simply by progressing on the subject and another consequence was that the author of this research did not have the necessity to repeat the question. Thus, this allowed to achieve a broad and in-depth impression of the issues related to understanding of smart garments, its business potentials and recognition and exploitation process within various organizations.

3.3 Method of analysis

In qualitative studies the most renowned and recognized data analysis methods are thematic analysis and coding (Rashid et al., 2019). This technique of analysis is considered as most appropriate method for achieving a broad understanding of a phenomenon (Maguire & Delahunt, 2017). According to Braun & Clarke (2006), as a method thematic analysis organizes and describes the data corpus by recognizing, classifying and creating patterns. The procedure entails conscious repeated observation of data to identify patterns within data corpus and creating categories based on the emerging themes for analysis (Fereday & Muir-Cochrane, 2006). Good codes have the necessity to capture the qualitative richness of the data source without any data interpretation at this stage (Boyatzis, 1998, p. 1 as mentioned in Fereday & Muir-Cochrane, 2006). Information encoding is necessary to organize the data by recognizing them and eventually developing themes (Fereday & Muir-Cochrane, 2006). Thus, method of research adopted in this study was quantitative descriptive method in the form of thematic analysis.

Thematic analysis is familiarised as an approach that is independent and reliable which provide skills to academics to conduct several other methods of qualitative analysis (Vaismoradi et al., 2013). Themes in this approach, captures contents of the data that are of significance in relation to the research question and endeavour to exhibit an overview of patterned responses (Braun & Clarke, 2006). Themes are apparent majority period in several different data set but the procedure of identifying themes several occasions depend on researcher judgments on what consist of a theme and retaining some flexibility is necessary in this situation (Braun & Clarke, 2006).

This study adopted a data driven inductive approach where there is an apparent close connection between the themes and the data. Themes were emerged and evolved from the data set and endeavoured to capture something significant from the data set. Inductive approaches are in explorative nature and allows to obtain insight from dataset (Fereday & Muir-Cochrane, 2006). The data coding

procedure in this analysis mostly data driven without attempting to fit into researcher's analytic perception. However, the crucial issue here is that in this analytic procedure, a researcher is not able to completely detach themselves from the theoretical framework or pre-conceive understanding of a study while doing coding since 'data are not coded in epistemological vacuum' (Braun & Clarke, 2006). As, the initial theoretical framework have influenced forming the interview questions, certain emerging themes have also been impacted by this throughout the interview and within the analysis.

In addition, the nature of the overarching themes was maintained in a broader sense which reflects on the crucial issues discussed in the interviews. Overarching themes consists of several subthemes that addressed different issues regarding it. The procedure of data categorization was carefully documented to ensure transparency in the emergence of the themes and an overview of overarching themes, subthemes and coding were provided in Appendix A.

Moreover, semantic approach was adopted where the analysis concentrates on the surface meaning of the data. According to Clark et al. (2015 pp 225), the notion of semantic meaning is the explicit meaning and researcher is not seeking anything beyond what participant has communicated or what has been written. The nature of thematic analysis is descriptive which is suitable for responding to the research questions that endeavours to describe a certain phenomenon (Fereday & Muir-Cochrane 2006). Thus, thesis embodied a comprehensive overview of the situation due to the diverse information accumulated through interviews and broadness of the research topic.

The procedure of thematic analysis in this research adopted six stages of identifying, coding and analysing the patterns suggested by Braun & Clarke (2006). These stages of analysis require constant backward and forward movement with the entire data set since these phases are non-linear and the process is recursive (Braun & Clarke 2006; Maguire & Delahunt, 2017). The first phase includes data familiarization where active repeated reading is required to search for meanings and patterns (Braun & Clarke, 2006). The interviews in this study were audio recorded and was transcribed. Then the transcription was verified back with the audio in order to ensure accuracy.

After repeated rereading of the data for several times and familiarizing them in order to discover potential patterns, the next phase involved formulating initial codes that encompasses all the information provided in the data set. Formulation of codes were guided by the research interest and derived thorough repeated reading of the collected data to highlight potential patterns. Around 79 codes were derived from the data source after continuous verifications and reverifications of overlapping codes and codes with similar meaning.

The third stages involve seeking themes or observing emergence of themes form the data collected (Clarke et al., 2015, pp. 230). The 79 codes were categorized and accumulated into subthemes and the procedure resulted in 31 sub themes providing overview of the codes. The next phase involved in reviewing and refinement of these subthemes by moving backward to the data sources to evaluate whether sufficient data exist to support the themes. This stage as Braun & Clarke (2006) mentions involves two levels of review. First level involves according to them, reading the accumulated codes for every pattern and seek for a coherent pattern. The codes in this study are carefully reviewed for each theme to discover that the data content is accurately represented by themes. Second level involves the validity of individual themes and accuracy of meaning of themes in relation to data set Reviewing also involves few changes or discarding or reshaping some candidate themes (Clarke et al., 2015, pp. 230). Thus, the process resulted in 20 final subthemes after careful regrouping of codes and combining the intertwined themes as well as separating the themes of their own.

After cautious review of the themes, the fifth phase includes identification of the essence of the theme by defining it and selecting a name to ensure the conceptual clarity of each theme (Clarke et al., 2015, pp. 230). The themes in this study, were named after determining what aspect of the data each theme capture, and five overarching themes were created that encompass all these subthemes. These overarching themes and subthemes provide a hierarchy of meaning within that data corpus and the procedure of deriving the final set of overarching themes and sub-themes were iterative. The final stage includes the writing of the analysis with vivid narrative data extracts where researcher provide analytic conclusion based on the themes identified with the evidence from the data extract.

3.4 Reliability and validity

The purpose of the qualitative research is evaluated by the two commonly considered criteria such as reliability and validity (Eriksson & Kovalainen, 2008, pp. 292). The object of the considering evaluation criteria is to ensure the transparency and to assure about the scientific nature, quality and trustworthiness of the research to the readers (Eriksson & Kovalainen, 2008, pp. 290). Reliability exhibits the extent to which similar observation performed by other researchers yields similar interpretation or conclusion (Franklin & Ballan, 2001) whereas Validity refers to the extent to which conclusions are derived in research provide a precise portrayal and clarification of the phenomenon occurred (Eriksson & Kovalainen, 2008, pp. 292).

Reliability criteria according to Miles & Huberman (1994, p. 228 as mentioned in Franklin & Ballan, 2001) encompasses several issues to consider such as clarity of

questions and its alignment with study design, parallel connection of results across data sources, and clear specification of analytical construct. Establishing these criteria in the qualitative research is challenging, however the reliability of the research is possible to be ensured by a detail explanation of the study procedure and demonstration of how the findings and conclusion were generated and derived (Eriksson & Kovalainen, 2008). For example, the findings were supported with direct quotations in order to ensure the reliability.

The present study to mention followed the thematic analytical approach suggested by Braun & Clark (2006) and the analysis of the results were derived through closely following the stepwise methodology of thematic analysis. This approach by maintaining cautious documentation of every stage of analysis and the derivation of themes, allows reader to comprehend and to reproduce the process although the analysis in this approach is subject to researcher's own interpretation.

However, there is a possibility for the reliability to be compromised in some aspects due to the interview limitations in terms of numbers and the nature of the qualitative research. The findings of the study were derived based on the issues significant to entrepreneurs, decision makers and specialist at the study period, the opinion on the topic of the issue under study is subject to be altered due to the experience being enhanced and the impact of leaning in forthcoming period. As a result, some results such as concerns and uncertainties that are relevant to the issues at this moment might be altered later. The consistency of the outcomes over time for this reason has a possibility to be jeopardized due to the nature of the research which might impact the reliability in the longer period, but a shorter period of reliability might be expected.

In addition, the majority interviewees of the study are involved in higher management position but some of the participants were specialists, and some were experts. Apart from the experts all the participants were involved in decision making and for this reason the participants are interviewed as decision makers within companies not as a private person. The perceptions that the research describes, were derived from them as decision makers in the organization. Only experts were interviewed to receive some personal opinion based on the relevant expertise they possess related to the topic of the study undertaken. However, there is a possibility that opinions provided in the interview by the decision makers did not always reflect the professional opinion but rather their personal opinion. This might have impacted the reliability of the study, but it also could be argued that it is challenging for decision makers on several occasion to completely detached their personal thoughts or feeling about the issues related to the research undertaken.

Moreover, the purpose of the research is to achieve a more general understanding of the topic and for this reason issues that has appeared as insignificant were

excluded. Only the most significant aspects in this situation were considered and accepted. Thus, not all the related issues were brought forward due to the strategic sensitivity of the issue under research and because of the qualitative nature of the study. Also, semi structured open ended interview questions impacted the reliability of the research as a result of the subjective interpretation of the questions (Eriksson & Kovalainen, 2008, pp. 82).

Validity and accuracy of the perceptions and responses on the other hand was ensured by cautious selection of the interview participants. Majority participants were from the higher management positions and experts possess higher educational background relevant to the study undertaken. The participants also exhibit their knowledge and interest related to the topic under study and the nature of the questions assisted them to demonstrate their opinions and perceptions. Besides, the framework of the interview enabled the participants to guide their interviews towards the concerns and issues they considered significantly relevant simultaneously maintaining the neutrality of the researcher by avoiding some suggestive questions. Likewise, the size of interviews and the saturation of the data influenced and ensured the validity of the research. This issue was addressed by adding the experts of fashion and technology in the interview list along with entrepreneurs, managers and specialist.

4 RESEARCH FINDINGS

4.1 General information

This section consists of four overarching themes derived through the thematic analysis conducted for this study. These overarching themes which are kept as general and are derived from different subthemes. The subthemes provide an overview of opinions and replies of individuals related to the comprehensive themes. The interview data conducted for the study addresses the understanding of Fashion 4.0 and smart clothing and the opportunity recognition and exploitation brought by the technologies. The themes encompass the Conceptualization and understanding of Fashion 4.0 and smart clothing, the Market potentials emerged due to the disruption of technologies related to fashion 4.0 and smart clothing, Resources and capabilities required to identify and exploit the opportunities as well as the Threat, risks and challenges. The discussion of this research will proceed further with describing these themes and the sub themes that emerged within the overarching themes.

In addition, an outline of subthemes will be provided withing the spectrum of the overarching themes to generate an impression of what companies considered important in terms of responding to the technologies related to fashion 4.0 and smart clothing as well as the identification and exploitation process of the market potential the technologies is introducing. An overview of the codes, sub themes and the overarching themes are attached as Appendix A and these themes and codes were recognized during analysis process. The fundamental basis of the findings is from the interview data and the responses provided in the findings exhibit empirical data which is supported by the necessary and relevant quotations from the data. The confidentiality of the interview participant is maintained by not disclosing the participant's identity or the organization's identity. The participants quotations classified according to the number assigned to each company and the classification list was provided in the Table 1&2 under the chapter 3.3.

4.2 Conceptualization of Fashion 4.0 and Smart clothing

Conceptualization and understanding of Fashion 4.0 and intelligent garment as a comprehensive theme consists of four sub themes encompassing *Automation of industry process, fashion and business, Technology influence of fashion, business and industry*, *Technology and electronics embedded garments* as well as *Intelligent garments with functional traits or benefits*. These subthemes are categorized under this overarching theme because they all exhibit the pathway the concept of fashion 4.0 and smart clothing is perceived and gestated by different company representatives. The perception revolves around the understanding of automation of industry process and fashion business, technology influence on fashion clothing and industry, clothing as a technology embedded garments as well as smart functional traits.

4.2.1 Automation of industry process, fashion and business

The subtheme deals with overall perception of Fashion 4.0 and throughout the data some key words were used by majority participants to convey the understanding such as digitalization, application of Industry 4.0 technology, mechanization and digital technology. These words several occasions were used in terms of the technology application in different areas of industry such as manufacturing, supply chain and logistics. Most familiar themes about the concept are related to the digitalization of manufacturing and supply chain.

''If we look at the research done in the area which discusses mostly about how we can digitalize our supply chain meaning production and supplier communication but also this manufacturing.'' (Company 2)

Some participants have understood the term fashion 4.0 that includes mechanization of and robotics into fashion business. One participant mentioned that automation will drive production adjacent to the local business.

''I don't know whether the corona situation is going to speed up the situation or change it somewhat, but I think it includes automation and robotics. At least in theory, it is talking about bringing back production closer to the market.'' (Company 4).

This conceptualization is supported by an expert of Fashion 4.0 studies who is on the opinion that fashion 4.0 as a concept includes augmented and virtual reality and digital technology into fashion and clothing.

''And of course, that can be also smart clothing if we think that a garment is made so that augmented reality can be combined with the environment but what I think that's really huge from the fashion 4.0 perspective and in high fashion and all the area of digital fashion and NFTs and stuff like that. So, they can really kind of start making money on virtual fashion. So, digital fashion.'' (Expert 4)

According to a sustainability specialist from another company, the concept is perceived as a discourse of digital technology adaption in traditional fashion industry.

''So, there is this discourse I feel sometimes I think like the technology is coming and of course everything is getting more digitalized and I also think digital technology is good in fashion since it's really an old fashion business or traditional and also sourcing materials like blockchain and DNA spray in cotton and stuff like that just to make sure it's like transparent for example people get the transaction money for their work you know.''(Company 9)

Apart from just including technology into clothing, one marketing specialist is on the opinion that the idea not only comprises technology and garments but also includes the aesthetic traits of the clothing and according to that specialist, aesthetic appeal is important.

''My perception is it's a combination of functional technology that's aesthetically nice to wear so that it looks good and also do something for customer. In business perspective, obviously there is other application such as medical, military which has less than an aesthetic need but in general I think fashion 4.0 is a combination of computer technology build into something that somebody can wear that is aesthetically appealing.'' (Company 1).

4.2.2 Technology influence on fashion, business and industry

This subtheme addresses the issues regarding the impact of technology related to Fashion 4.0 has on the organization and the industry level in terms of process improvement, product and customer relationship and, the functional and aesthetics traits of the garments. One participant views the concept based on how the technology is enhancing processing speed, ensuring quality and provide optimal service.

''I mean how these factories can apply digital technologies in order to improve the effectiveness and quality, speed of the process and in my point of view service provider and research and development provider.'' (Company 2)

Another participant has the awareness of the fashion 4.0 as how technology enables interaction between product and customer by establishing an infrastructure.

