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Analytical and Synthetic Phases of Path Development

Knowledge Bases and The Evolution of Swedish Textile Industry: The Case of Borås

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Abstract: The questions of how regions develop over time and new regional growth paths emerge have been widely investigated by economic geographers. This study, with a wide understanding regarding the role of history, enhances our perception on how evolution process acts and what type of dynamics are influential to create a new path development by unfolding the different characteristics of development phases given to the knowledge base approach. The theoretical framework built upon the knowledge base approach and the notion of regional industrial path development has been applied to the textile industry in Borås. The study concludes that, for the case of Borås, the evolution of the historical conditions into new technologies -high value-added products- has triggered the emergence of the new path within smart textiles which has been enabled by the inflow of analytical form of knowledge into the synthetic knowledge base. Several key actors and endogenous and exogenous triggering events have influenced and changed the development pattern of regional industry.

Key words: Knowledge bases, regional industrial path development, new path creation, smart textiles

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1 Introduction

The main endeavor of evolutionary economic geography (EEG) approach has gathered around the understanding of the behaviors of economic actors and paths of change with a relation to the dimensions of time and space (Boschma, 2012). Within this context, recent researches conducted in economic geography and innovation studies posted so much attention on the notions of restructuring processes in industrial regions (Tödtling & Trippl, 2012), emergence of new regional growth paths (Neffke et al., 2011), the evolution of regional industries and the mechanisms of regional path dependence, path creation and path renewal (Martin & Sunley, 2006; Martin, 2012b). "Evolutionary turn" in economic geography has adopted the evolutionary terminology and concepts such as path dependence, learning, and novelty (Martin & Sunley, 2006).

Most recently, knowledge base approach has been incorporated to the EEG concept to explore the changing dynamics of different stages within the innovation and knowledge creation processes which consist different knowledge bases and thus different forms of knowledge (Isaksen & Trippl, 2017; Martin & Trippl, 2015; Zukauskaite & Moodysson, 2016). However, despite the increased attention to the varying combinations of different knowledge bases, literature still lacks the role of history where triggering events and key actors can create an effect to shift the knowledge base and thus to create a new path in the course of history. This study, by offering a wide understanding regarding the role of history, identifies the distinct patterns of regional path development by relating the issue to the specific characteristics of dominant knowledge bases. With a focus on critical junctures in the history and the shifts between different knowledge bases, the process of evolution for a traditionally declining industry has been addressed to contribute the literature from a historical standing point. Thus, it was paid attention to understand what type of role has been played by pre-existing structures as well as endogenous and exogenous actors to drive the shift through the new growth path in the region.

Future events grow upon their roots that are hidden in the previous events in an evolving path-dependent process, (Boschma & Frenken, 2006) where David (1985) states that history matters. On that ground, studies belong to the field of path-dependency mainly describe the regional industrial development as a product of endogenous factors endowed in the region (Martin & Sunley, 2006). Moreover, branching processes through which new industries are created from the existing ones act as the source of growth (Boschma & Frenken, 2006). Isaksen and Trippl (2014) state that in academia there is a tendency to give an explanation by focusing on firm-specific routines, norms and tacit knowledge that go along well-established technological trajectories. Moreover, sectoral aspects (Malerba, 2005) or aspects regarding the national and regional context in which sectors operate (Whitley, 2002) are developed as models to explain the differences in development paths.

On the other hand, Isaksen and Trippl (2017) throw an insight into exogenous sources of new path development and policy actions by offering empirical evidence on peripheral regions. Bathelt et al. (2004) shed light on that firms in regional clusters need to combine locally available knowledge with another type of knowledge that is elsewhere in order to stay dynamic. Therefore, they should establish pipelines to certain global knowledge sources. Simmie (2012) argues the intentional creation of new technological pathways relying on a hybrid socio-economic theory proposed by him where he aims to understand the interactions among the evolution of path-dependent economic development and the social actions of pioneering agents such as individuals, universities, companies and/or governments. Recently, Isaksen and Trippl (2017), and Zukauskaite and Moodysson (2016) use a conceptual framework that combines path development and knowledge base approaches to provide a deeper insight into the complex development processes. They present findings on the notion of that the path development processes of firms and regions highly rooted in their knowledge base combinations.

Knowledge base approach provides an understanding where innovation processes of firms are shaped by knowledge bases that are specific to firms or sectors (Asheim & Gertler, 2005a), and their abilities to learn, change and innovate are embedded in the characteristics of the dominant knowledge base. The distinction of three different knowledge bases - analytical, synthetic and symbolic – (Asheim & Gertler, 2005a; Asheim et al., 2005; Martin & Moodysson, 2013) has enhanced our perception on alternatives that capture experience-based knowledge and non-R&D forms of learning (Herstad et al., 2014). This differentiation of knowledge bases comprises a mix of codified and tacit knowledge, codification possibilities and limits, competences and abilities, dependence on distinct types of organizations and institutions as well as innovation challenges (Asheim et al., 2005; Asheim & Coenen, 2006). In definition, `Analysis' denotes the understanding and explanation of features of the natural world while `synthesis' denotes the designing or construction of something to fulfill some functional goals (Moodysson et al., 2008a). Thus, while analysis belongs to the realm of natural science, synthesis is attached to engineering (Moodysson et al., 2008a).

Both of them exist in most industries but in varying intensities and in the different phases of product/process development (Moodysson et al., 2008a) with different spatial outcomes (Moodysson et al., 2008b). Moodysson et al. (2008b), in their analysis of biotechnology cluster, highlight the fact that the industry cannot be purely specified as analytical or synthetic, neither as principally local or global. Instead, industries include complex combinations of both of these classifications (Moodysson et al., 2008b). Coenen and Moodysson (2009) throw a hint on the inclusion of analytical knowledge base into traditional, or in other words into synthetic activities, as critical for the innovation process. Moreover, firms that blend the analytic and synthetic forms of knowledge are more likely to stimulate the new path creation than others (Zukauskaite & Moodysson, 2016). Zukauskaite and Moodysson (2016) unfold the development process of food industry which was able to start a new path through the emergence of high value-added products by adding health benefits.

In existing literature, there are several studies deal with knowledge base approach with a focus on knowledge base differentiation of industries (Martin & Moodysson, 2011; Martin & Moodysson, 2013; Moodysson et al., 2008a) or their combinations in different phases of product/process development projects (Moodysson et al., 2008a; Moodysson et al., 2008b)

and, industrial clusters (Asheim & Coenen, 2005) and, the intra-firm relationships of multi-national companies (Liu et al., 2013). Furthermore, there are several recent studies combine the knowledge base approach with path dependency or regional industrial path development literature to analyze varying paths of regional development within the same industry (Zukauskaite & Moodysson, 2016), and new growth paths of peripheral regions (Isaksen & Trippl, 2017).

Boschma (2018), classifies the studies in the field of knowledge bases into two distinct generations where the first one mainly points out the diversifying nature of learning and innovation given to the activities shaped by different knowledge bases by relying on a comparative case study approach to offer empirical evidence while the second generation interrelates the concept of the knowledge bases with evolutionary economic geography to develop more dynamic and combinatorial approach. However, the knowledge base literature still falls short to develop a stronger conceptualization of the role of history (Boschma, 2018). Beyond just associating dominant knowledge bases with a particular period of time, new studies should adopt a historical approach that explores the character of shifts between past and present such as whether it is radical or not, and the way to evolve from one knowledge to another (Boschma, 2018). Departing from that point, in this thesis, it is aimed to build on the aforementioned background on knowledge bases by unpacking the evolution process of a certain traditional industry- namely the evolution of textile sector- by referring to analytical and synthetic phases of path development. It has been analyzed the differences between the distinct paths of industrial development which belong to one particular industry in the same region, in this case, it is textiles in Borås, with a special focus on the role of history. Within this regard, this paper deals the questions of how evolution process acts and what type of dynamics are influential to create a new path development within a certain regional industry by stimulating a shift in the knowledge base. This standing point requires the adaptation of a historical perspective both to understand the endogenous and exogenous driving forces of new path creation. Here, the notion of knowledge base draws the guidelines of this transformation and complements the argument of path creation by unwrapping the distinct phases of development.

The thesis study is organized as follows; Chapter 2 provides the theoretical background and literature review on knowledge base approach and the notion of path development. Chapter 3 explains the methodology and data to analyze that will be utilized to discuss the findings of literature. Building on the theoretical discussion, Chapter 4 includes a case-study of the textile industry in Borås. The chapter starts by providing an overview of the textile industry in EU and Sweden. The development of the sector in a certain place cannot be elaborated without giving attention to the international and national dynamics. Thus, at first stage, it is crucial to get an insight on how sector acts in varying aggregation levels and what type of factors are influential on its changing character. After a short explanation regarding the current picture of the industry, section in question, presents the case study of Borås to understand the path renewal process of the textile sector through the knowledge base approach. Finally, chapter 5 summarizes important findings and draws some conclusions with an insight into future research.

1.1 Aim and Objectives

This thesis study aims to provide an insight into the knowledge base argument in the literature by identifying the different phases of regional industrial development of textile production in Sweden and relates the issue to the path development process to gain a clear understanding on how renewal process has acted through a historical perspective. The concept of this paper includes two main building blocks; the notion of knowledge bases and path development approach. By exploring textile clustering in Sweden as a traditional industry, the study contributes to the literature by using the combination of the knowledge base and regional path development approaches, which enhance our knowledge to distinguish between analytic and synthetic characteristics of regional industrial path development.

Borås has been selected as the location of the empirical research given its deep roots and strong position in textile sector as well as the changes in its innovation and collaboration network. In the empirical part of the study, the topic is introduced by presenting a brief overview of the sector in EU and Sweden and, then the argument is expanded to the development story of the industry in Borås region which is a strong representative of the general trend of the sector in the country. During that narrative, several factors such as regional institutional infrastructure and institution-building process, the type and roles of key actors, policy frameworks, and targets as well as initiatives taken by the central government institutions have been touched upon to handle the issue from a broad perspective.

Here, the research questions of this thesis study are;

- ✓ How did the transition process of a traditional industry, namely textile, evolve from one knowledge base to another from a historical point of view? How did the industry build the new regional path on the pre-existing structure?
- ✓ What type of dynamics was influential to shape a new path development within a certain regional industry by stimulating a shift in the knowledge base? What type of role was adopted by the endogenous and exogenous driving forces of new path creation?

1.2 Scope and Delimitations

Textile sector has a long tradition in Sweden that dated back early in the history. Throughout decades, the industry has dealt with several challenges and experienced structural changes to survive against the competitive conditions mainly induced by the imported low-cost products. Despite all difficulties, one important feature of the textile industry in Sweden, flexibility, made it possible to meet today's demand in the market. Furthermore, Swedish textile companies are capable to adjust themselves in a rapid way to changing character of this industry and nowadays the main agenda is mainly about new fibers and processes, and textiles with functions -smart textiles- (TEKO, 2015).

In that study, the evolution process of the textile industry has been primarily concerned to deepen our understanding on the synthetic and analytical phases of development. Challenges posted by international markets and growth dynamics vary between different industries where the modes of changes strongly rooted in knowledge bases. The evidence presented in this thesis has been confined to the transition from synthetic to analytical forms of knowledge, thus further researches can postulate more insights into the debate by considering the different combinations of knowledge bases (analytic, synthetic and symbolic) and the permutations of shifts between them with a focus on the role of history.

2 Theoretical Framework

This chapter provides an insight into the knowledge base approach in the literature which is crucial to understand the structure of innovation beyond tacit-codified knowledge dichotomy and relates the issue to path development approach. By combining two theoretical approaches, it has been aimed to define the distinct phases of path development process referring to the synthetic and analytical characteristics of industrial innovation behavior. Here, knowledge base approach enhances our understanding regarding the varying impacts of different types of knowledge to induce and reinforce the emergence and the growth of new regional industrial paths. Our concept includes two main building blocks; the notions of the knowledge base and regional industrial path development.