''It is using that the chips by way to enable like interaction directly with consumers at the public level. By sticking the NFC identity onto the item in theory that means you can build an infrastructure whereby the clothing item becomes a kind of a cause of social objects. In a sense, it always has been social object. People go to shop to engage with first of foremost round of items or product that isn't there and then nowadays if you can, you do get experience and enjoy experience around that. That's even better, but since the end day the product is the social object through the chips, there is the potential to make that much more engaging kind of interaction with using smart phones.'' (Company 3)

In another place the same interview respondent mentioned how technology also enables measuring this engagement

''Smart engagement as a company, is getting information about the product as well as about the consumers. How many times there are trying by smartphones to check it, how many times they're coming for shopping. so, we can get the number of times they like to buy or looking for something. Kind of measuring engagement.'' (Company 3)

Some interview respondents view the concept as how the design process, prototyping and other design process are influenced by the digital technology. According to one participant, design process, prototyping and sampling can be improved through digitalization which saves time and expenditure.

''Well actually this prototype and sampling which is a part of design process which something we could improve by kind of like digital manufacturing. That also and there is this amount of material, energy and products. We are actually producing only in design process. So, it is a huge cost to make those prototypes. In many cases you have 3 cycles. For one jacket you will get 3 prototypes. If you have a collection where 500 items even, you have 3 prototypes. It means you have prototype in every season you have 1500. So, it costs and then in selling and marketing you have so called salesman samples and I don't know how many percent of your production cost cover this salesman sample. So, it is so old fashion way.'' (Company 2)

Similar view was given by one expert of fashion 4.0 concept who is on the opinion that AI technology can assist designers to construct their design and design process digitally by utilizing the previous store data from database.

''In terms of aesthetic in general, if designers would work for example with AI like sketching or designing that would use pictures from the internet or their own data base or whatever and AI can generate for them. So, this Kind of stuff can have impact on what they are doing. If they want to do that to get ideas or to be

more data driven but I think what is real is that designers are getting like more ways just from doing the pictures, just fitting the physical prototype to kind of constructing things digitally.'' (Expert 4)

Apart from design process, customer engagement measurement and process acceleration, the core elements of fashion product such as aesthetic and functionality will be influenced by the industry 4.0 technology. One participant believes that nano technology or other smart technologies would assist the garments to repair itself and will be embedded in the design process. The respondent is on the opinion that apart from enhancing functionality and strengthening the design process aesthetic appeal is also important and technology will have impact on all these aspects of fashion.

''As I said earlier that the product needs to be look good. The devout ideology of fashion would be look good. For the design part I think responsibility and these kind of themes and things will be embedded more. So, you can easily recycle the garments or repair the garments or if you add some nanotechnology or some kind of smartness so that it can repair itself or something like that. So that needs to be of course applied to design process already. So almost all the aspect like design, functionality and aesthetics will be affected.'' (Company 4).

An expert from a renowned research institute has similar understanding of technology influence on all these aspects of fashion. According to that individual usability is an important functional trait of intelligent garments and since industrial design is evolving technology will affect all the areas starting from design to final process.

''I think all of them. Then as I said earlier if the clothes are some kind of piece of something else than only clothes then you have to take usability aspect into account which is something completely new. The think usability as pockets is in correct way but it gives new type of usability restrictions or requirements for the clothing. Personally, I don't know which one will affect more but I say that all areas you will have a huge effect. Like industrial designing is evolving into new direction and so there are lots of things happening in different levels of whole process from this designing to have a full piece of working.'' (Expert 3)

4.2.3 Technology and electronics embedded garments

The perception of smartness in clothing was revolved around associating it with different categories of digital technology embeddedness into a piece of garment as well as attachment of some electronics with the fabrics. Several participants perceive sensor technology is the most conventional technology attached to the

garments to present it as smart. According to a research and development specialist from one company, smart features include attaching different kind of sensors and electronics.

''We have been involved in VTT project many times. So, I have been leading one of the projects called smart clothing 2.0 and that was about bringing different kind of smart features into clothing. Integrating different kind of sensors and integrating different kind of features like LED lights or as such well practically no boundaries in anything, any kind of smart features that is possible to bring.'' (Company 5)

One company participant mentioned the virtual reality (VR) technology and wireless technology along with sensors attached into smart wearables which ensure communication and data sensitivity.

''That VR which actually helps us to create kind of new rehabilitation. Different ways to rehabilitate people. So, in a more efficient way and also in a more engaging way. For example, our gloves are with sensors and are wireless. So, you can take it anywhere you go. So, the technology was embedded.'' (Company 1)

Some participants associated several electronics to the garments that convert a standard clothing into a smart fabric. LED lights are the most frequently mentioned electronics. According to one company respondent LED lights combined with sensor technology will provide some bright colourful features into clothing.

''For example, if you have a nice LED light on the clothes or gloves quite nicely and with the sensors you can add beautiful lights on your cloths not only a randomize lights, but you can control what's happening in your shirts and trousers. So, it is possible to control, what is the colour of your shirts and so on. '' (Company 1)

An expert of Fashion 4.0 studies also is on similar perception of associating the smartness of the garments with electronics or smart jewelleries that would assist in data monitoring.

''What I know about it is that it's some kinds of electronics embedded in the either in the textile or is a wearable device, some kinds of like a ring or glasses or some other gadget that is embedded in a garment, or it's some kinds of a jewellery or shoe that is somehow monitoring the body of the user or making it like creating comfort for the user. So that's my understanding of smart clothing.'' (Expert 4)

Apart from, sensor technology, electronics, and smart jewelleries, one company R&D specialist associated compression technology along with several digital technology to define intelligent fabrics. The respondent mentioned it is possible

to deliver and collect data by integrating compression technology with digital features.

''Some smartness you have let's say a compression clothing, it has nothing to do with digital of course you can integrate the digital let's say there are some kinds of compression. Let's say you are making a pair of socks with digital features or it's a compression sock. In that specific sock, if you can integrate yarn or fibre as such that it will be able to send the data through something to something. Then you can utilize those data basically then digital thing is very possible not impossible but if we don't consider that kind of digital part also itself it is kind of smart. let's say a person has some kinds of disability in the in the legs or hands. This sort of compression technology will be healthy.'' (Company 5)

4.2.4 Intelligent garments with functional traits or benefits

The evaluation of smart garments as technology implanted clothing was also expressed as emphasizing on the functional benefits associated with technological embeddedness or on the enhancement of functional traits by the technology. Several respondents emphasized on the functionality traits such as safety, protection, comfortability, user-friendliness and conveniency. One participant mentioned smart garments has the necessity to ensure protectiveness and security,
''Yes functionality, more or less and then this protective clothing if we are thinking kids clothing is protective clothing kind of like and then this workwear again, because fashion, ok it might be a nice feature but then functionality is kind of display that you want to inform about something for instance, you have been too much and you realize enough and then the colour change and then you know that you should change the colour or go to shadow.'' (Company 2)

Another interviewee emphasized on the user-friendliness and usability as optimal functional benefits attached to the smart wearables

''In our gloves everything is much simpler and there are less complications. It's much user friendly and easier to learn and master and it's easier to learn how to touch your own hand than learning new kind of equipment's.'' (Company 1)

Functional traits such as comfortability, convenience and ease of use are also considered as optimal benefits of intelligent fabrics product by several respondents. One participant is on the opinion that smart wearables as a sport product requires ensuring pleasant usage experience.

''Functionality and usability will be mostly affected. In terms of comfortability, it depends on the product group if they are required. For sports wearable it has to be comfortable.'' (Company 3)

Similar understanding was observed from an expert from a renowned educational institution about smart clothing as a functional fashion garment that is comfortable, convenient and makes like safer.

''If we are going to add tech on clothing, I hope to see technology making peoples life make easier. For example, the jacket that would warm up when the weather getting colder so that you don't go back to home and put another layer of cloths that kind of innovations that like piece of clothing is something we are protecting and it is a cultural thing, it is an identity thing the way we present who we are. The protection is most important thing. We cannot walk around Finland naked because the weather conditions aren't like that so if a garment could make your life easier and safer, I think that would be something that is comfortable and convenient.'' (Expert 2)

Majority interview respondents associate the understanding of smart garments with the area of application such as health and sport and workplace. Response observed from one participant reveals that health industry possibly is one potential market for the intelligent fabrics.

''So, we have seen those products may be over a decade in sport and wellbeing. Shirts and jest pants made of textile in order to measure body condition and I believe next level of area of application we can find for workwear and health technology.'' (Company 2)

Another interview respondent considers smart garments as functional fashion sportswear that might attract athlete and technology-oriented individuals

''First phase for smart fashion product would be some kind of extreme athletes who are very tech savvy taste and pilot all the new technologies. For example, early adaptors who just buy the latest phone even though the old one is very good, but they want the updated version of everything.'' (Company 4)

Other participant is on the opinion that workwear industry as another area of application might also receive optimal benefits of intelligent fabrics.

''Then the second application area, is the work wearables. So, we can improve the safety and quality of the worker and meaning effectiveness. Lot of companies in health and safety industry are missing the areas where they could use the technology to improve.'' (Company 2)

However, acceptance of smart clothing as a luxury fashion merchandise received scepticism from respondents. Several respondents perceive smart fabrics as a functional fashion merchandise, but they are skeptical about individual's mass

acceptance of it as a luxury product or luxury fashion brands creating functional fashion product. Some company representatives are on the opinion that individual customers are not willing to spend additional money on it. One company participant is doubtful of traditional luxury apparel brand's recognition of intelligent garment as a functional merchandise.

''If we are purely talking about fashion products then well, I always link these technologies to functionality. Then I don't know how much these traditional fashion brands from Italy for instance are willing to make their cloths functional. Of course, if you take out this red light for instance of course it would be nice fashion feature but of course there would be chance to improve the safety of the user.'' (Company 2).

Another interview response observed from a company participant reveals that individuals are not prepared to accept smart clothing as a luxury product and not having the intention of doing additional expenditure on it.

''I think it could work as a fashion product, but I don't see it happens very fast: I don't see it in the shop tomorrow because either it's a very good product but if you think about walking into a store like H&M and you all of a sudden see their clothing with smart features, is that the customer would buy because it has someone who has to be interested in technology! may be. At this point. So, you have to do a lot of work either with the product, find your consumer, find may be the girl or guy who are ready to buy cloths that changes its colour with her body temperature. I don't think people are ready yet. I think it that order, when you don't have lot of money where do you save first or what you don't buy. You don't buy luxury products of course and start to save and want to buy consumer products.'' (Company 6)

Customer needs to be educated about the technology to purchase the smart clothing as a luxury product. Economic situation is another factor which is a significant issue that has an impact on consumers buying decision. The company representative here is emphasizing on creating an awareness about benefits attached to technology embedded luxury clothing, discovering potential market and consumer's economic capability and willingness to purchase.

4.3 Market potentials emerged due to disruptions

This overarching theme alludes to the issues regarding the business potentials that emerged due to the disruption of technologies in the traditional fashion industry and the motives behind the disruption. Market opportunities are related to both the technology and the smart garments and the broad- ranging issues of different market potentials appeared in the data are *Ensuring sustainability and salvaging time*, *Efficiency, quality and process acceleration*, *Optimal value offering and optimal customer management*, *Potentials in health, sports and fashion*, *data security, availability and monitoring* whereas the wide-ranging issues of motives of disruption are *Changes manufacturing, supply chain and retail process,* and *Changes in value offerings, business models and shopping behaviour.*

4.3.1 Ensuring sustainability and salvaging time

Technologies related to Industry 4.0 will ensure two fundamental benefits such as sustainability and ecological usage of materials. Digitalization per se was viewed as a means of ensuring sustainable product and less wastage. One of the respondents are on the opinion that with the assistance of digital technology application in the industry ecology friendly material usage is possible as well as reduction is waste.

''So, maybe I believe, or I like to hope that digitalization here would also like more like ecological use of materials and more sustainable, less waste and environment friendly. Then they could be more effective because they produce quality.'' (Company 2)

Factories becoming smart by digital technology is another factor one participant considers significant to ensure product sustainability.

''Because smarter the factories we have, the more sustainable is the product we have but then if the factories don't have the resources to buy computers you are not gonna
have smart industry or smart manufacturing and product.'' (Company 6)

Responses observed from several interview respondents that technologies related to industry 4.0 will assist reducing overproduction, overstock and wastage of materials. One of the participants perceive that application of the digital technology will accelerate the reduction of additional material manufacturing and will ensure clothing longevity.

''If you could apply the basic technology and inventory analysis systems that they have to do more enduring product, then that's the best of both cause because you don't get overproduction and you get enduring clothes. '' (Company 3)

Big data in this situation is considered as a beneficial technology application by an expert from a renowned educational institute in reducing additional inventory stock and unintended additional material production in traditional fashion industry.

''Luxury brands also like there has been discussion that luxury fashion will be like pre -order and it will be more personalized and over stock is something fashion industry wants to end anyway. So, the need of big data is inevitable to end the overstock and over production so that demand meets the manufacturing or other way around.'' (Expert 2).

Salvaging time and expenditure are considered as one of the benefits of industry 4.0 technology application in traditional fashion business. One of the company interview respondents mentioned above considers technology as a means of reducing expenditure and salvage time.

''So, it could be an opportunity to save cost and shorten the lead time. That's also one thing why fashion business is so difficult because you need to have stock and warehouse and you need lot of money. So, you have to have lots of money for collection and then they are in warehouse. Then you don't know who wants to buy. So, technology would help a lot in organizing this.'' (Company 2)

Another participant from a family fashion brand considers production automation would assist in localization hence salvaging time and expenditure form logistics and human resource.

''For example, Finland doesn't have almost any textile industry left. This way if we could fully automize production without people working on them we could bring clothing industries back closer to the places where the brands are. So, it would save in logistics, it would save cost in human labour.'' (Company 6)

Similar understanding was observed from an interview response provided by a fashion 4.0 expert reveals that automation of business will reduce overstock, additional expenditure and complication in production.

'' I hope that this technology will kind of evolve. So, basically designs could be made in a tailored way by using technology so that we would not need human interaction. So, something like that I see the future in that way so the companies would not need to spend on the money on the dead stock. They will also save time and hustle with production. I mean not only the dead stock, just stock. So, I think that's the future.'' (Expert 4)

A company R&D specialist is on the opinion that Fashion 4.0 technologies might introduce discontinuity in the traditional fashion industry if it ensures sustainability.

''Fashion 4.0 will not see any kind of disruption from the other's technologies as such, but it will be causing the disruption. Only one thing that would be coming against or will be requirement for including the fashion 4.0 into the clothing is the sustainability. Whether it's creating any disruption, sustainability or not, because sustainability will remain as big a trend. Well, fashion 4.0 will enhance it and yes and why not!'' (Company 5)

Besides being a reason for disruption and benefits, sustainability is also regarded as reason for companies to initiate opportunity exploitation. One expert from a renowned educational institute advised companies to exploit if the technology is ensuring sustainability.

''Yes, definitely the companies should exploit, because as I have mentioned earlier clothing industry itself is very polluting and very non sustainable now days. So basically, anything that make clothing long lasting or more sustainable is a good innovation.'' (Expert 1)

4.3.2 Efficiency, quality and transparency

In addition to ensuring sustainability, several sources are emphasizing the function of technologies in improving excellence, effectiveness, clarity and trackability incepting from production, inventory, supply chain and logistics to retail processes and final merchandise. Achieving excellence in production, proficiency and security are benefits that technology will provide.

''I think it will improve the production quality and effectiveness and as well as safety of the workers.'' (Company 2)

Moreover, technology assistance in ensuring proficiency in all areas of industry such as production, supply chain and distribution was emphasized significantly by several participants. According to one company representatives, digital technology implementation would ensure effectiveness in in manufacturing, inventory and retail process.

''I think efficiencies within the whole like pre-ordering and everything and then manufacturing to order and getting stuff quickly and monitoring when stocks getting low and reordering.'' (Company 3)

The issues of technology assistance to designers and brands to improve quality was also observed from a fashion family brand.

''I think brands would focus more on the fitting that it would be better tailored, and quality will increase also. It will require the designer have more knowledge that clothing design is not only that it looks just pretty but have to have also some technical function.'' (Company 6)

Accuracy is another important benefit of implementation of the industry 4.0 technology that has been observed from the sources.

''In terms of quality and perfection in the process, we will see these more when we will get the production management software implemented. Then there we will see better of that because we actually will have software that measure things better than right now. More accuracy and less flaw will be there. '' (Company 6)

Furthermore, several interview respondents also emphasized on the issue of enhancing performance and process acceleration as opportunities brought by the digital technology implementation.

''For example, in VR world you can get much more realistic understanding how it looks like or even how it feels like. Of course, if you think about manufacturing, there is a possibility to speed up the whole process and perhaps to find the factories to collaborate. So, this kind of benefits.'' (Company 1)

One participant mentioned automated manufacturing assisted improvement of process acceleration and increased the capability of the production.

''Speed has improved like automated cutting its so much faster because of its automated robotics type cutting. So, because of the speed we can take lots of volume. Before we had to put lots of cutting services out to other places because we couldn't cut everything in house. So, we had to buy some services out. Now we can do it all ourselves.'' (Company 6)

Likewise, the majority sources addressed on the significance of trackability and transparency of production, logistics and end product. With assistance of technology, it is possible to maintain product history and tracing.

''Yes, that what I meant about us looking into technology when I told you as a brand, we are looking into technology for trackability so that we can trace where the product was made, by whom, which places and what materials they have used and what suppliers are doing because you have suppliers in many stages. So, it would be nice if you really get to the raw cotton stage and get information about it. So, customer could see where the cotton was picked and then which mill it went through and which address. That's actually gonna make consumers more

sensible in understanding that textile has a big impact because it travels so much.'' (Company 6)

One participant is one the opinion that transparency in the entire firm's operations is essential specially in the logistics and supply chain to monitor harmful procedure and to ensure sustainability.

''Then for those supply chain technologies it's like transparency is important like more monitoring in the supply chain such as checking work conditions, harmful chemicals and dyes like chasing your supply chain far out. So, that would be related to sustainability of course. Sustainability in a sense that if the technology makes less waste or cutting waste or comes with better solution with that''. (Company 9)

Similar view about digital technology assistance in ensuring process clarity and sustainability was endorsed by an expert from a renowned educational institution.

''I hope that technologies can come and make the industry more sustainable. I see that more of an opportunity to make the industry more transparent. Transparency is important since we cannot exploit people anymore in some countries. So, sustainability and transparency are driving force for technology in fashion. I think that can solve lot of the issues in fashion industry and when we have transparency it will change the culture because then we can see the weak points and the blind spots when we become transparent. That trend has been going so long and now we are seeing results. So, many brands are more and more transparent now and from that I think whole industry probably will be changing but what I also see is that the consumers to brands communication will grow in a way.'' (Expert 2)

According to the expert, individuals are aware about product manufacturing, technology development and their impact on environment also the clarity derived from the application of industry 4.0 technologies will ensure changes industry practice and communication between fashion industry and final consumers.

4.3.3 Optimal value offering and services

This subtheme deals with the values offerings and improved services in all areas of business with the assistance of digital technology. Several respondents perceive that digitalization assists in establishing brand, offering optimal values, understand consumer requirements, engage customers with design processes and provide premier services. Response observed from one company representative

reveals the support of Virtual Reality technology (VR) in offering values and brand establishment.

''VR, it helps us so that we can have new ways of making people rehabilitate faster and make it more fun. At least, in terms of marketing and branding it is helping because we kinda have new ways of how to do business and how to help people specially with the mobility because we have wireless device you can connect with your phone, you tab or in your computer and you can see the exercises.'' (Company 1)

Another interview respondent is on the opinion that AI would assist in understanding consumer requirements and provide improved service.

''I think if you have some Artificial intelligence (AI) that reading the customers and all of that. If retailers could implement those solutions in their shops, then I think they have better customer service and avoid so much sending back or returning.'' (Company 6)

Apart from, premier value offerings and brand building, an expert of Fashion 4.0 study viewed digitalization as an opportunity to connect and engaging customers in the design processes.

''They can concentrate on design, and they can also concentrate on the customer. So really focus on how customer can inform their work also and how they combine their own creativity with customer needs and desires.'' (Expert 4)

4.3.4 Potentials in fashion and other industries

Interview response observed from majority interviewees reveal that significant potentials exists for intelligent garments in different industries including fashion industry. The other industries include wellbeing sector, security, sports and entertainment. According to several sources of data, there is a demand and existence of suitable market environment for any categories of smart clothing. One company representative reveals that they discovered a market need for their smart wearables and they have several possibilities to be successful than their competitors.

''We see a market demand and gap is there. yes, it's true that we are the only company making this kind of gloves, but we believe that the technology we are using is most developed and we have lots of chance compared to our competitors.'' (Company 1).

A sustainability specialist from another company is on the opinion that environmental issues such as climate change will create the demand for a product like smart garment in future.

''Yes sure! I guess there is gonna be a lot of you know! these smart clothing items like the smart jackets that can monitor you I don't know like if you go for travel or if changes happen in your body organism because of climate changes which might be very interesting in the future in relation to climate change or something like that.'' (Company 9)

According to one expert from renowned research institute, smart clothing might introduce several opportunities for the employees by creating a fluent work environment and ensuring process optimization.

''I do see opportunities of coming some types of consensuses, people who are using the cloths, are accepting the fact that they are measured for the purpose or the benefits of the employees. In that way, future work is more fluent and then also optimizes the processes. I see there are lots of potential there.'' (Expert 3).

Since demand exists according to majority sources, several industries such as security, health, sports and entertainment industry is able to harvest the benefit of smart clothing and technologies related to it optimally. A R&D specialist of a company is on the opinion that health and wellbeing industries are one of the biggest possible benefactors of intelligent fabrics.

''I think biggest smart clothing technologies will be in the health sector either in the facility hospitals and monitoring health of the elderly person. On the other hand, I also think it might be integrated into this kind of sportswear when you go running and doing some exercises it will automatically collect the data. you don't have to have watches or phones or something like that. that's what I think can be in the near future.'' (Company 5)

Another participant of a company who discovered the market gap mentioned above, recognized potentials in entertainment industry such as gaming and toy and is willing to extend the company business in future.

''Smart clothing as I said we can create another company as a subsidiary company. Then we can focus on gaming industry which is another subsidiary company. That's another potential consumer market. Then we go to even toys like smart toys.'' (Company 1)

Among the interview respondents, one expert of Fashion 4.0 study also perceive smart garments is able to provide several benefits in wellbeing, sports and security sector.

''Health and sports industry is getting help from smart clothing. They are really huge, and they really need it and well of course military. Military always ones first ones to try out things.'' (Expert 4)

Apart from these industries, several participants are on the opinion that there is a niche market also exists for functional fashion product and smart features in clothing. According to one respondent there is a demand for smart clothing as an aesthetic commodity.

''I could see there is a trend. Why not in terms of aesthetic because I think there will be a market for people who do want such a thing.'' (Company 3)

The R&D specialist mentioned above is also on the opinion that smart clothing has potential to attract a niche customer segment who are tech-savvy and willing to accept technology into clothing.

'' I think there are people let's say even for the clothing like ok now I am going for running, I don't wanna take the mobile phone. Usually, people take cell phone because of fear of missing a call. So, in my case I want to be still connected with the phone. Integrating the feature into the clothing will serve the purpose. I think there are kind of niche group who would like to get these features.'' (Company 5)

4.3.5 Data availability, sharing and monitoring

Information sharing and supervising along with availability through both the technology and smart garments are emphasized by several respondent. The data source exhibits the technology assistance in real time monitoring though data conveniency, data sharing and data monetizing. One company interview respondent reveals that appropriate application of technology and utilization of intelligent fabrics assist in collecting information about individuals' body and sharing with the suitable beneficiaries.

''The possibilities are a great amount. From fashion, health, and wellbeing point of view and also point of view of security and getting information about your body. There are many opportunities. Like from the point of view of health, the nearest hospital database is receiving information about your health.'' (Company 1)

In addition, according to another participant, a digitally connected production facilities allows data to be distributed, allocated and monetized in different areas of business function which provides a sense of real time monitoring.

''One perspective on connectivity part here is that the sewing industry, there is sometimes actually most of the times, the bigger factory but then subsupliers who are doing work for the bigger factories. In that sense many time the factories don't have the tools to know where their things at the moment. For example, you have a t-shirt, and one factory is doing the sleeves and other factories doing embroidery and another factory is doing the packing and you have this same product that lot of factories are contributing. Then connecting those and having a real time sense of the locations of the product, the status of it and the production then that's a really beneficial tool.'' (Company 6)

Moreover, interview responds observed from several interviewees reveal that real time monitoring through smart clothing assist in improving services for health.

''In health sector we can improve our diagnosis, we guaranty that each patient will get the same service. We can quantitatively monitor many people for many diseases. Many patients for different diseases and also, we can detect the intervention of treatment through these wearables. (Company 2)

Apart from health benefits, receiving information about consumer requirements through continuous monitoring of the market with the assistance of technology or the intelligent garment is also emphasized by several data sources. One specialist of fashion 4.0 study reveals that designers are able to receive actual information about consumer need through real time monitoring of the market.

''So basically, like the stock is huge and designer have to be kind of they have this crystal ball and think what the people need and may be use some sales data or trends report of whatever but it's always this crystal balls and it's never kind of facts but now with this fashion 4.0 technology that are involved, they can monitor the market and what people really kind of real time monitor the market and they can really response.'' (Expert 4)

The same individual in another place stated that through smart clothing, there is a possibility to accumulate data of consumer's purchasing patterns and clothing's usage patterns through smart wardrobes.

''So, conceptual opportunities and collecting data from customers that's another opportunity. I mean well, I don't know how good it is in terms of privacy, but they can collect the data how often people use their clothing, what kind of clothing they are using and how they are using and whatever or may be smart mirrors or smart wardrobes.'' (Expert 4).

4.3.6 Changes in manufacturing, supply chain and retail processes

Technological benefits several occasions are introduced by the technological discontinuity and reasons for disruption revolves around the transformation introduced in production, logistics and distribution and retails processes by technological trajectories. Several technologies were revealed from the data sources as a trigger of introducing discontinuity in the fashion industry such as RFID, 3D technologies, AI and VR technologies. Majority respondents are on the opinion that these technologies might bring disruption in manufacturing, supply chain and logistics. According to one company representative, RFID technology might introduce interruption in supply chain, distribution, and life cycle of products through product history.

''I think there's been lot of discussion about very long time for the RFID system but that not even broken through to the market. Even though it saves inventory and all the phases of the logistics chain. I think that's something that might happen. I don't know if it's gonna be RFID or QR code or the chip which gonna be cheap enough to added to the product. Then you can see the whole supply chain and the life cycle of the product, and it can be used in the beginning of the second life when it's done with the cycle that is originally made to but then it can be used as a raw material or something else. I think that can be some kinds of disruption.'' (Company 4)

In addition to logistics and distribution, production procedure might also be impacted by the digital technology and data sharing through smart clothing. One research specialist from a renowned fashion research institute was on the understanding that information delivered by clothing might influence the way manufacturers produce clothing, create design, and finally produce the product.

''The third party in this picture are the manufacturers. So, if they could actually understand how, why and where this cloth is used or is it used at all or is it washed. They might change the design the fabrics to understand and make more cloths that would be used more and that could be circulated as clothes more, meaning secondhand markets and changed the design based on information that happens to the piece of cloths when it leaves the store because this is what they don't know. They don't know when I buy the pants or whether I used them at all or throw them away the same day. So, it has been a bad design may be or something wrong with it. So, there could be a chance but how to measure it is and how to make the data flow is completely a different story.'' (Expert 3)

A specialist of study related to Fashion 4.0 endorsed similar understanding of digital technology introducing disruption in production and logistics. According to the individual, apart from the area of manufacturing and supply chain, 3D technology will bring disruption in designers work as well.

''Well of course, definitely, I think that may be the biggest disruption. I mean of course it always started with the social media and internet like disruption that made fashion flat in a way. More kind of everyone sees it immediately but all of this is definitely disruptive because it changes the whole supply chain, all the fashion changed that are involved in supply chain, the work of designers is different specially those who are using 3D technology for example and how the whole manufacturing and production works. It can disrupt that.'' (Expert 4)

Moreover, one company representative stated that Artificial Intelligent and Virtual reality (VR) technology will interrupt the traditional retail understanding through VR fitting rooms.