2.1 The Knowledge Base Approach

Knowledge, as a key driver of innovation, spurs the growth and economic development in the long-run perspective (Howells, 2002). Moreover, both creation and transfer of knowledge are substantial to stimulate a learning process through which competitive advantage of firms, industries, and regions is created (Boschma, 2005). Based on the notion of learning economy, competition between firms is greatly defined by the production, acquisition, and distribution of knowledge where this notion is true to some extent for all industries (Gertler & Levitte, 2005).

To gain a deeper understanding regarding the spatial aspects of innovation, economic geographers have elaborated the propensity of innovation to cumulate in particular areas with a focus on the tacit and sticky nature of knowledge (Audretsch & Feldman, 2004; Feldman, 2000). Moreover, many studies in the field of economic geography have studied the proximity and tacit knowledge as being the key components for interactive learning and crucial to innovate from an evolutionary perspective (Audretsch & Feldman, 2004; Gertler, 2003; Gertler & Levitte, 2005; Howells, 2002). The action of learning is just more than the transfer of codified knowledge which is accessible for everyone rather it stipulates interactivity and social process (Johnson et al., 2002). In other words, codified knowledge relies on tacit knowledge embedded in people and organizations to have an understanding (Moodysson et al., 2008a). With reference to a certain time and space, knowledge is also context-specific where without this context, it just can be defined as an information (Nonaka et al., 2000). Departing from aforementioned details, the growing body of learning regions puts so much emphasis on tacit knowledge and being co-located for innovation to explain the geography of innovative activity in relation to the social interaction (Asheim, 1996), and regional innovation systems put influence on collective learning where local actors perform systemic relations (Asheim & Gertler, 2005a).

Polanyi (1967)'s seminal work has laid the foundation for the "codified" and "tacit" knowledge distinction which is also the most well-known knowledge classification in the literature within different taxonomies. Based on this tacit and codified taxonomy of knowledge, the creation and transfer of knowledge across the network of innovators become more sensitive to proximity and personal relations built on trust gain more importance in line with the enhancements in the tacit character of knowledge (Bathelt et al., 2004). Conversely, the codified knowledge is less space-bounded (Bathelt et al., 2004). Tacit knowledge requires direct experience and face-to-face interaction for the transfer of knowledge due to its context-specific nature where distance matters. Therefore, tacit knowledge is regarded as "spatially sticky" and "embodied in the geography" (Howells, 2002; Martin & Moodysson, 2013). According to Polanyi (1967), the way of learning through tacit knowledge can be considered as "unawareness" because of the informal acquirement. On the contrary, codified knowledge can be transferred easily among various actors distributed over long distances regardless of the locational proximity and direct experience (Howells, 2002).

The downward trend of some traditional industries accompanied by the increasing importance of clusters in developing countries which have international linkages contributes to the growing debate on that the process of innovation and knowledge creation is complex in which both tacit and codified knowledge act together and affect each other (Liu et al., 2013). Furthermore, geographical proximity is "neither a necessary nor sufficient condition" for interactive learning and innovation to take place rather a factor that facilitates and strengths other dimensions of proximity (Boschma, 2005). Moreover, different geographical levels such as global, national and regional/local play a different role for the innovation activity, knowledge creation and learning processes to vary between clusters (Asheim & Isaksen, 2002). Asheim and Gertler (2005a) state that SMEs, in the long-run, should find new ways to access to the knowledge pools both at the national and global level and create a combination of informal knowledge and systemic knowledge which is derived from scientific researches to be able to upgrade their innovative capacity. According to Boschma (2005), in the absence of geographic proximity, other dimensions of proximity, such as cognitive, organizational, social and institutional proximity, can even behave as a transfer mechanism.

On the other hand, innovation and knowledge creation have been more complicated in a comparison with before given to the increased variety of knowledge sources and inputs used by institutions and firms where also the division of labor and interdependence among actors have upgraded (Asheim, 2007). Different from the perception of innovation which has been considered as a linear process pushed by science or pulled by demand, the new interpretation of innovation processes is adopted a more interactive understanding (Cooke et al., 1998). Furthermore, recent studies have argued the knowledge base approach, which defines the industry-specific characteristics to design the geography of innovation and is strongly influential to shape the innovation process rather than a generic perspective towards augmented diversity and interdependence in knowledge creation process (Asheim & Gertler, 2005b; Asheim & Coenen, 2005; Asheim & Coenen, 2006; Martin & Moodysson, 2011).

It is well-common to define knowledge bases for firms with reference to R&D intensity, accumulated R&D and technological profiles derived from the patent data (Herstad et al., 2014). Nevertheless, this type of assessment falls short to distinguish the intrinsic qualities of the learning process and generally comprises firms which use scientific inputs and execute

systematic R&D to generate novelty and that rely on science-technology innovation (Herstad et al., 2014). Therefore, to analyze the geography of innovation (Martin & Moodysson, 2013) and changing local-global interactions across different industries and activities (Liu et al., 2013), Asheim and Gertler (2005a) introduced a classification of three different knowledge bases: (1) analytical, (2) synthetic and (3) symbolic which explain the geography of innovation by relying on the knowledge that is inherently in the nature of a specific industry and crucial to innovate (Martin & Moodysson, 2011). The differentiated knowledge base approach offers a broad-based view, beyond the narrow, supply-side, linear innovation model by defining the innovation as an outcome of interactive learning processes stimulated by multiple actors and organizations such as entrepreneurs, firms, universities, public agencies, government, and civil society (Lundvall, 2007). This type of understanding is also in line with the innovation systems concept (Lundvall, 2007).

Moreover, the taxonomy of three different knowledge bases - analytical, synthetic and symbolic – (Asheim & Gertler, 2005a; Asheim et al., 2005; Martin & Moodysson, 2013) also encompasses the experience-based knowledge and non-R&D forms of learning (Herstad et al., 2014). Knowledge base taxonomy covers a mix of codified and tacit knowledge, codification possibilities and limits, competences, and abilities needed by organizations and institutions (Coenen & Moodysson, 2009). For a comprehensive and aim-oriented policy perspective, sector-specific characteristics of knowledge bases are crucial to be addressed (Asheim & Coenen, 2005). Innovation processes of companies are shaped by these knowledge bases which are specific to their activities (Asheim & Gertler, 2005a).

Within the body of knowledge base literature, knowledge and innovation characteristics of different knowledge bases in a relation to industrial activities have been widely examined (Herstad et al., 2014; Martin & Moodysson, 2011; Martin & Moodysson, 2013; Moodysson, 2008). However, the conceptualization of knowledge bases has evolved to adopt an ideal-typical and combinatorial approach which includes also a connection to evolutionary economic geography (Grillitsch et al., 2017; Isaksen & Trippl, 2017; Zukauskaite & Moodysson, 2016). In that context, knowledge base combinations for specific R&D projects, firms and regions have been studied, but the literature still so far lacks understanding of the role of history where triggering events and key actors can create an effect to shift the knowledge base and thus to create a new path in the course of history. In this paper, it is just focused on analytical and synthetic knowledge bases. Design and artistic concerns are inherently in the nature of textile production, thus to get a clear understanding regarding the shift between knowledge bases, the symbolic knowledge base is not included in the study.

2.1.1 The Analytical Knowledge Base

An analytical knowledge base (scientific-based) dominates the economic activities that are based on the scientific knowledge where codification and rational processes are substantial (Asheim et al., 2011a). Industries such as genetics, biotechnology and general information technology in which scientific knowledge is highly important can be exemplified for the analytical knowledge base (Asheim & Gertler, 2005a).

Applied and basic research are at the core of analytical knowledge base where industry-university linkages are relatively strong (Coenen & Moodysson, 2009). Moreover, innovation relies on the application of scientific principles and methods and thus, development of products and processes is conducted in a systematic way (Asheim & Gertler, 2005a). Industries that perform on analytical knowledge base generally build and exploit their own in-house research and development (R&D) departments as well as derive knowledge from universities and other research organizations (Coenen & Moodysson, 2009). Therefore, interactions between industries and public research organizations are more frequent in a comparison with other knowledge bases.

Since the generation of knowledge and innovation embrace both kinds of knowledge, the codified dimension of knowledge is dominant in that type given to the character of knowledge which is created based on formal models (Asheim et al., 2005). For that reason, the transfer of knowledge is less sensitive to proximity (Asheim et al., 2005). Radical innovations are more likely to happen where new products or processes are common forms of knowledge application (Martin & Moodysson, 2011). Moreover, new firms and spin-off companies are established on radically new inventions or products mainly generated by universities and research organizations (Asheim & Coenen, 2005).

2.1.2 The Synthetic Knowledge Base

Synthetic knowledge base (engineering-based) refers to the industries which produce innovation based on the application or novel combinations of existing knowledge, know-how and skills where knowledge mainly is developed as a response to specific problems coming from clients and suppliers (Zukauskaite & Moodysson, 2016). Industrial machinery, plant engineering, and shipbuilding are common examples for synthetic knowledge base (Asheim & Gertler, 2005a). Innovation considerably appears through applied research and in the forms of process and product development that can be defined as incremental where R&D activities are relatively less important (Asheim & Gertler, 2005a). Given to the dominance of applied research in innovation activities, linkages between industry and university are relevant (Coenen & Moodysson, 2009).

New knowledge is generated through an inductive process which primarily comprises the activities of testing, experimentation, simulation and practical work (Coenen & Moodysson, 2009) and is created through learning by doing, using and interacting (Asheim & Coenen, 2005; Martin & Moodysson, 2013). Due to the high dependence to the tacit dimension of knowledge, industries that operate on synthetic knowledge base have interactions with geographically close partners where the transfer of knowledge is more sensitive to space and proximity (Liu et al., 2013; Moodysson et al., 2008a; Martin & Moodysson, 2011).

Table 1 summarizes the main characteristics of analytical and synthetic knowledge bases.

Table 1 Main characteristics of analytical and synthetic knowledge bases

Analytic (science-based)	**Synthetic (engineering-based)**
Innovation by the creation of new knowledge Importance of scientific knowledge often based on deductive processes and formal models Research collaboration between firms (R&D department) and research organizations The dominance of codified knowledge due to documentation in patents and publications More radical innovation More globally spread	Innovation by application or novel combination of existing knowledge Importance of applied, problem-related knowledge (engineering) often through inductive processes Interactive learning with clients and suppliers The dominance of tacit knowledge due to more concrete know-how, craft and practical skill Mainly incremental innovation More national and regionally spread

Source: Asheim and Gertler (2005a) and Liu et al. (2013)

2.1.3 Combination of Differentiated Knowledge Bases

Debates on the classification of knowledge evolved to the notion that knowledge embodies both codified and tacit dimensions within the same body where proximity matters but not for all industries and not from all aspects (Martin & Moodysson, 2011). Moreover, knowledge creation and innovation require the combination of them where knowledge bases indicate differences regarding the dominance of tacit and codified knowledge content, the level of formalization and the context-specificity (Asheim & Hansen, 2009). Furthermore, in reality, most activities cover more than one knowledge base, and the degree of dominance for a certain knowledge base may vary substantially for different industries, firms and even for different types of activities and occupations (Asheim & Hansen, 2009). Figure 1 shows the visualization of how different knowledge specializations can intersect in reality.