''In fashion, first change would come I would say in retail like you can have virtual fitting rooms. You can have AI telling you what you should buy, when you should buy and what's the colour that suits you better. I see in the retail. I think people who are ready to use this kind of retail solutions they are not afraid of this privacy issues. Then are also ready to buy some more products.'' (Company 6)

Furthermore, according to one expert form a renowned education institution, technology like AI can assist digital services that will assess the old clothes and suggest new styles and combinations.

''I think new digital services in the clothing industry will be very beneficial for the younger generation. I think that will kind of make new digital platforms for making the clothing's use better than what they have. For example, we have lots of clothing in our closet but there are this kind of stylish services. They come and check your closet and check what kind of clothing you have, and they will make totally new outfit which you never thought of yourself you could mix with this garment to that garment. So totally new outfit out of what you really have. This kind of service are on the rise and can be done digitally. So, you take a photo of your garments and Artificial Intelligence (AI) will have some kind of algorithm that mixes what you have and your clothing styles and comes up with new styles, new ideas of combinations.'' (Expert 1)

4.3.7 Changes in business models and shopping behaviour

Transformation not only will appear in the of operation but also in the business infrastructure and shopping pattern of consumers as well. Responds observed from several participants exhibit that technology embedded into clothing might influence the current business model or might introduce a new one. According to a specialist from a research institute, designers and technology providers need to understand the requirements of both the fashion clothing and the electronics components and need to cooperate to produce an intelligent garment. There is a

possibility according to the individual that traditional business model might get influenced by this cooperation.

''They should take one step towards this kind of industrial designers who already are trying with all other things, may be good looking computer mouses that will fit very good in your hand but then the fashion designers also need to understand the new materials which are in the garment. So yes, it is a huge disruption but then it's also the business model things how you actually play together with electronic component providers or those and how you play together this part. So, it is actually disruption, and this also could slow down a bit the development in that sense that who takes the jump first the designers or the electronic part.'' (Expert 3)

In addition, Changes might occur in regular fashion trends such as one company participants believes that smart clothing concept would reduce the speed of fashion from 'fast fashion' to 'slow fashion'.

''Actually, what I would hope is that fashion changes from really fast moving I mean fast fashion to slow fashion. Then It's worth it to implement technologies on clothing because as long as we have this really fast working machine, I don't think the concept is gonna work. I think people will slow down and don't focus so much on trends but in more on the concepts. So, you could have same jacket for 10 years and only thing that update in the jacket is the actual technology and you don't want to change your jacket if you are more connected to it because of the technology into it.'' (Company 6)

Apart from, changes in business model, technology will introduce transformation in shopping experience by new trends like showroom shop. One respondent was on the opinion that showroom experience will also assist items being more intelligent with the assistance of technology.

''So, I predicted this showroom type situation is just going to grow much bigger and in order to do that the items need to be intelligent ideally so that the shopper can try it on for example if I like it, I order it now.'' (Company 3)

Also, Network based manufacturing system, Internet and e-retailing will change the buying and consumption pattern. According to a specialist of Fashion 4.0, e-retailing and internet shopping is already bringing disruption to the regular 'brick and mortar' stores.

''It won't be like going to store and pick. The store could be more like a website where we just go and you know try on something and order it and the internet of course the e-retail has disrupted a lot the industry. As we know, like all the stored are closing down and department stores are closing down. I guess that's direction in any way. Yeah, it's kind of disruptive in a way. '' (Expert 4)

4.4 Resources and capabilities

The central theme on *Resources and capabilities* encompasses six subthemes covering *Cognitive understanding and positive mental reaction*, *Earlier understanding and experience about market and technology*, *Association and collaboration*, *Constant market analysis*, *Technological capacity and possession* and *Economic resources and ability*. These subcategories are grouped under this overarching theme because they all deal with recognition and exploitation of market potentials of technology related to Fashion 4.0 and smart garments are introducing. These subthemes disclose what material and inherent resources such as technological understanding, personal or professional relationships and inner qualities along with the abilities such as economic and technological, organizations have in their possession to identify and exploit imminent business potentials exist in the market.

4.4.1 Cognitive perception & assertive reaction

Cognitive traits and positive feeling as a subtheme reveal several characteristics that were observed from various respondent with entrepreneurial qualities such as confidence, hopefulness, optimism, and positive state of mind. These cognitive traits emerged from several data source when the topics related to technology performance, future technology adaptation, quality and commercialization of smart products and business growth were brought forth. Optimism was the most observed cognitive traits from the data sources and this characteristic was noticed majority period related to technology implementation and adaptation. One company representative who held top position exhibit significant optimism about technology adaptation and implementation.

''So, first stage was to design the program so that it fit to our production and next stage is to introduce all the data there and the 3rd is to give training and the 4rth of course is to implement in practice. So, we are hoping that in end of the year. We have it running in the production.'' (Company 6)

In addition, Positive interest about benefits, future adaptation of technology and product development by technology as traits were also observed from several respondents with innovative and entrepreneurial quality. Another participant who was an inventor exhibit positive feelings of technological assistance on future product development and its mass production.

''Yes, potential I see. So, in future when we are developing for mass production big number of customers around the world then this kind of technology will be much more helpful and important for us than today because all our production is handmade and the number you can produce is quite small.'' (Company 1)

Moreover, confidence as another cognitive characteristics that has been observed from several respondents. A Response from a R&D specialist reveals that individual's confidence on product performance and its future commercialization.

''Actually, we have been working to bring some kind of technology that have been working last 10 years. We haven't been able to commercialize those, but we have worked in, we have been seeing the changes what is happening with the technology also. What we are seeing 10 years back and what is now. What kind of digital transformation has been happening. So, all in all we will be bringing this kind of features that is easily applicable, that will be commercially possible to apply '' (Company 5)

Furthermore, several respondents from top management demonstrate hopefulness as a positive metal state towards product market growth. One company participant with entrepreneurial background were hopeful about future exploitation of technology and smart product and the prospective business growth.

''Of course, we are going to adapt but still we have our base in fashion and design. So, I don't think we would fully turn into a smart product company. The smart concept we have for our product, we are developing it and hopefully it will become bigger and bigger but it's a slow process.'' (Company 7)

4.4.2 Earlier understanding and experience

Prior technological understanding achieved through education or a procedure several occasions assist in identifying future market potentials. Previous knowledge in tacit form either about technology or market has been observed as most common theme and the tacit or explicit technology knowledge in several circumstances were achieved through formal education or training. Response from a company CEO as a participant reveals her earlier explicit understanding about technology obtained through university education.

''I have masters in fibre textile and clothing science. I have made doctoral thesis about textile electronics for medical application.'' (Company 2)

In, addition, Tacit understanding of technology according to several, were obtained through new research on digital solutions.

''We use time to research and study new technologies and solutions'' (Company 8).

Besides new study, project work has also been observed as a means of learning about technological solutions.

''Well as an end product we haven't been able to bring anything to the market, but we have learned quite a lot from the project. So that will be helping us to bring some smart features in the future into our end product also that is commercially viable.'' (Company 5)

Moreover, interview responses form some company participant reveals that understating about novel technology solution several occasions were achieved through earlier technology experience.''

'' In principle the technology we are using is based on understanding capacitance of system and this is an old technology. This is not our invention, but we developed our electronic unit to measure the way the signal coming out from the glove. So, our technology is not invented by ourselves. It's an existing technology. People have known it for decades but were not able to apply or use in the context of wearables.'' (Company 1)

According to a specialist who has knowledge about Fashion 4.0 reveals the significance of tacit technological and market knowledge especially for product such as smart clothing.

''It's better to know and understand the technology you wanna invest in and of course it's also important for the people who invest also know how the industry work not only how the technology works. I mean the person has to understand the fashion industry really well when invest in technology because it's kind of embodies kind of tacit knowledge.'' (Expert 4)

Apart from knowledge, previous technology experience is also emphasized from several data source which assisted in learning through trial and error. A marketing specialist from a company mentioned above believes in experiencial learning.

''We have multiple versions. No! No!. We have idea to make or trying to make things wireless, but it took multiple phases or multiple years to get there. So, in the beginning we had a kinda PCI connector to this big green computer chip that was plugged into a laptop. Obviously! This was a concept we want it to try and test. Obviously, we have the idea to try to make it different and try to make that chip smaller. I am not sure if Bluetooth couple of years ago was that stable yet. So, we have an idea to make it as wireless, but we didn't know how. So, slowly but surely, we figured out we could buy this chips that were small, compact and

have blue tooth connectivity. But it took 3 or 4 years to get there. So, we didn't have a plan and we have been adopting lot of these stuffs. As we have gone along.'' (Company 1)

Previous experience about the market also was observed as a response from several participants. The company CEO mentioned above emphasized on the prior experience of fashion industry that assisted in understanding and adapting certain digital technology.

''I would say my previous experiences and networks in the global clothing companies and that assisted a lot in how to digitalize things. Also, the understanding about supply chain assisted me.'' (Company 2)

4.4.3 Association and collaboration

Networking as a social capital either formal or informal on several occasions, appear as intangible resources for companies that assist in identifying potential business benefits. Formal associations with partners, collaborator and personal relationships with friends and families assist entrepreneurial organization to seek out new opportunities. Several companies consider networking as a means of analysing the environment and be alert to novel market potentials. Formal ties appeared as major themes from majority interview respondents in the form of formal collaboration, partnerships and ties. Partnerships with different research institutes for a project work or joining trade fairs or business events were mentioned by several participants. One R&D specialists of a company mentioned that they collaborated with a renowned fashion and technology research institute for a project and participated in a joint trade fair. The project and the trade fair were optimal sources of accumulating information about recent technological development, about competitors and about new market potentials.

''We are in touch with many different forums like we have been doing many kinds of partnership like VTT, we have been doing partnership with many new innovative companies bringing this kind of technology. Well, it's more about the network. Something I would say that for example we as a company are interesting for many other companies like we would get this kind of request or people are coming with new kind of innovation, people are trying in many cases co-develop the innovation in because as we are an interesting company or brand in many cases for many in the world. We are visiting and not only visiting but also, also showcasing the products in many different fairs around the world.'' (Company 5)

Technology information through business partners or entrepreneurs as well as knowledge from co-workers are another means through which entrepreneurs accumulate market information. Co-workers several occasions are the conveyor of

the information of recent market development and other environmental change. According to a participant with entrepreneurial traits reveals that co-workers with similar entrepreneurial characteristics also provide important data about new start-ups and other established organizations.

''You get some information also from fellow entrepreneurs. That's a very important source of information. What other tech savvy companies are doing specially the start-ups who is pitching for funding and where and what do they say.'' (Company 7)

Informal discussion with friends about technology and market also provides valuable insight about the market.
''I realize there is a huge potential complexity such as getting logistical complexities and getting the retailers put their stickers on labels and I was interviewing one of my friends who was saying we need to do that because all of the product information you need are already in the market. So, the size, the colour and the item, the information already ready in the market.'' (Company 3)

According to the participant, friend's awareness about product and market information assisted the individual in realizing the challenges related to new venture.

4.4.4 Constant market analysis

Environmental analysis specially the surrounding market is another important aspect that influence entrepreneurs or organizations activities consistently to discover certain market potentials. Organizations several occasions scan the surrounding continuously by being active or several circumstances not being so active. Interview responses observed from few participants reveal that actively scanning the market assisted accumulating valuable information and obtaining knowledge about technological development and new potentials in different geographic region.

''Yes, for sure there are potential specially in Europe and USA to some extent I think the works are going on here and there. I have been in touch with many many of those initiatives and I know also quite a few companies who are trying to bring this kind of technologies but as such I do not see any challenge yet or I don't see any challenge here because we closely monitor or not really monitor but in touch with what is really happening in the industry.'' (Company 5)

In addition, continuous researching about the technology, the competitors and the market provide important information about competitors and the activities

of large organizations. Actively analysing the environment according one sustainability specialist, rescues the company from elimination and assist being updated.

''I think like these 3D technologies video kind of solutions, presenting collections and of course, we need to like see what the competitors are doing, we benchmark a lot with Nike and Adidas, and they are so hi-end already with these digital tools, presenting collections and communicating about them. I think also their pattern making and sampling is much more hi—tech. So those one I think are top one priorities because like you have to give image of course in the industry that you are not out.'' (Company 9)

Moreover, study the market and technology in constant basis direct the companies to exploit further. One company participant mentioned about constantly researching about contemporary technological and market development.

''We are exploiting many kinds of technologies all the time. It's the basic thing that we need to follow all the technologies all the time. Take the best one into use. The way I exploit it because I am also working in the University of Boras. Checking the research all the time about supply chain and material technology. Searching. So, I was alert on the market development kinda kept an eye.'' (Company 2)

Apart from being active, Entrepreneurs several circumstances identify opportunity just by scanning the market passively. One company participant is on the opinion that through personal shopping activities certain technological benefits appeared in front of that individual which regular fashion brands were ignoring.

'' Their business should be to move inventory as fast as possible with a reasonable price. I just thought it's not good for them and for me that this kind of breaking the, in a way the transparency of the need. My needs and their need actually are not getting met because we're not able to communicate effectively. I started to think about that and talked about it with my wife and we realize it would be same for like When I started getting more money, I will end up similar kind of thing and getting frustrated with new stuff, but I didn't do anything because of the technology. Even then I already started to think how could this smartphone be used with an intermediary device to bridge this gap! I didn't actually do anything because the technology wasn't ready, and Environment wasn't ready.'' (Company 3)

4.4.5 Technological capacity and possession

Resources and capabilities carried much significance in the opportunity discovering procedure of the firms. Technological ability is one of the crucial issues that influence entrepreneurs' decision to explore, and exploit discovered market potentials related to technology. Previous possession of technology on several occasions directed firms to venture into a novel one that disrupt the traditional market practices. Interview responses observed from majority participant revels that earlier technological possession assists in purchasing a novel one, assists in digitalizing the procedure and on several occasions insufficient technological capability deters entrepreneurs to exploit the opportunities further. One participant stated that adopting certain technology directed the firm to purchase a most recent and relevant digital technology.

''We have adopted some of the technologies in our production sights. The first time I think we started using Gerber. It's a company that provides this automized pattern. So, we switched from everything by hands to computer may be around 8 years ago. Then last year we started using the 3D option.'' (Company 6)

In addition, technology at hand majority period assist in digitalizing manufacturing processes. One R&D specialist from a company mentioned that earlier technology such as ERP and MRP assisted digitalizing the entire manufacturing process.

''So, in the backend digitalization has been done quiet comprehensively. We can practically say we are paperless. So, it was just an example, and the behind was to have all the Enterprise Resource Planning (ERP) functioning and also the MRP (manufacturing resource planning) and the other things that are supportive to ERP and MRP which should be functioning well.'' (Company 5)

However, insufficiency of technological capabilities discourages firms not to explore further and be stagnant. One participant from top management revels that not possessing appropriate technology directing them not becoming a market initiator.

''Our designers do really consider the recycling and the responsibilities already. That affects the material we select, organic recycle and so on. So that's we apply at the moment. So there not that kind of technology in the market that like I said we don't have the resources to be an early adapter. We don't have the will either'' (Company 4)

Significance of technological capacity in exploiting new market benefits is also observed from a Fashion 4.0 specialist. According to that individual, some companies already have digital technology like 3D technology to exploit opportunities further.

''The Finish companies definitely should try out the digital opportunities in virtual world because it doesn't need a lot of investments. It just needs the people who learn softwares. Finnish companies some of them are already using 3D technologies like sportswear companies.'' (Expert 4)

The specialist is on the opinion that organization who possess the digital technology might endeavour to invest on the virtual world since there are numerous hidden potentials in virtual sphere.

4.4.6 Economic resources and ability

Beside technology ability, economical capability in the form of tangible and intangible assets assist organizations to decide for further opportunity exploitation. Any financial resources assist in investing on new product idea, in purchasing innovative technology and in managing other resources.

''We also have got some investment in our company and without money you can't do anything. So, we were able to hire right kind of people, buy patent and making the technology work better such as less latency and better software.'' (Company 1)

In addition, economic resources as a monetary liquidity are important for investing on new technologies, on new business and automize the operation. One sustainability specialist is on the opinion that research on technology requires significant amount of monetary liquidity and investment to be updated in the market.

Yes, we are gonna exploit the technologies. One thing there is money to invest in it. this year covid has been very tough for fashion companies and you have to take lots of this R&D and investment kind of put them on hold. Like I said it's a tough business. It's very material and it's very physical and very low margin. So, if you invest millions on some new technologies, how do you fund that and possibly with certain loans then you really have to calculate if this makes sense for you in the long term you know and always there is a new technology, or something coming and makes older one obsolete. (Company 9)

Moreover, one expert from a renowned educational institute also agrees with the fact that financial situation or big investment is important for further exploitation.

''In my understanding, playing together two years with the workwear manufacturers in Finland and in Finland of course the companies are smaller in comparison to, if we think of international companies but they are not ready to take jump before they actually have the business. I think this is also something that slows down. Then we also know this google is also doing with Levi's things like that. They are the big players that take things like that and find a way how to cooperate. For the small players it's sad as well because they don't have money to put it into research and they have lots of bravery actually to go this direction at least in Finland because of the size of the companies we have here. This is my understanding about Finland in workwear context.'' (Expert 2)

According to the individual, numerous small companies possess the determination to initiate any technological innovation but do not proceed further due to insufficient financial ability to invest more on research.

4.5 Threats, risks and challenges

This last overarching theme alludes to the threats, uncertainties and challenges related to the digital technology. Technology not only introduces opportunities through disruption but also yields risks and threats associated with it. The comprehensive theme consists of three subcategories such as *Security, privacy and mismanagement of information*, *Washability, durability and sustainability issues* and *Risks associated with health, business and technology*. The sub themes were categorized under this overarching theme because it reveals the concerns about technology uncertainty and challenges from several sources of data. The concerns revolve around the security issues, risks of health and business and longevity of smart garments.

4.5.1 Security, privacy and mismanagement of information

Technology has the tendency to be utilized as a device to control as well as the data collected through the digital technology can be negatively exploited. There is a possibility to break through the data protection and being manipulated by the malefactor according to majority sources of the data. Several respondent mention that personal data can be purloined and abused by the physical and online bandits. One participant is on the opinion that data collected from smart clothing

will be mishandled and there is a possibility to be manipulated by information sharing through smart garments.

''Several possibilities that the clothes will be part over controlling people or getting information they want to give to other people. Security and data protection. it's like somebody is following you and they know exactly your location. Just like smart phone or any smart product. If your cloths are very technologically oriented, then you don't know how it can be used to get your information. You might be afraid that somebody can follow you or getting information you don't want to give.'' (Company 1)

Privacy infringement is another issue observed from several sources. Collective data collection through technology embedded in garments is perceived as threat due the possibility of being continuously monitored.

''I said also about this privacy collective data ownership thing can be something as a threat as well. So that you are like 24/7 monitored or somebody can track you I don't know whether that's in practice always the case now days if you have a mobile phone. That can be one aspect.'' (Company 4)

Another participant is on the opinion that smart clothing can be a threat to personal security and personal data privacy.

''I don't know what would be the threats. May be security. Privacy is the one big issue.'' (Company 6)

One expert of fashion 4.0 study reveals similar concern and is on the understanding that there is a possibility to be monitored and controlled by the totalitarian regime who might have maleficent motives towards people.

''About threats well, I see lots of threats in smart clothing. One of the threats is the privacy thing. Of course, it's different here in Finland but there are lots of totalitarian regimes in the world where govt. is kind of monitoring and also punishing people for the thing they don't like even in Europe at the moment like Belarus or Russia. There are lots of countries who are not innocent that way.'' (Expert 4)

4.5.2 Washability, durability and repairability issue

This subtheme incorporates issues regarding the longevity, washability and the repairability of technology embedded garments as well as the rechargeability of components, expensiveness and the sustainability risk. Majority respondents are concerned about the washability issue with the clothing with several electric

component implanted in it. One participant is on the opinion that washing clothes with electronics is not a practical.

''There are very very practical problems about wiring, material amount and printing possibilities to link little wearable cloths. These are quite difficult and other practical things like washing your clothes with with lot a of electronics and these kinds of things can be a problem to wash the cloths.'' (Company 1)

Durability of cloths and repairability of the attached electronics are other issues observed from several interview respondents. Apart from the washability issues, one participant emphasized on the longevity and on the reparability problem solution.

''If the technology is embedded into the garments, then technology must be washable, be wearable and be repairable so that it will last caring of the garments. It needs to be cheap enough, durable enough and so on. So, I think those must be solved first.'' (Company 4)

In addition, the concern of economic viability of power sources as a challenge observed from several sources. One R&D specialist of a company is on the understanding that any feasible economic solution for the power source is not available for integrating it on garments.

''The main challenge is that why it's not well spread because there are some kinds of barriers. First of all, the power source. It's a very important issues because no one yet has come up with a sort of commercially viable solution about the power source which readily available or easily applicable or can be integrated into the clothing.'' (Company 5)

Moreover, high expenditure of maintenance is another challenge that was observed from several participants responses. One specialist from a renowned research institute raises the concern of explosiveness of sealed components if these are wasted due to washability problem.

''Of course, you can change the battery and so on but then comes the other part which is the washability component. I know today you can wash lots of component in the washing machine, but this kind of sealed components are expensive'' (Expert 3)

Likewise, one specialist from a renowned educational institute has similar understanding of components preservability related to washability problem. According to the expert, sustainability risk of components needs to be considered.

''The threat of the technologies is the price, washability, durability and the batter life. Needs to be solved that they are affordable components and then of course the components sustainability point of view.'' (Expert 2)

4.5.3 Uncertainties associated with health, business and technology

Insecurities associated with health, business and technology as a concern apart from functional issues related to washability and repairability, was also observed from the interview responds from several participants. Several company interviewees exhibit their apprehension of negative impact of electronics on health as well as business uncertainties associated with technology adaptation. According to one participant, technology such as nano technology might enter into human body and create health problems.

''I mean that when you have some electronics next to skin there is some research that there is some kinds of health risks is there because of the electronic field or magnetic field which is a delivering waste but on the other hand the nanotechnology. Once we are talking about these textiles electronics then we know that nano sized particles go inside your skin and into your body and they possibly stay there. So, this kind of research should go further. So, we know that the technology is absolutely safe to use because I think that there is some groups there might have seen that they are not safe to use at the moment.'' (Company 2)

One specialist of Fashion 4.0 study from a renowned education institution was on the opinion that data revels through electronic embedded clothing might have negative psychological influence on the individuals.

''Also, in terms of human wellbeing, like if people are too monitored and how they are self-perceived. It will change if we suddenly find all the faults in our bodies then we will feel like sick even though we are not sick that kind of stuff.'' (Expert 4)

Apart from health and wellbeing concern, uncertainties related to technology selection for business is another issue that has also been noticed from several sources.

''Of course, the challenges are to choose the right technology for you and if you are not familiar with your own processes, own production or own brand it's difficult for you to choose the right tool.'' (Company 6)

A specialist of a renowned research institute was on the understanding that decision of not automizing might direct the business towards extinction.

''Because I agree with you that it's a future and you have to understand what change coming to the future for example one person told me in the construction site that they are trying to measure people there. So, the sensor is in clothing because they have to wear those clothes. So that's the more natural way to put it. He said, 'if you don't do it then somebody will'. This is the reason why, but this requires some sort of bravery out of people to do it.'' (Expert 3)

In addition, the company representative who were concerned about business risk associated with technology mentioned above, was also on the opinion that consequences in investing before being prepared might also cause business extinction.

''I think there is a risk on investing too early then too late. It's good not to be the first one. It's quite a relief. If you come too late and you don't innovate, then you are also out of the game.'' (Company 6)

According to the participant, appropriate timing is significant in achieving successes in any technological adaptation.

5 DISCUSSION

5.1 Overview

The purpose of the research was to provide a perception of Fashion 4.0 and smart clothing by interviewing several entrepreneurs, individuals from top management of fashion companies, specialist and experts from the fashion industry. The second objective was to identify the market potentials emerged due to the disruption introduced by technologies related to these two concepts. The third goal was to demonstrate the recognition and the exploitation process of these market opportunities for new business venture.

The findings in general reveal that the perception of Fashion 4.0 and intelligent garments revolve around the technology embeddedness in fashion products, digital technology adaptation in fashion industry and overall technological influence on fashion, business and final fashion commodity. The study also demonstrates that the concept of smart garments is viewed as functional merchandise related to health, sports, security and entertainment that have numerous prospects in these areas. Acceptance of smart clothing according to this research, more as a functional fashion product not as a luxury fashion accessory and a certain level of scepticisms has been observed as well as about its acceptance as a luxury merchandise.

In addition, the findings of this study exhibit that technology related to industry 4.0 is introducing certain changes in fashion industry, hence triggering a disruption. the changes are expected to appear in all areas of industry stages such as manufacturing, supply chain, inventory and final product as well as changes in business models and consumers' purchase patterns. Certain issues that appear as potentials are also considered a reason for disruption as well as a stimulator of exploiting the opportunities. Sustainability to mention have appeared as such a category of issue and according to the findings of this research, it is viewed as an opportunity for organizations to exploit the technologies related to Fashion 4.0. The issue of sustainability along with changes in supply chain, design processes and business model are considered as factors that might introduce disruption in traditional fashion industry if appropriate adaptation and utilization technology ensures it.

Moreover, earlier technological understanding and experience along with social capital in the form of networking according to the findings of this study, has acted as significant factors in recognizing the opportunities the technologies are introducing. This discovery supports the findings of García-Cabrera & García-Soto (2009) that previous technological explicit knowledge and ties with col-

leagues acts as important determinants in identifying the technological opportunities. The study findings also support Choi & shepherd's (2003) proposal on the importance of technological capabilities and Kuckertz's et al. (2017) findings on the importance of economical capabilities on entrepreneurs' decision on further technological opportunity exploitation. Similar to these studies, the present research findings reveal that insufficient technological and financial capacity restraints organizations to consider future exploitation decision.

The discovery of this research confirms and expands several more arguments and findings of previous study on fashion, technology and opportunity identification and exploitation. In the following chapters, the three fundamental research objectives are discussed in the light of previous research and the theoretical contribution of the study are also addressed.

5.2 Perception of Fashion 4.0 and smart clothing

The Literature of fashion and digital technology consider the term Fashion 4.0 as the application of digital technology or industry 4.0 technology into fashion industry. In the study of Bertola & Teunissen (2018), the concentration is to demonstrate an elaborate overview of possible implication of forth industrial revolution in fashion industry, potential trajectories and the development of the concept of Fashion 4.0 in a more comprehensive context. This study has been inspired by that idea and has endeavoured to explore further in the context of Finland about what understanding Finnish clothing apparel market have towards the concept of Fashion 4.0. This research has also elaborated the perception of smart clothing and their market potentials with similar explorative intention inspired by the suggestion provided by Behr (2018) and Fernández-Caramés & Fraga-Lamas (2018).

The concept of Fashion 4.0 provided by Bertola & Teunissen (2018) is viewed as the implication of industry 4.0 technologies such as AI, VR, IOT and AR into manufacturing, supply chain, logistics, retail, and final product is supported by the findings of this study. This present research to mention is an attempt to explore the findings of Bertola & Teunissen (2018) about potential transformation introduced by industry 4.0 in apparel and textile industry and the opportunities the digital transformation would yield by restructuring the fashion industry. This study attempted to elaborate the undiscovered potentials of smart clothing in the fashion industry mentioned by Fernández-Caramés & Fraga-Lamas (2018) in the context of Finnish fashion market.

The findings of this research reveal that the understanding of the term Fashion 4.0 revolves around the automation or mechanization of manufacturing and supply chain or applying robotics into fashion business. The understanding of the

term is not only limited to the notion of digitalization of industry processes but also encompass the final product as functional technology embedded into clothing with aesthetic appeal which advocates Bertola & Teunissen's (2018) idea of the term as digital innovation or transformation of fashion industry. Several technologies such as AR, VR and AI are considered significant in this study in introducing digital fashion in apparel and textiles industry which according to Beher's (2018) belief is recognized as Fashion 4.0.