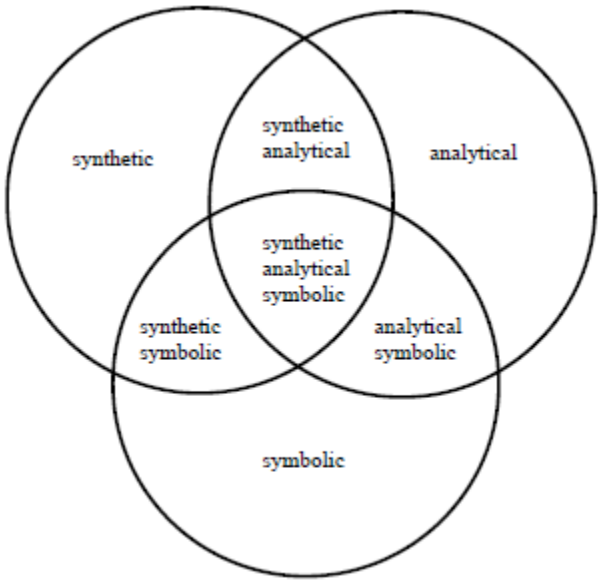

Figure 1 Intersection of knowledge specializations (Martin, 2012a)

Manniche (2012) presents the evidence for that, three categories of knowledge bases rarely can be found in absolute form, in reality, instead, they can identify empirically observed differences regarding the types of knowledge, actors, and contexts which are partaken in innovation processes in differing ways and moments. It is even hard to observe same or similar patterns of innovation behavior for narrowly defined industries (Zukauskaite & Moodysson, 2016). Innovation mainly takes place by integrating the divided but interconnected interactions within different knowledge bases, learning communities and contexts where companies act on combinatorial knowledge bases (Manniche, 2012). Moreover, Jensen et al. (2007) draw attention on the notion of that all forms of knowledge carry weight for both modes of innovation, and companies which combine different modes of innovation are mainly more innovative than other firms that depend on one mode. Martin (2012a) analyzed the degree of specialization in particular knowledge bases for Swedish regions and highlighted that many regions were dominated by more than one knowledge base and found evidence for the specialization especially in the synthetic knowledge base in some regions.

Keeping that in mind, Asheim and Gertler (2005b) extend this aforementioned debate on the coexistence of knowledge bases to the different degrees of spatial concentration. They shed light on that industries depend on analytical forms of knowledge are spatially concentrated as much as the other forms of innovative activity that belong to the synthetic knowledge base. Therefore, analytically based industries show an uneven geography of innovation which could be ascribed to several reasons such as highly localized knowledge spillovers, a specialized labor market given to the specificity of job opportunities, and the high importance of locations regarding the high quality of life (Asheim & Gertler, 2005b).

Boschma (2018) elaborates the knowledge base literature and divides it into two different generations of scholars. The first generation includes the studies that shed light on the nature

of knowledge sharing and the geography of innovation and explain main dissimilarities between knowledge bases (Martin, 2012a) as touched upon. Building upon the first one, the second generation mainly adopts a combinatorial approach to innovation and complements it with an evolutionary concept. There is a clear shift from the first generation where industries, organizations, and regions tend to rely on the combination of more than one knowledge base which notion makes them thrive (Trippl et al., 2015).

Grillitsch and Trippl (2014) put forward evidence for the combination of different knowledge bases within the scope of their analysis of knowledge sourcing activities in the Austrian automotive supplier industry where the results indicate the reliance on both synthetic and analytical knowledge bases. The automobile industry has been regarded as traditionally being dominated by synthetic knowledge (engineering) and even symbolic knowledge (design of cars), however today, a shift to analytical knowledge has appeared in line with computer-led mechanization (robotics) and the development of the self-driving car (Boschma, 2018).

Exploration regarding the combinatorial knowledge bases offers deep insights to understand how interconnections of heterogeneous knowledge resources can be influential on the innovativeness of firms, industries, and regions. Additionally, by distinguishing the sources of various forms of new industrial path development, the combinatorial concept enriches the conceptual tools to shed light on the relation between knowledge bases and regional path development (Asheim et al., 2017).

2.2 The Notion of Path Dependency

The questions of how regions develop over time and new regional growth paths emerge have been widely investigated by economic geographers (Isaksen & Trippl, 2017; Martin & Sunley, 2006; Neffke et al., 2011; Simmie & Carpenter, 2007) as being one of the challenging issues in the field of economic geography. It has been widely argued in the literature that pre-existing industrial and institutional structures shape the regional environment where economic and innovative activities occur and new ones come into existence (Neffke et al., 2011). This notion may lead to persistence of regional industrial structures and institutional set-ups in the long-run (Isaksen & Trippl, 2014) in which the regional path-dependent development encompasses a tendency to explain the regional industrial evolution by putting emphasis on endogenous factors (Isaksen & Trippl, 2017).

Boschma et al. (2012) debate to which extent the technological relatedness of firms and industries in a certain region can influence the nature and scope of knowledge spillovers among regional companies, and its effect on shaping the new activities that branch out from existing ones. Regional branching explains how new economic activities rise upon the existing composition of industries in a region where industries diversify into new but related activities (Boschma et al., 2012). A certain degree of diversification within firms and sectors can provide favorable conditions for regional industries to branch out into new but related fields where inherited knowledge and skill base embodied in a firm can provide the basis for the related new local paths to rise on existing one (Martin, 2010). Here, local spin-off firms

can inherit the routines and competences from parent firms to develop new products and processes (Martin, 2010). As stated by Martin (2010) "new paths may be latent in old ones, or spin out from existing ones". Moreover, as investigated by Ndonzuau et al. (2002), commercialization of research results through spin-offs can also trigger the emergence of new industries or act as a supplementary condition to flourish the existing structure by creating a new technological trajectory.

Path dependency approach captures the institutional perspective from two sides while regarding institutions as both hinderers and enablers in terms of innovation and renewal processes. From that perspective, accumulation of institutions can underpin the innovation through the increased cooperation, learning and knowledge transfer (positive lock-in) while also they can hinder the progress by being transformed into impediments to innovate (negative lock-in) (Zukauskaite & Moodysson, 2016). Despite the fact that, accumulated competences are persistent over time, the subsystem of knowledge generation and diffusion which includes the regional research and educational organizations, intermediaries and etc. can alter given to a set of reasons such as expanding universities, new educational programs etc. The quality of research organizations can be enhanced over time by hiring new and high-qualified research personal and unfolding new scientific fields (Tödtling & Trippl, 2012).

Path dependence and lock-in are geographically bounded processes where some regions decline due to being trapped into path dependency while some others develop new paths or trajectories (Martin & Sunley, 2010). The literature covers three types of path development; path extension, path renewal and new path creation (Isaksen & Trippl, 2014). Path extension may be created staying within the existing industries and technological paths by incremental product and process innovations. In that scenario, it is highly possible for regional industries to experience stagnation or gradual decline given to the non-existence of renewal (Hassink, 2010). Path renewal denotes the shift of existing local firms to different but mainly related activities and sectors. Thus, related variety in a region can be regarded as a strength to foster the possibilities of path renewal (Isaksen & Trippl, 2014). Finally, path creation is mainly used to refer radical changes in a regional economy and covers the emergence of new firms in new sectors for the region or firms that offer different types of product, adopt new techniques or organize differently than what have appeared in the region up to that time (Martin & Sunley, 2006). Tödtling and Trippl (2012) identify two types of new industries in a region, the development of established firms and the rise of totally new industries. The first one can rely on sectoral diversification of existing firms or inward investment where the second mainly requires the commercialization of research results and establishment of new firms or spin-offs (Tödtling & Trippl, 2012).

Martin (2010) reinterprets the idea of path dependency to lift the borders of the canonical model by considering the notions of "layering" and "conversion" within a local industrial context. Layering refers to a changing mix of firms within a local industry in which the local industry grows and develops continuously through the new company formations such as spin-offs from existing firms, entirely new ventures, or implants from outside the locality. Also, some firms fail and exit the region. Entry or exit of competing entities underpins the variety which is a fundamental principle of evolution. Newly established firms with a comparison to old ones are more likely to embody more advanced techniques, to present competitive and high value-added products. The focal point here is that, changes in the composition of the

population of firms that exist in the local industry trigger an ongoing evolution and further transformation of a whole industry (Martin, 2010).

On the other hand, the notion of "conversion" denotes to change in the characteristics of existing entities within a system and is a key mechanism for evolution. According to the interpretation of Martin (2010), the idea comprises new products, techniques, business organization etc. that are resulted from an ongoing innovation process by firms. Also, the establishment of new firms that adopt newer techniques, different types of products etc. is one of the sources of conversion where they stimulate the spillover effect on pre-existing companies. All these notions can gradually alter the local industry as a whole over a period of time (Martin, 2010).

Regarding the role of path dependency in the different knowledge bases, Asheim and Coenen (2005) draw attention on that, regions which rely on synthetic knowledge base will display a more path-dependent evolution given to the nature of that knowledge base which mainly produces incremental innovations based on the application and new combinations of existing knowledge. Asheim and Hansen (2009) also offer evidence for that understanding and, regard the capabilities of regions that are reliant on synthetic knowledge base are not sufficient to change their established trajectories. However, Boschma (2018) declares many disapprovals to such statements for being lack of any systematic empirical tests.

Isaksen and Trippl (2017) draw four different scenarios in relation to the emergence of new industrial paths by referring to the analytical and synthetic routes of path development. First, studies mainly indicate that core regions are more favorable to foster the formation of new industries given to the analytical forms of knowledge derived from universities and research organizations, other science-based industries, a highly trained workforce, etc. (Isaksen & Trippl, 2017). Therefore, spin-off processes triggered by the knowledge organizations and science-based, analytical industries located in core regions are the main origins for new industries to spawn (analytical route). Second, branching process of traditional industries in core regions might also stimulate the creation of new path which route Isaksen and Trippl (2017) define as the synthetic. Thus, the emergence of new industries frequently is based on an increase of systematic R&D activities, where the infusion of analytical knowledge into the synthetic form of knowledge that is present in the region is essential for that type of path creation.

The third scenario throws attention on the peripheral regions in which the settlement of knowledge organizations (universities, research institutes) or the establishment of analytical firms that moved from outside create ripple effects to increase the dominance of analytical knowledge base. Finally, the development that is mainly based on the synthetic knowledge base for peripheral regions may result from the ripple effects fostered by the settlement of synthetic firms and industries; renewal of traditional and synthetic regional industries (Isaksen & Trippl, 2017). For all cases, analytical knowledge base provides the ground for scientific novelties and thus the path creation. On the other hand, for certain cases, the integration of synthetic knowledge base is also crucial for the commercialization phase of science-based innovations (Asheim et al., 2011b). Keeping that in mind, it is fair to say that innovation and new path development are more likely to take place where a combination of different, related and unrelated, knowledge bases exists (Isaksen & Trippl, 2017).

The basic rationale of the conceptual framework applied in this paper is to understand the process of inclusion of analytical knowledge base to the synthetic form of knowledge for a traditional declining industry and the roles of actors to foster the new path creation. A historical point of view has been adopted to shed light on the industrial evolution throughout the decades.

3 Methodology

This master thesis is based on a case study, the evolution of the textile industry in Borås, to understand the new regional path development process by identifying the distinct phases of path development within the framework of knowledge base approach and to explore the dynamics as well as the endogenous and exogenous driving forces that are influential to shape the new path development by stimulating a shift in the knowledge base. In that matter, a case study is a suitable method for enhancing the understanding of the industry in its real context and over time, and it is a preferred method for the analysis of industries and clusters in general, and for knowledge base and path development notions in particular (Asheim & Coenen, 2005; Boschma, 2018; Isaksen & Trippl, 2017; Martin, 2012a; Martin & Moodysson, 2011; Martin & Moodysson, 2013; Moodysson et al., 2008a; Moodysson et al., 2008b).

During the research, it was intended to collect information to depict how textile sector developed and transformed in the region over the last several decades, how new products and processes were established, which actors involved in the innovation and collaboration network, what were/are the main triggers or impediments for the innovation and what type of role tailored for the region during that process. It is not a chronological order to be explained in series of years, rather the narrative of which institutions emerged and became influential in the path, how they have changed the behaviors of other actors and developed new possibilities for growth and when it happened.

The analysis is developed based on data collected from different sources. For the empirical part of the study, text analysis and semi-structured interviews have been used as main methods for data collection. In that context, three type sources of knowledge laid the ground for this study. First, a review of previous academic studies on innovation processes within textile in Sweden and some other advanced countries, as well as non-academic texts such as reports about the development of textile industry in generally and specifically in the region are included in text analysis which simply refers to the desktop study. This phase mainly generated an analysis of various reports, policy documents, and available statistics.