In addition, the impact of technology in fashion, business and industry is also emphasized in shaping the understanding of the term Fashion 4.0. The term is on several occasions has perceived by how the application of technology enhance performance, ensure quality and assist in establishing a structure to enable interaction between product and customers as well as how the technology implication influence the design processes. The present has study disclosed that the primary element which is predominantly influenced by the industry 4.0 technology is functionality of the garments. This finding exhibits a parallel understanding with the literature (e.g., Görçün, 2018) on how digital technology guaranty functional improvement and excellence through real time monitoring, robotics and 3D technology. Aesthetic elements of fashion have also been considered important by the interviewees which demonstrate how technology and fashion simultaneously impact each other (Matković, 2010).

Moreover, similar perception of smart clothing has been discovered from this research about its association with electronics and other digital technologies. The literature has described the definition of it in the context of technological aspect, human aspect and area of application (Cho et al., 2009; Suh et al., 2010 and Dunne, 2010). The study findings also demonstrate this similar multidisciplinary approach of intelligent garments in the context of technology embeddedness of the garments, the emphasis on functional traits and its area of implication. Digital technology attachment with the fibres and yarns has presented the clothing as smart specially the electronic attachments (McCann et al., 2005).

Correspondingly, in the aspect of the technology, sensors, wireless connectivity, 5G technology and some electronics technology such as LED lights are mentioned by the interview partners as some important gadgets that prepare a garment as smart if some other material such as chromatic, phase change and shape memory is not sufficient to prepare it as smart (Lam Po Tang & Stylios, 2005). Like literature (e.g Langenhove & Hertleer, 2004 and Castano & Flatau, 2014) sensors are considered as one of the necessary functional elements of the smart garments. Similar to literatures such as Kenny (2005, pp 1-15) and Chin et al., (2019), the findings of this study exhibit that, sensors attached in clothing ensure data sensitivity, data communication and information collectiveness as well as is able to monitor human body movement.

Apart from sensors, wireless communication appears important in depicting the perception of smart clothing which assisted the physical engagement, ensure flexible data transferring and ensure efficiency. This is observed to be parallel to the discoveries of Fernández-Caramés & Fraga-Lamas (2018) which mentions that the connection to the internet facilitates the access to numerous applications which have the possibility to utilize the larger database and remote processing power.

In the context of functional aspect, majority literature concentrated on the durability, comfortability, security, functionality and aesthetics (Cho et al., 2009, Suh et al., 2010 & Dunne, 2010). The research has discovered that humanity issues such as convenience, user-friendliness, protection and comfortability have significant role in defining the perception of smart garments. These are primarily the traits that deals with human issues and are expected to be present in an intelligent garment as a functional product (Cho et al., 2009). Durability and washability are other functional characteristics discovered to be significant by this research similar to the findings of Cho et al. (2009) and Dune, (2010) and there are challenges in ensuring these traits specially the sustainability of the power sources and longevity of the garments after wash as well as protection from any skin related diseases (Cherenack & Van Pieterson, 2012; Dune, 2010).

Apart from functionality aspect, as some literature such as Cho et al. (2009), Suh et al. (2010) and Dunne (2010) demonstrated that the perception of smart clothing several occasions formulated on the groundings of the area of implications and future potentials on these fields such as health and wellbeing, sports and entertainment, military and security and finally workplace environment. Similar to these studies, this research illustrated that intelligent garments are viewed as a health or sports garments or workwear clothing. Assistance of smart clothing in receiving the data from patients with disabilities and elderly individuals is discovered in this study which is corresponding to Mahoney & Mahoney's (2010) analysis on intelligent garment's potential health benefits for elderly individuals and adolescent.

This present study also reassures Scataglini et al.'s (2020) discoveries of benefits of smart clothing as a sports product that monitor performance for athletes. The understanding of the garments as a workwear is also revealed as a garment that is able to improve quality of the employee, ensure security and optimize work processes. Figure 10 provides an imagery depiction of smart clothing based on the present findings.

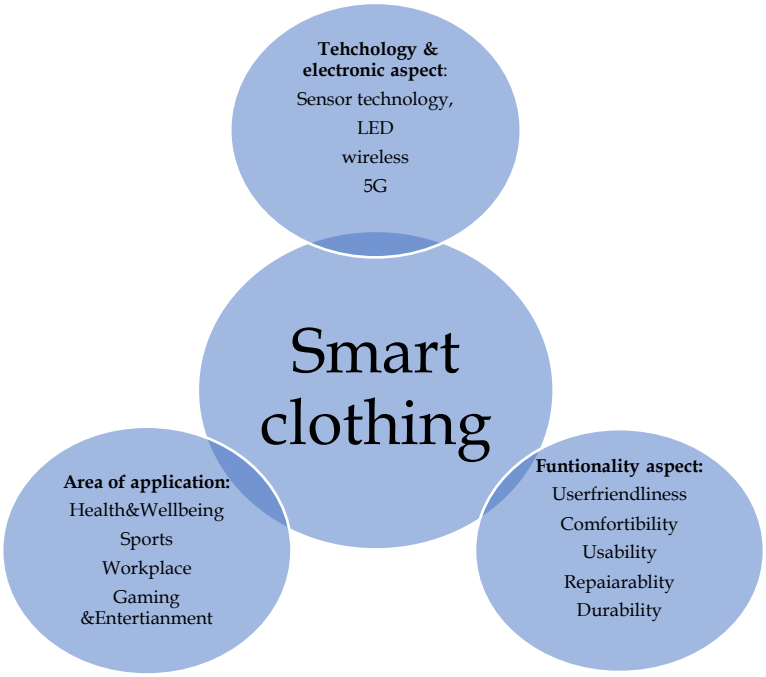

Figure 10: Smart clothing perception based on different aspects and area of applications.

Furthermore, the findings of this research also exhibits that the aesthetics parameters are evaluated on the grounding of functionality which presents smart clothing as a functional fashion product. Functionality is discovered to be emphasized more than aesthetic requirements. Thus, the study discovers that smart clothing is not accepted as a luxury fashion merchandise since majority consumers are not prepared to accept it as a luxury product and also not willing to do extra expenditure unless the value is reasonable and economical. So, economic value of the intelligent fabrics is discovered to be a significant factor of introducing it as a luxury brand.

Likewise, this issue of affordability has reassured the studies of Ariyatum et al. (2005) and Perry at al. (2020) which has discovered that consumers prefer smart fashion wearables that are comfortable and matching with the lifestyle only if it is available with affordable economic value and will not purchase any smart clothing that is not economically affordable. However, the aesthetics need in this study is not fully denied rather expressed as secondary consideration and accepted only as a sport and workwear garments for tech-savvy athletes and employees who would also prefer a functional garment with aesthetic design.

5.3 Market Potentials emerged due to disruption of technologies

Similar to classical understanding on technological trajectory, present research has discovered that the technological diffusion introduced by I4.0 technologies revolves around manufacturing, supply cain and logistics and, retail and distribution processes which reassures Ehrenberg (1995) models that describes any technological disruption would introduce changes in efficiency, product and processes transformation and changes in competence and resources. Response from majority interview participant disclose that industry 4.0 will bring disruption in the production, distribution, inventory and customer services in fashion industry through technologies such as RFID, 3D technology, AR, VR and AI.

Adjacent to the idea of Braglia et al. (2020), RFID technology is discovered to be introducing interruption in supply chain through historical data and real time data of customers' and products. The real time information sharing by smart clothing will transform the manufacturing procedure, design processes and final merchandise. The study findings also discloses that 3D technology will introduce disruption in designers work in the traditional fashion industry through process changing and providing more freedom in design options (Arribus & Alfaro, 2018). Apart from 3D technology according to this present study discovery, AI, AR and VR will interrupt the traditional fashion retail service by introducing VR fitting room which provides the consumers an experience of virtual environment where AI will suggest the most suitable and appropriate options for them.

Moreover, the technological trajectory as the research exhibits will impact on the existing business model of the companies and in several situation will compel the firms to introduce a novel one. This supports Gilbert's (2003) own assumption on the changes in business model as a potential benefit introduced by disruption. The present study similar to literature (e.g Bonetti et. al., 2017) has also revealed that technology will alter the traditional shopping experience and by converting the regular items into an intelligent one through RFID, NFC, AR, VR and sensor technology. Technology will also alter the purchasing behaviour pattern by establishing network-based manufacturing system. As a result, item selection and purchasing will be minimum time consuming, and consumer will receive more transparent information about the product history from beginning to the final consumption (Bertola & Teunissen 2018).

These disruptive transformation in different level of industry and retail procedures according to this research outcome, revealed several potential benefits as Clark et al., (2006) findings exhibit that any technological trajectory appears due to the impacting forces present in the market. As a result, new technological opportunity arises which introduce novel technological and market potentials with

impulsive nature. Similar to Gilbert's (2003) idea of disruption presenting opportunities in terms of growth, new business model adoption and creating new consumer segments, this present study has also discovered novel potentials of adopting any disruptive technologies in the field of production, logistics, inventory and retail services as well as opportunities for final product in different industries. Increasing efficiency, transparency and quality, assurance of sustainability, salvaging time and expenditure as potentials are referred to the opportunities introduced by the 4rth industrial technology disruption whereas optimal value offering and new business models, novel industry potentials for smart clothing and real time data sharing and monitoring are opportunities referred to intelligent garments.

Furthermore, Sustainability issues are discovered to be significantly valuable technology adaptation. According to the discoveries of this research Industry 4.0 technologies might bring disruption in fashion industry and eventually would be considered introducing opportunity if sustainability is ensured by the technologies. Consistent with previous studies such as Ghobakloo (2019), the participants of this research are on the opinion that achieving sustainability is possible by reducing overstock and wastage material as well salvaging energy and redundant expenditure. Industry 4.0 technologies in this situation is ensuring it through innovation in business model and proficiency in production.

The findings also disclose that few participants with expertise are on the opinion that companies should exploit the technology if sustainability is ensured. Anything that guaranty reduction of pollution and wastage in fashion industry according to the interview respondents, is a novel innovation which supports Sarma et al. (2022) findings on sustainable entrepreneurial activities that have the possibility to address environmental issues through innovation and invention. Thus, the term sustainability is acting as a common stimulator of being an opportunity, a reason for disruption as well as a reason for exploitation. Figure 11 bellow depicts sustainability as a common antecedent connecting a reason for disruption, the opportunities and a reason for exploitation.

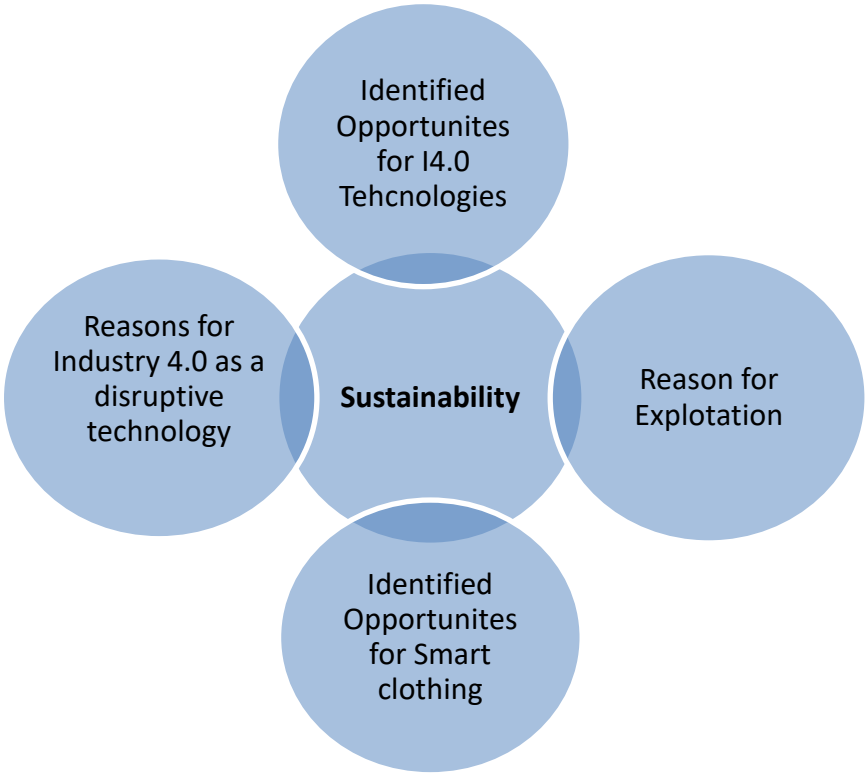

Figure 11: Sustainability as a common antecedent.

Likewise, industry 4.0 technologies according to the research findings will also ensure quality, transparency and accuracy in production, logistics, inventory, and retail processes. These technologies also enhance performance and guarantee process acceleration through VR, AR and automated cutting (Bertola & Teunissen 2018). Apart from ensuring clarity, precision and functional improvement, digital technology such as AR and VR will provide optimal value offering, and brand establishment (Paparistou et al., 2017), AI will assist in service improvement and consumer need understanding (Sohn et al., 2020) and 3D technologies will provide assistance in connecting consumers in the desing procedure (Arribus & Alfaro, 2018).

Correspondingly, market potentials in terms of smart clothing were discovered by this study are related to the area of application such as health, sports, entertainment, and workwear. Similar to the findings of Suh et al. (2010), the present research also discovers numerous opportunities exist for smart garments in the entertainment industry such as music, gaming and toy industry. Parallel to the literature of Ariyatum et al. (2005), Perry at al. (2017) and Scataglini et al. (2020), this research also found that smart clothing has numerous potentials in the field of health and wellbeing and security. Sports is another potential field of application along with workwear where smart clothing has the possibility to be accepted as a functional fashion merchandise since consumers and employees prefer a garment with pleasant aesthetic design. There is a niche market has been discovered

by this study that exists for intelligent garment in these two areas specially for tech-savvy individuals.

Similarly, another potential of smart garments that this study has revealed is the possibility of real time data sharing and monitoring. Corresponding to other previous literature such as Mahmood & Lee, (2020) and Chen et al., (2016), it is discovered that digital technologies such as sensors and big data will assist in accumulating information in the database about individual's health especially older adults. The health diagnosis and services are assumed to be improved and communication is expected to be transparent about individuals' overall health conditions.