To understand the general overview and main dynamics of textile industry, the report of the Swedish Textile Industry from TEKO (2015) has been utilized widely. In 2015, TEKO (2015) conducted a sector analysis with its member companies covering 78 companies out of 196 members to explore the main strengthens and challenges of the textile industry. This report has provided the first insight into the industry and drawn a general view of the current situation. Moreover, websites of textile companies and relevant institutions related to textiles, as being main data sources of this study, enhanced our understanding of the industry at first stage.

Second, as the following step of text analysis, publications produced by Smart Textile Initiative (ST), special magazine editions published by ST, interviews given by key people

within the body of ST and context-specific reports such as project evaluation reports of ST Vinnova project have been analyzed deeply to create the narrative of this study. Especially, documents sourced from Smart Textiles and relevant institutions such as publications of Baltic Fashion Project are regarded as reliable. Moreover, Vinnova evaluation reports provided a detailed picture of the progress of smart textiles for the period of 2008-2016 which have also drawn the guidelines for the further development of the industry in the region. Lars-Gunnar Larsson from Vinnova has contributed to the study by presenting the evaluation reports of Smart Textiles project that has been supported in the framework of Vinnväxt program. Project evaluations have been conducted by international experts in a peer review where the team is created by "peers with generalist expertise in innovation systems and cluster development" and "peers with specialist expertise in knowledge development, innovation and commercialization in the specific field for the initiative". Moreover, the evaluation process has consisted of background material, panel review (interviews and meetings with relevant actors), analysis and conclusion (workshops), feedback meeting and evaluation report.

Third, the puzzle regarding the evolution of textile sector and its dispersion process within the region was complemented with the outcomes derived from the interview with the Smart Textiles Initiative which is currently the key actor to strengthen the regional cluster. In that part of the study, desktop research was enhanced by that interview which provides an insight into the applications in the field. The interview was conducted with Linda Venhagen from Smart Textile Initiative who also has duties in Science Park Borås. She has provided a qualitative view of the textile industry in Borås and its evolution.

It has been contacted with several institutions and firms that share roles for the development of smart textiles to arrange interviews including the Smart Textiles Initiative, the Textile Fashion Center, the Science Park Borås, Borås Regionen, Borås Stad, The Swedish School of Textiles, Incubator Borås, FashionInk, the Textile Museum, Vinnova, AB Svenskt Konstsilke and AB Ludvig Svensson. The Smart Textiles Initiative, the Science Park Borås, The Swedish School of Textiles, Incubator Borås, FashionInk and the Textile Museum are situated under the roof of the Textile Fashion Center where they act in strong collaboration and mostly share the same work staff. They pointed out the Smart Textiles as the key actor and the best source for the narrative. Nevertheless, some interpretation stemmed from the informal talks with those shareholders has been included in the study. Whether providing access to documentation or giving narrative regarding the evolution of the textile industry in Borås, they all enhanced this study by offering a diverse point of view.

3.1 Validity and Reliability

To guarantee a high level of validity and reliability regarding the conclusion of this paper, the case study has been developed upon multiple sources of knowledge in order to grasp the many nuances of the industry and smart textiles. In addition, a cross-check has been made between different knowledge sources such abovementioned documents, websites of key actors, news published on websites, and informal talks and interviews etc.

3.2 Limitations

The term of generalization can be used in a limited way in qualitative research (Creswell, 1994) due to the context specificity of case studies where sectors perform in changing dynamics and requirements. Furthermore, the value of qualitative research can be measured based on the particular description and themes defined in the context of a specific site. In fact, particularity can be regarded as the hallmark of a good qualitative research (Creswell, 1994). Therefore, one should be careful before generalizing results to other industries.

4 Empirical Analysis

In that part of thesis, beyond quantitative analysis that gives idea about the general overview of the textile industry, it has been aimed to add a qualitative perspective, derived from expert interviews, evaluation reports and other context-specific documents, to gain a deep understanding on how textile industry created a new regional development path during its historical evolution. It has been applied a knowledge base approach to identify the distinct phases of development. Throughout the narrative of the history of textile industry in terms of its development, challenges and the impacts of the endogenous and exogenous triggering factors on that evolution, the characteristics of the dominant knowledge base have been examined. This chapter explores the transformation process from an institutional point of view and gives the narrative of how the creation of analytical knowledge base has been conducted with the involvement of several key actors.

4.1 Textiles and Clothing Industry

4.1.1 The Definition of Textiles and Clothing

Textile is mainly used to refer to clothes, beddings, and elements of interior design. While it is true to some extent where these components make up a big share of textile industry, sure it is more diverse than this generality. Textile can appear almost everywhere in different forms and even can be a part of the numerous products ranging from small components used by industries in their processes to sails on sailboats (TEKO, 2015). Moreover, the textile and clothing industry encompasses a wide range variety of functions from the transformation of natural (cotton, flax, wool, etc.) or synthetic (polyester, polyamide, etc.) fibers into yarns and fabrics to the production of a great extent of products such as hi-tech synthetic yarns, bed-linens, industrial filters, and clothing (European Commission, n.d.).

In the report from TEKO (2015), the textile industry is simply broken up into three main sectors: fashion & clothes, interior textiles, and technical textiles. Sweden primarily has a reputation for its fashion & clothes and for the Scandinavian design. On the other hand, it also holds a strong position in interior textiles and technical textiles given the production of several niche products. A relatively big part of the exports in the Swedish textile industry is created by fashion in line with the high popularity of Big Swedish brands around the world which are also world leaders in fashion. Interior textile covers a wide range of variety from bed sheets, towels, carpets, mattresses, upholstery, window blinds and curtains to tapestries and sound absorbers. Sweden is also known for its quality of interior textiles relying on a long tradition where carpets have been produced in Scandinavia for centuries. Also, today Sweden

hosts some well-known niche carpet production companies such as Bolon and Kasthall (TEKO, 2015).

Technical textile comprises the products that are produced to utilize for technical and industrial purposes such as sails, parachutes, fire hoses, hygiene products and air filters etc. The technical textile segment provides a large portion of the production value in the Swedish textile industry. Sweden is counted within the world leaders that contribute much to technical textile production in which market Europe producers, especially the northern countries, are dominant. This type of textile production is also a field where strong competition has been felt due to the growth of the technical textile sector in India, Korea, Brazil, and China. Notwithstanding, Europe as well as Sweden are distinguished by their competitive advantage in quality, design, innovation, technology, and high value. Moreover, Sweden puts so much effort to reinforce research in the field of textile. Textile Fashion Centre located in Borås is a good example of that endeavor to create a hub for the interaction of various shareholders in textile research. Moreover, the school has the opportunities of a full-scale textile-manufacturing environment and the laboratories for research and development. In addition, Centre is also affiliated to The Centre of Textile Research (CTF) (TEKO, 2015).

Before the introduction of smart textiles, technical and functional textiles were the advanced textiles of their era. They have included some properties such as being water-proof or protective, but they are not designed to operate themselves due to being in lack of any smart material. Therefore, they are passive. In contrast, smart textiles can response their changing environment by means of an energy transfer which enables them to change. In other words, they perform the ability of processing, analyzing and responding (Dadi, 2010). According to the definition in literature, smart textiles are "*materials and structures that sense and react to environmental conditions or stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources*" (Peterson et al., 2009). Smart textile is an interdisciplinary field where both specialists in information technology, microsystems, materials, and textiles work in collaboration. This new area targets to develop the enabling technologies and fabrication techniques for the economical production of the textile-based information systems (Dadi, 2010).

4.1.2 The Swedish Textiles and Clothing Industry

Sweden was an active member of a broad range of textile production where activities of weaving and printing of all type of materials from interior industry and clothes embraced the large share of the industry. But, the crisis in the 1970s created new challenges for the industry and brought along the several structural changes. In the face of hard competitive conditions introduced by imported low-cost products, local firms had to reconstruct themselves and chose to specialize their production. These structural adjustments created the today's strength and success of Sweden given to its high value-added products. Today, the future success in textile industry lays down within the integration and combination of old and new skills as well as textile and technology (TEKO, 2015).

The report published by Sverige Textil&Modeföretag (TEKO, 2015) defines the main characteristics of Swedish textile industry from history to today by referring to three

keywords; design, flexibility, and sustainability. The word of design symbolizes the world widely well-known Scandinavian traditional design. Flexibility refers to the quick adaptation capability of Swedish textile companies to rapidly changing dynamics of this particular industry. Sustainability represents the presence of long-term aims to achieve continuous development. Nowadays, sustainability of the textile industry is characterized by new fibers and processes, and textiles with functions such as smart textiles. Moreover, it is also the interaction between different industries to keep environmental effect at the minimum (TEKO, 2015).

The Swedish Textile Industry generated a total turnover of 121 billion SEK in 2013 in which main contributors were retail (34%) and wholesale (52%) sectors with a total share of 86%, and production accounted for 12% of total turnover (according to the sector break-down of retail, wholesale, production, and agents) (Figure 2). If one excludes the fashion and clothing to gain a different insight, production would increase its share to approx. 44% of total turnover while being the biggest sector (Figure 3). This result indicates that production of textile products in other sectors such as interior textiles and technical textiles except for fashion and clothes has still been operating to a higher extent in Sweden (TEKO, 2015). On the other hand, manufacturing of textiles is approx. five times bigger than the other fields of production (the production of wearing apparel and manufacture of leather) based on their shares in turnover for 2011 (Baltic Fashion, 2013).

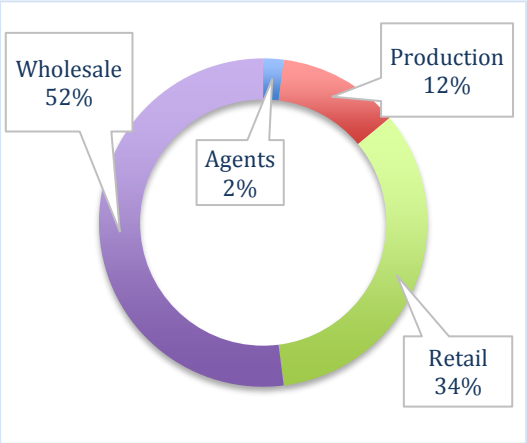

Figure 2 Total turnover, broken down by sector, 2013 (TEKO, 2015)

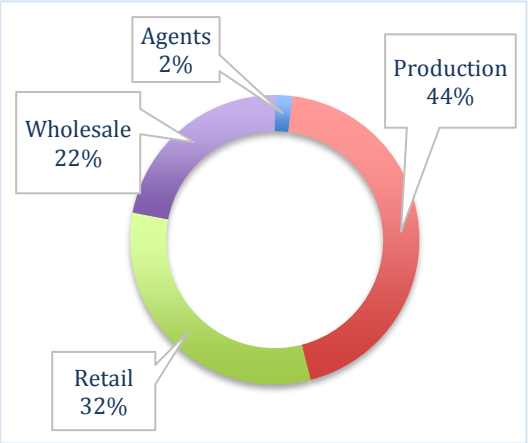

Figure 3 Total turnover, broken down by sector, 2013 (fashion and clothes excluded) (TEKO, 2015)

According to the business structure, 61 percent of companies acting in the Swedish textile industry is covered by sole proprietors where large companies account for a share of 0.2 percent. Sole proprietor companies technically don't have any employees other than business owners. Despite their lowest share within total textile companies, 33 percent of the total turnover is found within large-scale enterprises. The number of micro companies is equal to 35 percent of total textile companies which then indicates that within Swedish textile industry, 96 percent of the companies act with less than 10 employees. Furthermore, the distribution of enterprises in textiles according to their sizes is in line with the general picture of the Swedish enterprises (TEKO, 2015).

The sector has employed 60.130 people in 2013 where the biggest number of employees gathered in retail while production and agents hold the smallest shares, respectively 12% and 2%. According to a comparison between the Swedish textile industry and other industries in Sweden in terms of employee numbers, textile industry counts slightly bigger than the timber and pulp/paper industry and, the food and drink industry but much smaller than the building and construction industry with 2012 values (TEKO, 2015).

The Swedish Fashion industry is popular with its transnational retailers such as H&M, Lindex, KappAhl, MQ and others (Gina Tricot, Dressman, RNB Retail, and Brands). The sector follows a gradual growth trend in exports where it still ranks in steadily developing sectors given to its strong players that have the predominance of retailers. Even though they have their production plants abroad, several factors such as the liberalization of the global trade, revolutionary changes in economies that previously had low-cost labor like China, India and other Asian countries, emerging markets in Southern America, increasing costs of natural resources and transportation costs have been posting new challenges for the further growth of the sector in Sweden. Therefore, nowadays it is possible to catch some debates on the in-source production that had been lost in the 1970s (TEKO, 2015).

Some recent example of in-source production trend is Eton, a Swedish men's shirt producer, which re-opened a small production plant in Gånghester within Borås Municipality to produce a luxury assortment of shirts. The facility is located where before they had a large-scale manufacturing field and the current location of the Eton's head office. However, there is no adequate evidence to believe that a vast portion of the production for the fashion sector will relocate in Sweden. Even for the Eton case, the reason why it has moved back to Sweden was to produce a special segment of high-end products that have buyers at high price levels in the market and therefore it is profitable to sew men's shirts in Sweden (Mouwitz & Holm, 2013).

4.1.3 Textiles and Clothing Industry in the EU

Throughout past 200 years, dynamic changes have been witnessed in the development of textiles (Dadi, 2010). The sector has experienced radical transformations to sustain its competitiveness and shifted towards high value-added products. Textile and clothing sector plays a crucial role in the European manufacturing industry by creating employment opportunities for 1.7 million people and producing a turnover of EUR 166 billion based on the data from 2013. For the same year, 185.000 companies were recorded in the industry which account a 3% share of value added and a 6% share of employment within total manufacturing in Europe (European Commission, n.d.).

About three-quarters of EU production comes from five EU countries that are the biggest producers in the industry; Italy, France, the United Kingdom, Germany, and Spain. Southern countries such as Italy, Greece, and Portugal; some of the new EU countries such as Romania, Bulgaria, and Poland; and to some extent, Spain and France have much more presence in total clothing production while northern countries such as the United Kingdom, Germany, Belgium, the Netherlands, Austria, and Sweden mainly serve within the textile production, especially technical textiles (European Commission, n.d.).

Several reasons such as technological changes, the changes in production costs, the emergence of international competitors, and the elimination of imports quotas after 2004 contributed to the radical transformations in the industry. To be able to stay competitive, companies have led the way to a broad range of products with higher value-added instead of the mass production of simple products. Also, new thinking perspective has been acquired by European Union regarding the industry's clustering strategy. For some certain activities, one can state that cooperation at local, district or regional level is still important while new circumstances make it necessary to adopt a clustering strategy of diversified activities within a wider geographical area (European Commission, n.d.).

4.2 Evolution of Textile Industry: The Case of Borås

4.2.1 Borås: The Capital of Textile

Borås is in western Sweden at the heart of the Sjuhärad country. Given to 1.5 million people who live within a 100 km radius, region that includes Borås can be defined as being highly populated. With more than 106,000 inhabitants in 2014, Borås is the second largest municipality in western Sweden as well as the thirteenth in the country. On the other hand, the city of Borås has 71,700 residents in 2018 which makes it eighteenth in Sweden. Thanks to its closeness to big cities such as Göteborg, Borås is a very attractive place to live and work. Good transport connections with Göteborg and western Sweden strengthen Borås' strategic location. Moreover, Borås is the hub of four national roads, including the motorway between Göteborg and Stockholm. All these advantages explain the reason why lots of companies choose to locate in Borås (Västra Götaland, n.d.).

Today, Borås is mentioned as being the center for design and trade. Also, it has a long tradition and heritage in textile and keeps its reputation by holding a leading position in textile design and development. Borås is the center of Swedish textile and manufacturing industry. Anything related to textile from clothing manufacturers, knitting and weaving mills to manufacturers of technical textiles have a presence in Borås (THS, n.d.). Famous textile and clothes manufacturing chains such as Hemtex, Gina Tricot, SVEA and 8848 Altitude still have their head offices in Borås. Engineering and electronics are other industries that play a major role in Borås' industrial environment where one can find well-known companies including Ericsson, Volvo Bussar and Parker Hannifin (Västra Götaland, n.d.).

According to the official statistics, the number of enterprises operating in Swedish TCL (textile, clothing and leather production) sector is counted as 846 and distributed between the different branches of industry as 509 firms for manufacturing of textiles, 248 firms for manufacturing of wearing apparel and 89 firms for the manufacturing of leather and products. The notion here is that Eurostat Database and Statistics Sweden publish the accumulated data of Swedish TCL business regardless of manufacturing place. Therefore, they include both the production in and outside Sweden. To see the general picture of the industry or to make a comparison of differences at country level in terms of productivity they could be useful but

are not capable to reflect the real situation of companies actively manufacturing in the country (Baltic Fashion, 2013).

Nevertheless, the survey of Swedish apparel manufacturers in 2013 that has been performed within the EU financed Baltic Fashion Project reached the result that there are just 23 companies -all subcontractors in the clothing or fashion industry- that actively produce in Sweden and their total employment capacity is not more than 261 employees (Baltic Fashion, 2013). Of the 23 businesses that have been listed under the project, eight companies are located in Borås and another ten are located in the neighborhood of Borås. Remained five businesses are distributed between Malung (leather) in the north to Halmstad in the south. Based on that evidence it is fair to claim that Borås still hosts the cluster of textile manufacturing enterprises (Mouwitz & Holm, 2013). The only shortcoming of this study is the exclusion of manufacturers of technical textiles which would extend the list of manufacturers.

Given the high representation competence of Borås for the development narrative of the textile industry in Sweden, it has been chosen to explore the evolution of the sector. In that subsection of the study, the textile industry is analyzed throughout decades by applying the knowledge base approach to clarify the analytical and synthetic phases of its regional path development process.

4.2.2 The Early Phase of Development: Origins of Textile and Clothing Industry

Textile can be defined as the first mass-production industry in Sweden as it was anywhere else (Magnusson, 2000). The industrialization of textiles in Sjuhärads district where Borås is located with other several municipalities dates back to 1800s. Regional specialization dominated the main trend in Swedish economy from the end of the eighteenth century onwards (Schön, 1982). Given that tendency, three regions Sjuhäradsbygden, Ångermanland, and Norrköping unfolded into centers of textile manufacturing (Schön, 1982). There is early evidence for that the economy of Sjuhärad region was intensively dominated by household handicraft production which widely expanded in the eighteenth century and grew to encompass a large portion of the population. Sjuhärad district was a center for linen-weaving textile crafts (Magnusson, 2000). Then, linen was gradually replaced by cotton starting from the 1820s, and in the 1870s (Schön, 1982) estimated 50.000 people were employed in textile crafts segment (Magnusson, 2000).

The upturn of the 1850s is followed by the expansion of domestic market and rise of wages. As a result of higher wages, basic industrial products became affordable for a large proportion of the population which factor induced the replacement of home crafts production with purchases. Consequently, all these factors boosted the emergence of a mass market for products including the coarser textiles (Schön, 2012). In a sequence, it has induced the mechanization in production where the 1850s is regarded as a critical juncture for the modern factory system to emerge, especially for the cotton mills and textile industry (Schön, 1982; Schön, 2012).

The period after the 1850s witnessed the structural transition from agricultural proto-industry (handicraft production) to factory manufacturing when modern manufacturing system experienced its initial breakthrough (Magnusson, 2000) which has changed the course of Swedish economic growth (Schön, 1982). Especially in Sjuhärads district, step by step, factories superseded the old rural system and cotton mainly took the place of traditional raw materials such as wool and flax utilized in the area. Afterward, the mechanized cotton-mills were established in increasing numbers. Simple cotton-mills where coarse yarn was produced became the first mechanized factories (Magnusson, 2000). The best-known cotton-mill of that era was the Rydboholms mill built outside Borås in the Sjuhärads region in 1834 (Magnusson, 2000; Schön, 2012). It was the first mechanized weaving mill which followed shortly the breakthrough in the British mills (Schön, 2012). With Rydboholms mill, several others were built in rural areas where formerly hosted the traditional home craft production. While automation accelerated, the processes of spinning and weaving became more integrated which led the factories to manufacture the finished cloth from raw cotton (Magnusson, 2000).

After the early nineteenth-century cottage industry evolved through the spinning of yarn and weaving to sewing following the development of mechanization in the textile industry. The supply of cheap yarn from factories stimulated household weaving while cutting down spinning at home (Schön, 2012). In the 1860s, the dominant production method in Sjuhärads region was household weaving. During the course of expansion in the 1870s, several large factories were established for just weaving or for the combined production of spinning and weaving in and around Borås. Increased dominance of the factory production in Sjuhärads district triggered the transformation of a large textile home craft production region (Magnusson, 2000).

Some of the household workers have switched to knitting and sewing while other parts have participated in the factory production system with new contributions to industrialization (Strömberg, 2010). In line with the rapid transformation in textile production, combined textile mills that operate with more than a thousand workers became quite regular and common while the industry was being widely characterized by largescale production at the beginning of the twentieth century (Magnusson, 2000). New factory system supplied the necessary labor force mainly from the cottage industry situated in Borås or according to Schön (1982) from the handicraft factories in Göteborg that has closed down. Thus, knowledge flows through the labor mobility substantially relied on the recruitment of new workers who have gained experience in same industry.

It was after the 1860s when greater efficiency in factory manufacturing system has led the cottage industry to become smaller in size (Schön, 2012). Notwithstanding, in the competition between the cottage industry and the factories, household work accomplished to keep its existence until 1920 but in a different way with a comparison to 100 years earlier (Strömberg, 2010). Moreover, despite the fact that the clothing industry has experienced its breakthrough in the 1920s and 1930s, sewing at home was still alive (Schön, 2012). The existence of cottage industry in the first part of the 1900s indicates that textile industry in Borås has kept the basic and traditional structure in textile manufacturing in which incremental innovations such the efficiency increases in production and improvements to decrease the production costs are main areas to innovate.

In line with gains in manufacturing, leading agents in cotton industry in the Sjuhärad region, such as P.A. Akerlund and L.J. Wingquist, who early benefited from putting-out system, in which they have supplied their products from cottage industry, invested factories instead to cope with the increasing competition (Schön, 1982; Schön, 2012). Thus, starting in the 1870s, Sjuhärads region and the town of Borås transformed into a center of mechanized textile manufacturing, especially in cotton weaving, rather than a center of house-to-house peddling (Schön, 2012).

Another textile branch was the knitting mills industry which has developed later than the other sub-sectors and was able to reach its peak at the 1940s. In the 1930s, a wide variety of raw materials such as wool, cotton, silk and artificial silk was exploited in knitted textile production. Like the cotton industry, the neighborhood of Sjuhärads with Borås was at the center of the knitted textile industry. During the period between 1930 and 1955, employment in the knitted textile industry enlarged from 8,002 to 8,747, with a peak value of 11,651 in 1940 (Kyaga, 2017). Based on the localization maps of the Swedish textile industry for the years of 1945 and 1958, the manufacture of tricot and cotton industry centrally situated in Borås and Sjuhärad region (Oldenburg, 1963). Furthermore, at the end of the nineteenth century, manufacture of artificial silk had its first industrialization experience in Borås with the establishment of Swedish Artificial Silk in 1918.

From a historical perspective, traditions in the region that are related to the cottage industry have mainly been perceived as a precondition for the development of textile mills (Schön, 2012). As being a textile district, Sjuhärads was also supported by the authorities for town-based manufacturing which has been built on its endowments derived from handicrafts production, especially textile handicrafts, with some other places in the country such as Hälsingland and Ångermanland (Magnusson, 2000). All new mills that started to operate during the 1850s utilized the subsidies provided by Manufakturdiskontfonden (the Manufactory Discount Bank) (Schön, 1982) which is the evidence for the influence of exogenous triggering events to foster the early development of textile industry in the region.