Apart from health, with assistance of technology or smart clothing designers are able to receive actual information about consumer's needs, their purchasing patterns and clothing usage patterns through real time monitoring of the market and consumers. This supports the study of Schrauf & Berttram (2016) on digital technologies assistances on creating manufacturing, supply chain and logistics more efficient, responsive and consumer oriented. Also, a digitally connected manufacturing facilities through real time monitoring allows information to be accumulated, distributed and monetized in different areas of business (Braglia et al., 2020).

However, several uncertainties and challenges were also observed from the findings of these research related to technologies of Fashion 4.0 and smart garments. Corresponding to the literature such as Cho et al. (2009), Suh et al. (2010) and Dunne (2010) washability and longevity of the technology and garments have appeared to be challenging issues. Economic viability of the power sources and repairing of the electronic components also have raised some concerns. In addition, data privacy is considered to one of the significant challenging issues for smart clothing since individuals might encounter negative psychological experiences specially patients. Likewise, privacy infringement and data abuse also considered as threatening to the wellbeing of individuals. Similarly, uncertainty also exist in terms of not responding towards the adaptation of disruptive technologies hence risking business extinction.

5.4 Understanding about opportunity recognition and exploitation

Discovery of the understanding of opportunity identification and recognition procedure of technologies related to Fashion 4.0 and smart clothing were concentrated on the antecedent of identification process in the context of fashion and apparel industry in Finland. The findings of this study parallel to earlier studies (e.g Ardichvili et al., 2003; Baron, 2006; Shane & Venkarataman, 2000 and George

et al., 2016) has revealed several factors that carries significant weight in the decision-making procedure such as cognitive awareness and positive mental reaction, previous marketing and, technological understanding and experiences, association and collaboration and constant market analysis. Nevertheless, later three antecedent carries greater weight in this study context. These discoveries reflect and support the resource-based view that considers knowledge and associations as valuable resources in identifying market potentials (Choi & shepherds, 2003).

In addition, cognitive traits such as optimism, positive interest and hopefulness are discovered in this present research as an antecedent in technology adaptation, implementation and future commercialization which is corresponding to the research of Ardichvili et al. (2003) mentioning the importance of optimism in motivating individuals to search for different business opportunities. Confidence and risk-taking tendency are also observed from this study findings which assures Baron's (2006) understanding of individuals with risk taking nature who has the capability of perceiving an extensive depiction of opportunities around them. Several participants with entrepreneurial quality are confident about their smart product's performance and its future commercialization.

Moreover, corresponding to the findings of Baron (2006) and Shane & Venkataraman (2000), this research also discovers earlier understanding of technology and business environment are significant in recognizing the potentials of Fashion 4.0 technologies and smart clothing. Knowledge was achieved both in a tacit and explicit form. The technological explicit knowledge was achieved through formal education such as university education and research activities whereas tacit understanding of technology was obtained through project works. The technological knowledge was also attained through training and testing. Similar situation was revealed for the prior experience of market which is accomplished from personal and professional experience that assisted in adopting certain digital technology. This research findings reassured Corbett's (2005) own discovery of individual experiential learning and its importance on recognition processes as well as Siegel & Renko's (2012) findings on higher ideocentric technological and business knowledge and, its significance on discovering of larger opportunity recognition.

Furthermore, social capital such as networking, association and collaboration are also revealed in this study as significant antecedent in identifying technological and market opportunities. Similar to earlier research such as Ardichvili et al. (2003), Kontinen & Ojala (2011) and García-Cabrera & García-Soto (2009), weak and strong ties, association with research institutes and project collaboration have appeared as important factors in identifying hidden technological and market potentials. Trade fairs and business events are mentioned several times that assisted in accumulating information about recent technological innovation, about competitors and about new opportunities which is supported by García-

Cabrera & García-Soto (2009) findings. In their discoveries they have mentioned that trade exhibition is an optimal source of gaining knowledge about hidden business and technology potentials for technology start-ups and this study reveals that it is also applicable for fashion companies.

Apart from, formal ties, strong ties such as relationship with friends and colleague with entrepreneurial qualities also provide valuable information about market, technological development, and activities of other competitors. Informal discussion with friends and business associates assisted in achieving important insights about market and hidden potentials. Weak ties are also mentioned in the form of new acquaintances in exhibition or project activities assisted in gaining significant knowledge. These findings are parallel to the discoveries of Hite (2005) and Jenssen (2001) on the significance of both strong and weak ties on opportunity identification.

Similar to the association and collaboration, the present study also discovers constant market scanning as another major factor not only in identifying but also exploiting opportunities related to Fashion 4.0 technologies and smart clothing's. Actively searching the market has assisted accumulating valuable information about technological development and potential market region. Researching in a constant manner, reveals information about competitors and other organizations business activities. This supports Krizner's (1997) idea on individuals with entrepreneurial ability sensing the future potentials in the environment through a surprise recognition which he mentioned as 'notice without systematic searching'.

Corresponding with Ardichvili et al. (2003) study, Passive scanning such as personal shopping was discovered in this study to be beneficial for individuals with entrepreneurial qualities in discovering unidentified technological opportunities and challenges which also challenges Baron (2006) and Fiet et al., (2005) studies of methodical opportunity search process. Other than recognition, scanning the market also have significance in opportunity exploitation phase. Earlier studies such as Kuckertz et al. (2017) and Fuentes (2010) has recognized the importance of earlier knowledge and the impact of social networking on exploitation decision and this study findings reveal that constant market analysis is also have substantial influence on the exploitation procedure.

In consistent with antecedents, capabilities are also significant in influencing the exploitation decisions procedure apart from resources and this present research has revealed two such important abilities for example technological and financial abilities. Previous technological possession assisted purchasing or adopt a novel one and several technologies such as ERP, MRP and 3D technologies assisted in exploiting further industry 4.0 technologies which supports Cho & Shepheard's (2003) analysis on the impact of earlier technological capability on exploitation decision. Parallel to Wood & Pearson's (2009) findings, this research has also discovered that inadequacy of technological ability would deter companies to delay

or reject further opportunity exploitation. Several companies according to this study findings, are still scanning the market and not taking the decision to exploit further due to inadequate financial resources or searching larger investment for further exploitation.

Apart from, technological possession, economic capability is also important in decision making procedure of opportunity exploitation. These capability and resources appear in the form of tangible and intangible assets. This present study corresponding to the study of Kuckertz et al. (2017) revealed that intangible assets such as monetary liquidity is important in investing on new technology, novel product idea and managing other resources. Larger investment from stakeholders also assists in further opportunity exploitation (Gumel, 2018). An imagery depiction of market potentials emerged due to the disruption introduced by the technology related to Fahsion 4.0 and smart clothing and the recognition and exploitation process is provided in Figure 12.

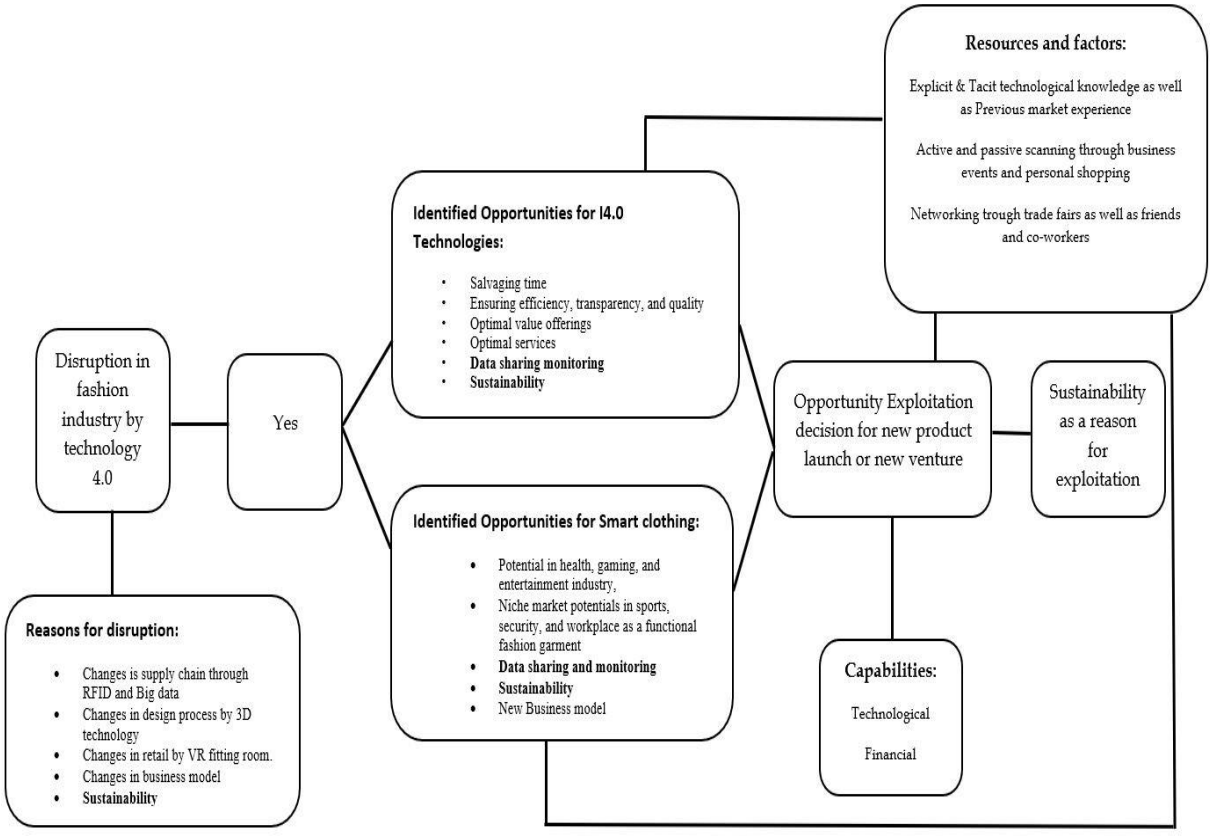

Figure 12: Identified opportunities and the recognition and exploitation procedure.

The figure above demonstrates several opportunities introduced by the disruption and sustainability according to the findings, appears as a common anteced-

ent in this context. Sustainability appears as a reason for discontinuation, a market potential and a reason for exploitation. This supports the discoveries of Ghobakloo's (2019) study of industry 4.0 revolution introducing several opportunities for sustainability such as manufacturing agility, enhanced production proficiency, expense reduction and energy sustainability as well as Sarma et al., (2022) discoveries on sustainability as opportunity for entrepreneurs to initiate further exploration and exploitation. Optimal value creation and functionality enhancement this research also reveals as two important potential sustainable benefits introduce by industry 4.0 technology which supports Thorisdottir & Johannsdottir (2019) findings where these are mentioned as two of several driving forces that ensures sustainability in fashion business model.

Apart from sustainability, the present study discovers earlier understanding as an important antecedent in identifying sustainable industry 4.0 market potentials as well as impacting on exploitation decision which supports Choongo et al. (2016) findings on entrepreneurs' knowledge in recognizing the ecological requirements. The findings have also discovered that active and passive scanning has significant impact on exploitation decision as well besides networking and previous market experience.

Summarizing the earlier discussion, the findings of this research in the context of fashion and technology demonstrated smart clothing more as a functional fashion merchandise and have numerous potentials in health and wellbeing, sports and workwear industry. These opportunities are introduced by the industry 4.0 revolution in vertical and horizontal aspects of industry processes. Sustainability is appeared as an issue in this context of discovering the hidden potentials of technology related to smart clothing and Fashion 4.0 as well as revealed as another important factor that has the possibility to influence exploitation decision.

6 CONCLUSION

6.1 Concluding Remarks

Fashion industry has been influenced by technological advancement throughout history. Several innovations have occurred due to the technological advancement, and which has directed fashion companies to adapt with the novel technological invention. Industry 4.0 is such a recent phenomenon that is introducing disruption in the traditional fashion industry. Fashion industry due to this technological revolution are compelled to accept digitalization and the impact of digitalization already have started being visible in the clothing and apparel products which comprehend not only the functional apparel merchandise but also the luxury clothing accessories. Today's fashion organizations have started dealing with the changes introduced by the industry 4.0 technology in all areas of fashion industry. Digital technology embeddedness in clothing introduced a new understanding of fashion as Fashion 4.0 and smart garments as a part of it (Bertola and Teunissen, 2018).

This research is an attempt to reveal in this regard the understanding of Fashion 4.0 and intelligent garments from the perspective of Finnish apparel and clothing companies, to disclose different market opportunities appear due to industry 4.0 disruption and to demonstrate the understanding of identification and exploitation procedure of market potentials introduced by technologies related to industry 4.0. The findings illustrate that conceptualization of the term Fashion 4.0 revolves around phrases such as digitalization or mechanization of industry procedure or electronics into clothing whereas smart clothing is perceived as a functional fashion merchandise or based on its area of applications. Functionality aspect was significantly emphasized in the findings of the study.

In addition, the study also reveals that the technologies related to Fashion 4.0 and smart garment introducing disruption in industry processes such as production, logistics and inventory, distribution and retail as well as for the final consumer products. The benefits in the market emerged due to the technological trajectory has concentrated on enhancing performance, ensuring transparency and quality in all aspects of industry processes as well as are providing optimal value propositions. Real time data sharing and monitoring has appeared in the research discovery as potentials for both technology and intelligent garments. There is a niche market has also been observed form the outcome of the study for the smart garments as functional fashion product specially for sports athletes and workplace individuals who are technology oriented and prefer aesthetic features. Sustainability issues have appeared as a common stimulator for disruption and exploitation of the opportunities as well as a potential itself.

Moreover, the discovery of the study also demonstrates that resource and capabilities of organization influence the decision-making procedure of opportunity identification and exploitation (Cho & Shepheard's, 2003 and Kuckertz et al. (2017). Three factors are discovered to have significant influence on the recognition procedure as well as the exploitation processes such as previous understanding and experience of technology and market, association and collaboration as well as the constant market scanning. Tacit and explicit understanding of technology played a crucial role in identifying the market potentials as well as networking in trade fairs business events. Sustainability as mentioned earlier also discovered by this study as a factor that is suggested to be considered in making decisions for further exploitation. Nevertheless, few uncertainties and challenges have appeared in terms of data security and data privacy as well as the washability, durability and repairability of electronic components. Apart from these risks, both the technology and the smart garments posses' numerous potentials in different industries (Fernández-Caramés and Fraga-Lamas (2018).