At first stage, cottage industry raised a resistance to factory manufacturing in the period of the early modern factories where industrial outworking achieved to keep its existence for a long time. But it was then the domestic industry tradition has gained more significance to boost the development of the factories, particularly for the example of Borås (Schön, 1982). Heckscher (1954) throws a hint on the continuity from proto-industry to mechanized factories and explains the development of Sjuhärads district and the city of Borås into a center for the textile industry in nineteenth-century by associating it with two main conditions that represent the connection between the domestic industry and the mechanized factories. First of all, the putting-out system adopted in Sjuhärads district shaped the core for the evolution of the modern textile industry and transformed the region into a textile center following the development of factory system (Schön, 1982). The most important condition that had underpinned the growth of domestic industry was the abundance of occupational skills. The existence of occupational skills and dependence upon paid labor created by the domestic industry provided favorable take-off conditions for modern factories to grow upon the old while facilitating the employment of labor force in factories. Second, the first modern weaving mill that was built by a putting-out capitalist, Sven Eriksson, in Rydboholms which

was in the heart of the domestic industry was also important as an initial condition (Schön, 1982).

Vogler-Ludwig and Valente (2009) define the main dynamics of the early development period of Swedish textile industry as being labor-intensive until the transition period in the 1960s where we find the same pattern for the case of Borås. Three main factors define the characteristics of that early development era of textiles in Borås. First, traditions in textile industry gained by household manufacturing were transferred to factory system through the recruitment of labor from the cottage industry. Knowledge flows through labor mobility facilitated the development of mechanized textile manufacturing in Borås. Second, to become more competitive, new methods to increase the efficiency in mass production have been introduced in the form of incremental innovations. The main accomplishments of factory system to cope with the increased competition were the greater efficiency gains and low-cost production. Third of all, the capability of cottage system to sustain itself hand-by-hand the factories just by relying on the simple production techniques presents the evidence for the old, more traditional nature of textile manufacturing. Thus, to some extent, the factory and cottage industry complement each other. Keeping that in mind, one can simply classify the strengths of the region in the traditional textile production and mass production of textile and clothing products for the early phase of regional path development as the general attributes of the synthetic knowledge base.

4.2.3 The Decrease of Textile: Outsourcing of Production

The period between 1930 and 1975 can be defined as the peak years of the industry in which the early 1970s has witnessed the prosperity of textile industry in Borås (THS, n.d.). In the 1930s, Swedish sectors, especially the ones that produce basic products for domestic use such as agriculture, food, textiles, and clothing benefited from the increased self-sufficiency. Given to the decreased international trade as result of war and the profound crisis, protectionism had been prompted widely in the world. The share of imports in domestic consumption for textile and clothing decreased gradually from 30 percent to 20 percent and found its peak point during the war with 12 percent (Schön, 2012).

During the 1930s, Sweden was 100 percent self-sufficient in terms of ready-made production of clothing where 90 percent of local demand for knitted garments was fed by local supply. The company structure for the years between 1930-1950 was characterized by small and medium-sized companies in Swedish clothing industry. In 1955, one of three large-scale companies and the biggest one in terms of the employment capacity with 1,648 employees, Algot Johansson AB, was located in Borås. Other clothing companies ranked respectively as Aktiebolaget Melka (1,544) in Göteborg and AB Schwartzman & Nordstrom (998) in Uddevalla. Moreover, the assembly line system in production was initiated by Algot Johansson AB which was the first Swedish company to apply it (Kyaga, 2017).

In the mid-1950s, Borås was one of the biggest cities with Stockholm, Göteborg and Malmö where manufacturing of women's clothing has mainly gathered around. Almost 90 percent of workers employed in Swedish clothing industry were living in urban areas in which 50 percent were living in Borås, Göteborg, Stockholm, and Malmö. This urban concentration, to

a large extent, can be explained in line with the level of accessibility for female labor that dominated the large share of the textile workers. To refer the significance of Borås in textile and clothing industry, it is important also to note that, Textilradet that was established in 1939 to enforce the linkages between the government and the industry elected its first chairman as Axel Bergengren from Borås Wafveri AB (Kyaga, 2017).

Starting from the early 1930s until the end of the 1950s, the textile and clothing industries as a group kept its place as the second or third largest industrial group in Swedish economy (Kyaga, 2017). However, textile and clothing industry with the food production became the major losers in the post-war restructuring period. Both industries benefited from generous growth rates during the interwar years and almost captured 40 percent of total industrial output while being heavily concentrated on the domestic market. Nevertheless, rapidly growing foreign trade and territorial expansion of industrialization to lower-wage countries hit these industries where textile and clothing industry suffered much more due to severe competition (Schön, 2012).

In 1950, total employment in textile and clothing industry in Sweden was approximately 100.000 people in which two-thirds embodied by women. Within relatively 25 years, in 1975, two-quarters of the labor force lost their jobs which changed drastically the composition of Swedish industry compared to the early 1970s. In the 1970s, textile and clothing industry embodied the 10 percent of total industrial workers in Sweden, but it decreased sharply to only a couple of percent. Borås, Norrköping, and Örebro were the classic industrial towns but after 1975 they have undergone a structural rationalization and rapid deindustrialization (Schön, 2012). The bulk of the production in textile and clothing industry in Borås has moved to other countries to produce cheaper (THS, n.d.).

Johanna Engman (personal communication, 20 April 2018), who works in the Textile Museum of Sweden under the title of industrial heritage coordinator, describes the general situation in Borås with his own words as stated below;

> *"During the 1970s, the textile industry went through a turbulent time in Borås…New international trade agreements were part of the reason why it became harder and harder to produce in an economically sustainable way. The garment industry, that before the crises were very strong here, moved abroad. This was a hard blow to the textile industry in Borås."*

Given to the structural change in the 1970s, the city of Borås has mostly lost its main industrial endowments in terms of the production of textile and clothing. However, a few of the companies were successful to keep their existence in the region. The exit of industries from a region strengthens the local industrial portfolio in terms of the increased technological coherence between existing portfolio members (Neffke et al., 2011). Thus, the more technological relatedness means the more effective knowledge transfer mechanisms which embody the power to embed industries in regional production structure (Neffke et al., 2011). Based on that notion, it is possible to claim that enormous changes driven by exogenous sources that industry undergone in the region have underpinned the technological relatedness which has been supplemented by the survival of technologically advanced firms.

According to Lundvall (2017), learning sometimes can lead to unwanted results and create the situations of "lock-in" which may diminish the economic development of a region or an industry due to obsolete capabilities of what has been learned. Thus, experience-based learning, if it is not combined with other types of information, just can induce incremental change within the existing trajectories. On the other hand, such gradual processes are crucial to absorb the radical innovation and turn them into valuable outcomes. Nevertheless, the old technological trajectory may impoverish the gains of past in the face of new developments, particularly when facing situations of underdevelopment and major crisis. As a matter of fact, it is a necessity to open up new trajectories (Lundvall, 2017). For the case of Borås, the crisis in the 1970s which diminished the growth of textile and clothing industry in developed countries can be regarded as a stimulus for the new path development. Regarding the huge effect of the crisis on companies which forced them to move out of Sweden and especially Borås, it has triggered the creation of new trajectories while indicating the outdatedness of the old regional path. Moreover, as stated by Asheim et al. (2005), it is crucial to point out the effects of globalization to grasp a deep understanding of the dynamics of how knowledge bases that belong to different sectors change over time.

This external shock on the industrial structure of the region symbolizes a radical shift in the course of development where old regional context turned into a constraining factor for the development of the industry. Furthermore, according to the original narrow explanation of path dependence, the process which leads to lock-in could be broken only by external shocks (Simmie, 2012) which notion seems to explain the destruction of old development path of the textile industry in Borås. Nevertheless, this standing point lacks any adequate explanation on how new path creation has been shaped and evolved. For the case of the textile industry in Borås, the clues of new path development can be traced in the knowledge creation process for high value-added textile products which offers a combination of different types of knowledge. Departing from that point, in next sub-section, the field of smart textile as a new technological trajectory in Borås is explained by referring to the changes in institutional setting and the dominant form of innovative activities which is the analytical knowledge base for smart textile.

4.2.4 The New Path Creation: Smart Textiles

The 1970s was a critical juncture in the development of Swedish textile industry when the crucial part of the traditional textile and ready-made clothing industry transferred its production out of Sweden. After that period textile sector in Sweden has evolved through fundamental changes (Peterson et al., 2009). The industry has undergone a severe deindustrialization which gave its first signs in the second half of the 1960s. Nevertheless, for the example of Borås with Sjuhäradsbygden, the textile industry has achieved to update itself in a different form which is, according to Strömberg (2010), more than the legacy of the old.

Sjuhärads region was successful to complete a transition from cottage industry to industrial production as opposed to some other places which entirely lost their proto-industrial production patterns in the 1800s given to several reasons. Today, there is a new transformation period of traditional industries such as shipbuilding and textile industry which were almost eradicated in the industrial regions of Sweden (Strömberg, 2010). Especially,

textile industry by relying on its long tradition which delivers a certain degree of know-how and skill to keep the business alive (TEKO, 2015) has been upgrading itself from simple to complex goods as well as from mass production of standardized products to the flexible production of high value-added, technology-intensive and specialized products.

A survey within the EU project Baltic Fashion in 2013 which aimed to generate the mapping of the production in Baltic countries draws attention on the evolution of the situation of Swedish textile industry. Companies that are operating in this continuously changing market, developed new business models and strategies. For the past decade, the main endeavor has been gathered around on new products and markets and on cost and resource management. The low cost producing countries in the Far East are not competitive to meet the demand for high-tech products and fashion items that need to be presented quickly to the market. Therefore, these two main areas have shaped the strategies of developed economies (Baltic Fashion, 2013). Moreover, starting from the end of the 1980s technical textiles, smart textiles and wearable technology have appeared as new research and development fields of the industry following a radical structural transformation (Alänge & Jacobsson, 1994).

According to Vogler-Ludwig and Valente (2009), the textile industry in Europe, especially for developed countries, creates its new competences within the body of the specialization in high-value segments where more innovative efforts and R&D is required for the product development. In light of this situation, close cooperation between companies and, universities and research institutes plays the key role for the further development of the industry (Vogler-Ludwig & Valente, 2009). The case of Borås, throughout its evolution, can be exemplified for that notion where the institution-building process has played a crucial role to shape the regional development path by increasing the collaboration between industry and educational and research organizations. Johanna Engman (personal communication, 20 April 2018) sheds light on the role of innovation and science driven by knowledge generating institutions which both have led the textile industry in Borås to draw upon the old heritage to flourish the new growth path.

In that study, the emergence of high value-added products in the textile industry located in Borås has been referred to as a new path creation in line with the definition provided in the conceptual framework. The textile industry in the region has found its niche area in smart textiles which refer to the combination of smart materials and integrated computing power into textile applications (Berglin, 2013). The transformation process into smart textiles has occurred through a shift in the knowledge base where science-based analytical knowledge increased its dominance in knowledge generating and innovation activities. In next-coming sub-sections, the roles of the different institutions by referring their effects are detailed to understand how the textile industry has been evolving into an analytical knowledge base throughout last decades. My exploration regarding the new path creation within the textile industry through smart textiles illustrates how the structure of Smart Textiles Initiative has been shaped in a dialogue with several actors including national and regional public institutions and research organizations by paying close attention to the nature of its activities.

The University of Borås and The Swedish School of Textiles

The heritage of textile education in Borås dates back to 1866 referring to the foundation of "Tekniska Väfskolan" (the Technical School of Weaving) which then became the Textile Institute (Textilinstitutet) in 1936 (University of Borås, n.d.). Following the relocation of courses from the Institute of Textiles in the Chalmers University of Technology together with the Textile Engineering Programme to Borås, The Textile Institute was transformed into The Swedish School of Textile (THS) that is a part of the University of Borås in 1982. Over years, the educational system has been updated to meet the demands related to skills and knowledge from the textile industry where textile materials, textile techniques, textile and apparel design have been the main areas to carry out research in THS (THS, n.d.). Today, the Swedish School of Textile has around 900 students and is located in the Textile Fashion Center (University of Borås, n.d.) to enhance the close collaboration with the business community, the industry, and the commercial sector.

Borås has a fairly well-developed analytical knowledge infrastructure with a university and research institutions that embodies specific research competence in smart textiles, and knowledge links through which the university and companies interact are relatively stronger for start-ups and spin-offs. Companies in the region are surrounded by a well-cooperated institutional structure that is qualified in the production of knowledge and skills and in their diffusion and transfer to the business system. Here, public research institutes, technology mediating organizations (initiatives) and educational bodies (universities, vocational training organizations, etc.) are main players that constitute the subsystem of knowledge generation and diffusion.

The Swedish School of Textile has been the pioneer to give inspiration for the development of new path in smart textiles. Nevertheless, in spite of its long history in the region, the origins of that path can be traced back until the late 2000s. The vision of transforming Borås into a center for smart textile has been accepted by taking the advantage of city's textile heritage (THS, n.d.). It has been mainly achieved through the creation of an initiative -Smart Textiles- whose development has been reinforced by local and regional authorities as well as by exogenous sources. The initiative was the key triggering event for the creation of new path given to its role to guide the development and foster the future growth of smart textile in Borås. The idea of Initiative and the guidelines of its playing field have been identified by a core team which has been created with the involvement of the academic staff from the University of Borås. Afterward, they have shaped the management body of Smart Textiles (Venhagen, 2016).

The roles of key actors in new path development with their intentional behaviors to change the regional environment and to introduce new technologies are crucial to drive the change (Miörner & Trippl, 2017). In Borås, the higher education institution has shown the ability to guide the regional industry by generating scientific knowledge and designing education programmes to feed the regional labor market in the direction of smart textiles. Thus, the evolution has first started within the body of the university. Technological advancements and challenges posed by the global markets have triggered the change of educational focus where textiles and fashion have been identified as the prioritized research areas and design, textile technology, and textile management have appeared as new educational fields. Thus, one can

state that the university has performed above meeting the requirements of the industry and created a new field to act in collaboration with the industry.

Asheim et al. (2007) throw attention on that, industries which rely on synthetic knowledge base can flourish regardless of the urban-rural dimension in the existence of conditions for personal interaction such as spatial proximity to suppliers and users. To the contrary, industries, that are characterized dominantly by analytical knowledge where the exchange of scientific knowledge is crucial compared to local buzz, should be surrounded by excellent global connections and located close to leading universities and research organizations (Asheim et al., 2007). By taking into consideration the importance of scientific knowledge in the generation of smart textiles, development of new education programmes and the endeavor presented by the higher education institution to develop its competences in terms of recruitment of new staff and the improvement of research facilities paved the way for a favorable environment. Both regional and non-regional actors including public bodies, policy initiatives, entrepreneurs can create a favorable environment for the further evolution of a regional industry (Dawley, 2014). The case of Borås also owes its development through a new path substantially to regional actors, especially to the University of Borås, where they have put remarkable effort to transform the regional and institutional set-up.

The role undertaken by the university to introduce Smart Textiles as a policy initiative has transformed it into an enabling regional actor for the promotion of the new path creation which has grown endogenously. They were successful in their activities for bringing together diversifying actors from all parts of Triple Helix and channeling resources from various spatial scales under the roof of Smart Textiles. Initiation of Smart Textiles as a new institution for the region facilitated the design of new policy instruments and created a fostering environment by defining an identity focused on smart textiles.

Smart Textiles Initiative

Smart Textiles (ST) is an ongoing a long-run project which is conducted with the involvement and cooperation of companies, research institutes and the Swedish School of Textiles at the University of Borås (Peterson et al., 2009). The Initiative has been founded in 2006 and works mainly in three focus areas; health and medicine, durable textiles and, architecture and interior (Smart Textiles, n.d.). The focal point of departure to introduce the Initiative of Smart Textiles in Borås was to design the region as a milieu for the development of smart textiles. Therefore, the Initiative aims to underpin the infrastructure and to create the preconditions where the textiles of the future will be built on. In that frame, the combination of technical textiles, portable technology, and smart textiles supplement each other to achieve a better outcome within an interdisciplinary environment (Bresky et al., 2008).

From 2006 to 2016, ST has taken part in 452 company and research-driven projects in the fields of health and medicine (incl. sports) (42%), sustainable textiles (28%), architecture and interior design (22%) and, others (8%) (Nejderås, 2016a). Additionally, Smart Textiles has contributed to the development of 60 products and 197 prototypes while acting role as an initiator for 51 business establishments. The segment of health and medicine (incl. sports) covers the materials with medical functions that are applicable to the inside or the outside of the human body. Sustainable textiles adopt an environmental concern for the long-term use of textiles and offer solutions for raw materials, pre-treatment, production, and use. Finally,

architecture and interior design refer to the textile space, textile complexity and textile interaction in relation to the technical challenges (Nejderås, 2016a). ST has been successful to develop larger-scale significant projects of some prototypes (Propris et al., 2015).

Smart Textiles Initiative was financed by Vinnova (The Swedish Agency for Innovation Systems) within the "Vinnväxt – Regional Growth through Dynamic Innovation Systems" programme which aims "*to develop an institutional infrastructure that supports innovation within the renewed industrial structure of the region."* through an innovation system approach. The qualifications of winner defined as "*to qualify as a Vinnväxt winner, the proposed strategic idea must renew the traditional strengths and clusters of its region. It must address them by forming new combinations with other sectors, such as the IT infrastructure, service management etc."* (Vinnova, 2016). Swedish Vinnväxt program has an emphasis on collective learning accompanied by more comprehensive innovation policy approach built on the notions of participation and engagement (Coenen & Moodysson, 2009).

The Interactive Institute's Design Research Unit, one of the contributors of the Smart Textiles project, regards the project as the second building block on their previous research in "IT+Textiles" (RISE, n.d.). To refer to the transformation of the textile industry, it also can be called as "textile industry 2.0" which aims to add a smart function to textiles and strengthen the interaction between the enterprise-driven development project and experimental research at institutes, colleges and universities (Smart Textiles, n.d.). Aforementioned explanations regarding the nature of smart textiles point out a shift in the knowledge base of traditional textile production in Borås where scientific knowledge that is developed with the interaction of diversified disciplines is of crucial importance. First, smart function within textiles requires the knowledge input from different fields and the product development process mainly starts with scientific research. This issue will be touched upon later in detail. Second, attention paid to traditional strengths in the framework of Vinnväxt program requires the enrichment of current industrial structure that has rooted in the history. Given that motivation, public funding and the requirements to sustain this support have enabled the characterization of the evolution. Moreover, Propris et al. (2015) draw guidelines for the further development of the Initiative in the region on more-intensified scientific research which will cultivate the seeds for the new product development process and thus, increase the dominance of analytical knowledge in the long-run. Therefore, policy actions led by exogenous drivers to feed the analytical knowledge base of region laid the foundation for a well-structured development. Additionally, Västra Götaland Region, Sjuhärads Kommunalförbund, Stiftelsen Föreningssparbanken Sjuhärad and other several research financiers also have provided funding to Smart Textiles in varying amounts and in different stages.

Not only at the regional or national level, smart textile is also an extensive research activity at European level where the total funding provided to the EU-projects has reached to the amount of 70 Million Euros that can be defined as a high financial contribution. On the other hand, given the high collaborative structure of smart textiles, the money is distributed between researchers in different fields such as textiles, electronics, wireless technology, battery research and system engineering etc. which complement each other for the new product development (Berglin, 2013).

The activities covered by the Initiative provide an insight to understand the interaction between different knowledge bases for the knowledge creation and innovation processes. As being a part of the University of Borås and the Swedish School of Textiles, Smart Textiles embodied a wide range of facilities to conduct scientific and applied research mainly with the contributions from industry. Initiative delivers a comprehensive concept which has been built on three main phases of product development; experimental research, prototype production and financial support (Science Park Boras, n.d.). Thus, from basic research to prototype development, Smart Textiles boosts the flows of knowledge which is generated in academia to industry. Furthermore, the presence of the Initiative in the region facilitates the inclusion of analytical knowledge which creates an environment that is conducive for the radical innovations. Therefore, the Initiative can be defined as one of the key factors to underpin the creation of new path.

Financial support provided by ST offers funding to develop projects and thus support the knowledge generation process especially for the projects driven by companies. Therefore, ST endeavors to embed the smart textiles in the regional context by promoting the integration with the textile industry and is well-aware of the importance of coherence between the university and industry. Moreover, all facilities that operate under the umbrella of ST serve to satisfy varying needs of industry as well as the scientific research.

The Initiative of Smart Textiles is built upon four main pillars; technology lab, design lab, business innovation, and prototype factory (Nejderås, 2016b). Figure 4 illustrates the interaction among these pillars. All that functions provided by the Initiative actually reflect the innovation characteristics of smart textiles where different knowledge bases create a combination. For example, technology lab was initiated in a cooperation with the researchers in the US and in Bangkok (Propris et al., 2011) and, embodies the analytical knowledge base where new generations of textile products are developed through experimental research across a wide collaboration of disciplines. Additionally, a large number of national and international collaborators of Technology Lab such as the SP Technical Research Institute of Sweden, the Chalmers University of Technology, Department of Materials and Manufacturing Technology, Polymer Materials and Composites etc. reveal the innovation network and geography of smart textiles distributed over long distances and different disciplines which reflect the easiness to convey the codified knowledge regardless of the proximity. On the other hand, Design Lab refers to the symbolic knowledge that we are not interested in this paper. But it is important to note that new expressions of textile design are limited to the possibilities offered by the technology (Bresky, 2013b). Thus, the interaction and flows of knowledge between the Technology Lab and Design Lab are very intensive.

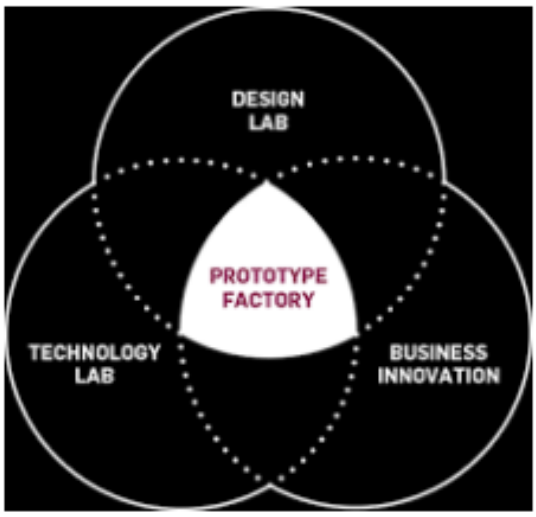

Figure 4 The interaction among three pillars (Smart Textiles, n.d.)

"Prototype Factory", which is at the heart of Smart Textiles, is a relevant example that indicates the way paved for the collaboration between the university and the industry in terms of innovative activities. With the concept of Prototype Factory, it was aimed to create a well-equipped research environment including the facilities of the Swedish School of Textiles as well as the expertise and, to support the companies for the development of new ideas in the field of smart textiles. Prototype factory with its facilities -such as fibre lab, weaving lab, knitting lab, finishing lab, printing lab, sewing lab and media lab- serves for the realization of ideas and the product development through the production where it combines the experimental activities with productivity and mass production (Smart Textiles, n.d.). Each one of these assets -Tech Lab, Design Lab, and Prototype Factory- enforce the open innovation environment (Propris et al., 2011). Within them, Tech Lab and Design Lab are more research and university-driven while prototype factory underpins both the academic and industrial research and combines them for the extension of knowledge. Moreover, the co-location of R&D with prototype production and incubation connects the two crucial phases of innovation processes; (1) from innovation to prototype and (2) from prototype to product (Propris et al., 2015).

Indeed, all these functions conducted under the roof of Smart Textiles Initiative represent each one of the knowledge bases and put evidence for the inclusion of analytical knowledge to traditional textile industry through the production of smart textiles. The need for the generation of industry-relevant R&D and the creation of pipelines for the knowledge transfer between different industries to supplement the analytical knowledge base has been provided by means of the presence of ST. The role undertaken by the Initiative stands for the new path creation where the synthetic knowledge base has been enriched by the analytical forms of knowledge. To understand this notion, three crucial projects that have been implemented with the involvement Smart Textiles are exemplified to gain a deep insight about the network of innovators for smart textile and the interaction between analytical and synthetic forms of knowledge.