6.2 Managerial Implications

The perception of fashion 4.0 and smart clothing introduces several possibilities for managers to explore the technologies and prepare a strategy for how to adapt the technologies. The findings would assist manager in cooperating design processes and technology together to achieve common ground where design and technology are combined together to fulfil the gap exist in technological understanding and designers understanding of smart garments as well as recognizing the customer requirements. The individuals from higher management from clothing and apparels can invite technology company to cooperate with designers to develop a clothing merchandise that satisfies the consumers' functional and aesthetical requirements.

To present the collaboration more effective, a cooperative project can be initiated where technology developer and designers from fashion brands will engage consumers in designing to produce and provide an appropriate smart garment for them. Managers also can ensure resolving uncertainty issues related to washability, repairability of power source and durability by involving tech-companies and designers from both fashion and industrial designer in a project so that longevity of the technology and comfortability of the garments is ensured.

In addition, the fashion brands can explore more about smart clothing as a functional fashion brand. As the findings reveal that there is a niche market exists, the higher management of top brands can cooperate with gaming industry and design relevant functional fashion intelligent garments for gamers as well as can arrange a project with costumes companies to prepare relevant intelligent costume wear. Industrial sector is another area where both technology and fashion

brands work closely to prepare a functional fashionwear. The companies can engage consumers in receiving ideas and feedback while designing the product and can create customized product based on the functional and aesthetic requirements of the employees. Fashion brands can engage industrial designers while developing an intelligent clothing. Health sector is another area where they can also engage different individuals such as surgeons, physiotherapist and nurses while developing the product and receive information about expected functional and aesthetic requirements of the garments.

Moreover, VR fitting rooms is one possible area according to this research findings where fashion brands and tech companies can collaborate and introduce an exotic retail service with the assistance of technologies such as AR, VR, big data and AI. This strategy will provide managers sufficient data about consumers purchasing and commodity usage pattern. They can restructure their business model to establish more customized production which will assist them to avoid any extra expenditure and wastage of material. This can provide assistance to them to concentrate on producing more sustainable product by considering consumers' requirement and also by solving the technology and data privacy issues with smart clothing as well as by enhancing products longevity through resolving washability issues.

Furthermore, the study findings also reveal networking and actively scanning the market are beneficial in discovering the potentials of technologies and intelligent garments. Managers and entrepreneurs can receive the advantage of this networking factor by joining several trade fairs and business events so that they can receive relevant information about technology and market development. Also, involvement in technological project work which provides sufficient explicit understanding about recent technological development which can provide them enough information in assessing their resources and capabilities for deciding any technological exploitation.

6.3 Educational implications

The implications of this study area not limited to the practical application rather extend beyond it into the area of designers, technology developers and educational institutions. They disclose a necessity for designers to involve themselves in more educational course about technological development so that they can receive more information about technological advancement. Technology developers can attend some designing session so that can receive understanding of the product from a designer's perspective.

This study also exposes a necessity for the educational institution specially fashion institutions to accumulate technology into the fashion designing curriculum

so that they have the possibility to learn about the technological requirements of smart garments along with design requirements. They can arrange real life project for students engaging technology developers and designers as well as business entrepreneurs so that actual potential of smart garments can be revealed and be presented to the consumers. They also can accommodate sustainability awareness in all the courses of fashion designing and technology so that both the designers, tech developers and business students can establish common understanding that will assist them to address the gap exist between technology developers, entrepreneurs and designers.

6.4 Limitations and future research

The design of this research similar to other studies, is subject to certain limitations which has the necessity to be addressed. One of the limitations is that this research encompasses three broader concepts combining together such as fashion, technology and entrepreneurship. Considering broadness of each theme against limited time period, the present research was unable to conduct an extensive study of each theme. It was challenging to attain an equality in the selection of interviews based on the research interest on fashion, technology and business. The strategic sensitivity of the study requires interview participants to possess some entrepreneurial qualities or be actively engaged with management position that allows them to demonstrate some of these qualities and within the limited time frame it was challenging to accumulate such interview participants.

Another limitation was that majority interview participants were contacted through email and over LinkedIn and were asked to communicate with the researcher if they are interested. Also, some of the interviewees were a referral to another interviewees. So, repetitiveness of the interviewee might be on the standpoint of questioning due to such self-selection of participants. Companies who are not actively engaging in the field of fashion, technology and entrepreneurship may not presented authentic understanding of the topic this research is seeking even though due to the nature of the business they are selected. Also, selection of the specialist and expert were conducted based on their interest and their responds. Researcher did not have the freedom to select from a pool of interviews rather accepted the participant for interviews as long as they show their interest. In addition, company specific factors such age and business field were left outside of investigation which may affect how companies respond.

Other limitation was that interview was taken on zoom and it was challenging to observe accurately the body language of participant especially fascial expression due to internet frequency on some occasion which also reflected on the data tran-

scription. Also, several coding that also have valuable information were not considered since the size and time of the research allowed considering only most relevant coding data. Considering the broadness of the topic of Fashion 4.0 and smart clothing which included the realm of fashion, technology and entrepreneurship, maintaining a concentration on the topic and not to be distracted by the extensiveness of the topic was challenging.

Other than limitations, topic certainly offers several future research possibilities. The present research accommodated three broad perspectives of aesthetics, technology and entrepreneurship. Separate research can be conducted on the perception of Fashion 4.0 and the understanding on smart clothing. In depth study is possible to initiate on the conceptualization of Fashion 4.0 in terms of the timeline the concept is developing, that factors that are important in the development procedure and what potential impact the concept may create in business and fashion. Several research has already been conducted on the functionality and area of smart clothing. This study findings reveals that aesthetic needs are also important even as functional merchandise specially in sports and workwear. Future researcher can concentrate on the actual aesthetic requirements in these two fields as well as in the health and wellbeing sector.

In addition, future scholars also can consider conducting in-depth research on each of the technologies related to industry 4.0 in the context of fashion industry, what type of opportunities they may introduce and in what area they may disrupt the industry separately. The findings reveal the importance of technology such as AR, VR, AI and big data in the fashion industry. Several research can be conducted on how these technologies can improve the retail services and how virtual environment will influence consumers fashion shopping experience. Future research can also be conducted on the consumer shopping patterns, shopping trends and usage pattern of merchandise if the technology like AR, VR, AI and big data are involved.

Moreover, the third theme of the research addressed the opportunity identification procedure of smart clothing and technologies related to it and this present research is the first attempt to investigate the theories of entrepreneurship specially opportunity recognition and exploitation procedure in the context of Fashion 4.0 and smart clothing. More elaborate research is necessary to achieve the understanding of the 'black box' procedure of the opportunity discovery in this context and academics in future can concentrate extensively on the identification and exploitation of opportunities of technology and smart clothing separately. The research can be conducted on the perspective of entrepreneurs, specialist and experts of related field separately to obtain border perspective of exiting market potentials of smart clothing as an aesthetic merchandise.

Furthermore, sustainability appeared as one of the important findings of this research which necessitates further exploration on how smart clothing can ensure sustainability in terms of reduction of waste materials, less purchase of unnecessary clothing and assisting slow fashion. Research can be conducted on how entrepreneur can introduce sustainable innovation in this context, what opportunity exist for smart garments as a sustainable product and how these opportunities can be explored and exploited. Future researchers also can concentrate on the factors or reason behind companies not perceiving it as luxury fashion merchandise other than consumers excuse of the garments as not economically affordable. Final conclusion can be derived from the fact that Fashion 4.0 itself an extensive topic in which several future research is possible and there is a necessity also for the similar extensive study for smart garments in the perspective of fashion specially on the recognition and exploitation of opportunities of technologies in fashion industry.

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APPENDICES

Appendix A: List of themes

Overarching Themes	Sub themes	Categories of sub-themes
Conceptualization and understanding of Fashion 4.0 and smart clothing.	Automation of industry process, fashion and fashion business	Combination of fashion and technology into clothing with aesthetic appeal
		Digitalization of manufacturing and supply chain in fashion industry
		AR and digital technology into clothing and fashion.
		A discourse of digital technology adaption
		Mechanization and robotics into fashion business.
	Technology influence on fashion, business and industry	Improved processing speed, quality and service.
		Technology enables interaction between product and customer and measuring the engagement.
		Technology impact on designing process, prototyping and sampling
		Technology influence on both aesthetics and functionality
	Technology and electronics embedded garments	VR, sensor and wireless technology embedded in smart wearables.

		Electronics like LED lights and smart jewelleries embedded into fashion textile.
		Compression technology into clothing.
	Intelligent garments with functional traits or benefits.	Importance of functionality in clothing in terms of protection, safety, usability and due to technology emphasis.
		Functional fashion garment that is comfortable, convenient and makes like safer.
		Sceptical about mass market acceptance as a luxury product and about peoples purchase intension.
		Functional health and sportswear and workwear ensuring safety, user-friendliness and performance
	Ensuring sustainability and salvaging time	Big data will assist in reducing overstock and overproduction.
		Digitalization will ensure sustainability and ecological use of materials in fashion.
		Automation will save time and expenditure
		Technology as reason for disruption if ensures sustainability
		Technology should be exploited if ensure sustainability

Market potentials emerged due to disruptions	Efficiency, quality and transparency.	Production quality improvement, effectiveness and ensuring safety.
		Efficiency and accuracy in manufacturing, inventory process and retail process.
		Enhancing performance and process acceleration
		Trackability and transparency of production, logistics and end product.
	Optimal value offering and services	VR assistance in offering optimal values and brand building.
		Engaging customers in the design process through technology
		AI would help understanding consumer needs and provide better service.
	Potentials in fashion and other industries	Potential market for security, health and entertainment industry
		Acceptance of smart workwears for more fluent work and process optimization.
		Niche market for functional fashion product and smart features in clothing
		Potential demand and market environment for smart garments
	Data availability, sharing and monitoring	Collecting data of consumers buying pattern and cloths usage patterns.

		Real time monitoring of the market for designers to receive actual consumer need.
		Security, data availability and sharing with smart gloves
		Connected production facilities and real time monitoring.
	Changes in manufacturing, supply chain and retail processes	3D technology will bring disruption in designers work and digitalization will bring disruption in supply chain, manufacturing and production.
		Information delivered by clothing can change the way manufacturers produce clothing and do design and finally produce the product.
		Technology like AI can assist digital services that will assess the old clothes and suggest new styles and combinations.
		RFID technology can bring disruption in supply chain, logistics and life cycle of products through product history.
		AI and VR will bring change in Retail.
	Changes in business models and shopping behaviour	Electronics into clothing might introduce new business model, impact on current business and change whole business model.

		Changes to slow fashion from fast fashion
		Network based manufacturing system, Internet and e-retailing will change the buying and consumption pattern
		New trends like showroom shop and showroom experience will make items intelligent with the help of technology.
	Cognitive perception and assertive reaction	Confident about product quality, performance and its future commercialization.
		Positive interest about benefit, future adaptation of technology and product development by technology.
		Hopeful about future exploitation and business growth.
	Earlier understanding and experience	Tacit and explicit technological knowledge gained through formal education and project work
		Earlier technology experience helped in learning through trial and error and adopting through prototyping.
		Previous experience about the market and Networking.
		Tacit Knowledge about technology through experiential learning.

Resource and Capabilities	Association and collaboration	Partnerships with different research institutes, companies and attending trade fairs.
		Technology information through business partners or entrepreneurs and knowledge from co-workers.
		Discussion with friends and colleagues about technology.
		Joining business events.
	Constant market analysis	Actively monitoring the industry and gaining knowledge about the industry.
		Opportunity identified through shopping experience.
		Researching about technology and market by being conscious about changes.
	Technological capacity and possession	Previous technology possession assisted purchasing and adopting new ones.
		Previous technology assistance in digitalizing manufacturing process.
		Lack of technological capabilities for development.
		Some Finnish companies already have digital technology like 3D technology to exploit opportunities.
	Economic resources and ability	Importance of financial resources in investing on new product idea

		and managing resources.
		Financial situation or big investment is important for further exploitation.
		Money is important for investing on new technologies, new business and automize the operation.
Threats, risks and challenges	Security, privacy and mismanagement of information	Information misuse and controlling issue
		Privacy can be hampered due to data sharing.
		Threat to security and data privacy in terms of technology and clothing.
		As a means of controlling population
	Washability, durability and sustainability issue	Durability of cloths and repairability of the technology.
		Longevity and recharge ability of power source.
		Sustainability risk of components.
		High expenditure and no economic solutions for power source.
	Risks associated with Health, business and technology	Risks in investing before being ready.
		Choosing the right technology for business
		Health risk associated with skin and psychology
		Chance of dying out of the market if don't do digitalization and don't update themselves.

Appendix B: Interview questions list

Question related to perceptions of smart clothing and Fashion 4,0 and meaning of it for the company

What understanding do you have about fashion 4.0 technologies?
What is your perception about fashion wearables and internet of smart clothing?
How technology related to fashion 4.0 and smart clothing is influencing design techniques, aesthetics and functionality of fashion products related to your company?

Question related to Technological change and its influence in Fashion?

Do you view Fashion 4.0 technologies as a disruptive technology? Why?
Which part of fashion has got affected most by the technologies?

Questions related to Opportunity recognition, evaluation and exploitation

What future you see for fashion 4.0 and Internet of smart clothing in general?
What future you see for your company about these technologies.?
How these technologies related to fashion 4.0 will benefit your company?
What are the opportunity and threat of Fashion 4.0 technologies and internet of smart clothing?
How do you come about knowing fashion 4.0 technology? R
Would you invest on these technologies as opportunity or why do you think them as opportunities? What criteria you consider?
Does your present resource ability help in adopting the technology or seeing these technologies as opportunities?
Why and how do you want to exploit these technologies as an opportunity?
What would stop you exploiting these technologies?

Questions related to risk and challenges of fashion 4.0 technologies

What are challenges related to Fashion 4.0 for your business?
What are your company strength and weakness?
What are the risks of investing, not investing or investing too late?