Knowledge flows within smart textiles – project examples

According to 2017 statistics, Smart Textiles was in cooperation with 194 stakeholders including the financers of the projects that have been developed to strengthen the position and infrastructure of Smart Textiles (Smart Textiles, 2017). Notwithstanding, it is a huge innovation network shaped by the involvement of various partners that comprises both the providers of analytical and synthetic forms of knowledge such as universities, research organizations, public institutions as well as companies. Smart Textiles is blending a number of research areas such as research into textile materials, electronics and medicine (Propris et al., 2011) where every project has its own unique characteristics (Venhagen, 2016). Therefore, it is important to find the right collaborator that will provide the relevant knowledge and expertise (Venhagen, 2016).

Three project examples are listed below to reflect the infusion of the analytical knowledge base into traditional textiles production;

- ✓ *Water purification;* photocatalysis is a process which includes chemical reactions that are harmful to the microorganisms in the case of interacting light with certain

substances, such as titanium dioxide. A textile which is relatively inexpensive and flexible is coated with titanium dioxide. The idea could be seemed simple, but it enabled the water to be purified and if it is exposed to the sunlight it can function just relying on solar energy. This type of water purification system and suitable form of product for manufacture have been researched in Technology Lab of Smart Textiles. It can be the solution for the challenging issues of our future in terms of the access to clean water (Bresky, 2013b).

- ✓ *Shirt recharges cellphone:* although some materials can convert the movement into electricity, in that project it was achieved by using textile material enhanced with fiber. If it is exposed to movement, shirt starts to produce the electricity. The research was conducted with the contributions from Fiber Technology Team at Swerea IVF (Bresky, 2013b).
- ✓ *The textile disk that will increase the mobility:* mainly a chronic pain in the lower bask is derived from the misaligned vertebrae in the spine. Arthrodesis can be a solution for the pain but also mainly results in decreased mobility. Smart textiles and the medical technology company Ortoma conducted a research to develop soft artificial disk prostheses that will be partly adjusted to be convenient with the individual patient. The product is planned to be generated by using a biological, textile material (Bresky, 2013b).

Aforementioned three projects refer to different collaborative innovation networks in the fields of chemistry, fiber technology, and health while representing the broad research area of smart textiles. Developments in technology open new research areas where textiles can be used in different forms with an increased variety and complexity. Smart Textiles contributes both research and product development in textiles not least at the regional level but also national and international level while changing the main industrial dynamics of Borås region. Here, the role undertaken by the Smart Textile Initiative is the key driver to foster the transformation of the industry and to gather all participants under the same umbrella for a shared goal.

"Ideas for smart textile projects can be research-driven and company driven. If we look at the numbers to compare their account in total, we can say that there is a balance between them. Sometimes companies come to Smart textiles with a clear understanding of how they will develop the idea to product, in that case, Smart Textiles can undertake the role of financer for the projects. But sometimes they have just the idea and we put forward our knowledge and facilities. Nevertheless, regardless of the source of the idea, the generation of smart textiles requires a wide range of collaboration between different institutions act in distinct fields" explains Linda Venhagen from Smart Textiles (Venhagen, 2016).

Moreover, Vinnova Report of 2015 sheds light on the balance between the company-driven project ideas and research-driven projects and their combination within the body of Smart Textiles (Propris et al., 2015). Contrary to the 2011 evaluation which has reflected a skewed Triple Helix model with more weight on the university, now mainly given to the reputation of the Initiative for excellence in smart textiles, one can declare that companies are more closely and more farsighted engaging with Smart Textiles (Propris et al., 2015). This notion also puts evidence for the increased knowledge transfer between the research focused institutions and the industry which indicates a common feature of the analytical knowledge base. Moreover,

ST attracts regional as well as national companies to develop new ideas. Nevertheless, in contrast to the earlier phase of industrial development where innovation and knowledge were created through the synthetic knowledge base, today's picture is radically different given the dominance of research activities and the science-based information. The University of Borås and Smart Textiles Initiative are well-engaged with scientific research and gaining reputation in international area day-by-day while the industry is coming one step back. Instead of producing knowledge in their in-built R&D centers, companies choose to transfer knowledge from research organizations but they are well qualified in production techniques and different applications of textile which is evident from the list of company-driven projects published by Bresky (2013a). In line with the increasing reputation and developing competences within ST, links to international partners have been intensifying. The innovation network of smart textiles is distributed over long distances covering universities, research organization, companies which is evident from the collaboration network that covers 194 shareholders just for 2017.

Nevertheless, companies located in the region hold the lion's share based on the participation rate to the projects which are developed with the involvement of Smart Textiles in a comparison with companies outside the region (Venhagen, 2016). Additionally, despite the research-driven nature of smart textile, high personal and face-to-face interaction between shareholders is rather intensified in contrast to the main dynamics of analytical knowledge base where codified knowledge is less-sensitive to proximity and space. Moreover, it has been several times also stated during the interview with Venhagen (2016) that the most important achievement was the establishment of Textile Fashion Center in which all partners have located in close cooperation. The Center has opened its doors in 2014 and today is the primary meeting place for the partners of smart textiles in the buildings of old factories. Venhagen (2016) defines the main innovation network of smart textiles as intensified in the region in a comparison to national and international partners. This notion was also taken place in the report of Vinnova (Propris et al., 2015) by pointing out the need for fortifying the international collaboration with distant knowledge generating organizations and for the creation of new partnership areas by means of involving in Horizon 2020 research projects.

In contrast to the dominance of analytical forms of knowledge, geographical concentration of innovation activities differs from the main understanding of analytical knowledge base for the case of Borås. Notwithstanding, intensified network activities of innovators regarding the creation and transfer of knowledge at regional aggregation level can be explained by taking into consideration the uneven geography of innovation of analytically based industries in line with the explanations by Asheim and Gertler (2005b). They state that, as touched upon in the theoretical section, industries that rely on analytical forms of knowledge are also spatially concentrated as much as the other forms of innovative activities that belong to the synthetic knowledge base.

Despite strong interactions prevailing between the Smart Textiles and the industry, Propris et al. (2015) draw attention to insufficient networking opportunities for a spontaneous dialogue to establish cross-company cooperation within the regional industry. The transfer of tacit knowledge requires face-to-face interaction and personal communication that is built on trust. Moreover. cognitive proximity which performs at the highest level among the actors that belong to the same industry makes it easier to transfer knowledge between companies. The

acquisition of knowledge for industries that act on synthetic knowledge base where the dominant form of knowledge is tacit, mainly relies on knowledge sources which are less formal such trade fairs, exhibitions, thematic workshops etc. But, companies in Borås region cannot benefit from knowledge transfer opportunities which include greater potential for cross-company partnership due to the weak culture for inter-firm cooperation. It is evident from the Vinnova report that knowledge sourcing regarding tacit forms of knowledge is not well-established in the region. This notion also indicates the dominant character of the analytical knowledge base in the regional industry given stronger ties among university and companies.

Keeping in mind the above-mentioned networking activities in smart textiles, knowledge transfer mechanisms between the actors in regional context mainly take place between knowledge generating institutions where the patterns of inter-firm interactions are not visible. Moreover, despite the dominance of codified knowledge, key actors still put importance on the personal communication which is also highly intensive between shareholders. Therefore, one can postulate a discussion on that the interaction between different knowledge-bases can reveal mix patterns of knowledge sourcing and acquisition. But, it is not interest field of this particular study to discuss the characteristics of knowledge bases rather understand their effects on regional industrial development.

New Companies vs. Old Companies

Textile Fashion Center has been the flagship of smart textiles in the region where it has built a combined concept of research, education, and business with a wide range of facilities including the Science Park Borås, InkBorås and FashionInk (incubators for start-up companies), Textile Museum, and The Swedish School of Textiles. The project covers a wide range of shareholders from society, academia, and industry where the ownership of the institutions is diversified. For example, as a strength to serve for the future creation of smart textile industry in the region, the Science Park Borås is owned by the University of Borås while the ownership of the Incubator is retained by the City of Borås (O'Mahony, 2018).

The early phase evaluation report of Vinnova points out that there are just a few companies survived the structural change, but they are mainly strong and internationally successful. On the other hand, some new companies are doing remarkable work for the development of textile industry. Nevertheless, Vinnova report of 2011 states that while ST offers strong capabilities in inventions and in generating prototypes, commercialization side is very weak and lack of expertise. One of the focal points appeared in 2011 report was the need of upgrading the local textile cluster by means of start-ups and spin-offs of innovative firms and channeling new ideas to entrepreneurs (Propris et al., 2011). Today, Science Park and the Incubator both act upon supporting the commercialization of newly developed products and the formation of new companies under the roof of Textile Fashion Center in a close collaboration with the other facilities of ST. InkBorås -a specialized incubator in the fields of technology, textiles and fashion- assists start-ups for further business development and presents the office facilities, studio, machinery plant and other related infrastructure where start-ups have the opportunities to be in close touch with partners. Technical and commercial networks supported by financing options promote the networking activities inside and outside the region where both analytical (codified) and synthetic (tacit) forms of knowledge find an

arena to interact. Services related to incubator supplement research activities and complete the process which leads from idea to market, therefore, serve to underpin the transformation of regional industrial structure into smart textiles by means of new company formations. Introduction of supplementary organizations such as incubator and science park has speeded up the incremental processes of adaptation of institutions within the regional framework while strengthening the position of the Initiative by accumulating more institutional power.

For the 2006-2016 period, 51 business establishments were initiated by means of ST where in 2017 it was just 4 new companies. According to the evaluation of Vinnova, the close collaboration between the incubator and research facilities is crucial to convey the prototypes to market. Nevertheless, despite the increasing number of far-reaching research-driven projects, the count of start-ups and spin-offs is not sufficient to meet the supply of prototypes (Propris et al., 2015). Rickne and Jacobsson (1999), in their analysis, point out the role and the importance of new technology-based companies for the industrial renewal of Sweden which are relatively bigger than the contribution provided by the diversifications of established firms in the generation of new economic activity. According to Venhagen (2016), the same explanation is applicable to the case of Borås where ST actively works to increase the number of new companies to open fields for the newly developed products where new technology-based companies have been the flagship to embed the smart textiles within the regional industrial structure.

On the other hand, one of the main achievements has been experienced by ST which is evident from the 2015 report is that the share of company-driven projects has been augmented. This result points out the stronger relations with the industry, increased knowledge flows and widened innovation network. Additionally, the presence of strong actors that belong to the business world in the Steering Group of ST (such as IKEA and the Södra Älvsborg Hospital) enhances the engagement and to some extent secures the commercialization of prototypes (Propris et al., 2015). Furthermore, there are also old companies which are the representatives of the traditional textile production in the region that have driven projects within smart textiles (Venhagen, 2016).

For example, AB Ludvig Svensson in Kinna, just outside of Borås, has managed to survive the change of the 1970s. Curtain production had formed the foundation manufacturing field of the company which has then evolved into the production of technical textiles for the greenhouse cultivation in which today Svensson is the world's leading producer (Svensson, n.d.). The 70 percent of the company's annual turnover is generated by the climate-controlling screens for greenhouses which are technologies that regulate the temperature, humidity and UV radiation in a high degree of precision (Nejderås, 2016c). The company has been in partnership with ST for several projects based on the list published for company-driven projects (Bresky, 2013a). Now, climate-controlling textile as a material for curtain production is a newly developed technology area (Nejderås, 2016c) which can mean a return to their traditional production activity with a smart turn. Additionally, the early adaptation of firm to technical textiles is also a facilitating factor for the transition to smart textiles.

Another company that is one-century-old is AB Svenskt Konstsilke (SKS) located in Borås which was one of largest cell wool and artificial silk companies in 1948 (Kyaga, 2017). The company has been founded in 1918 as a viscose spinner and has been successful to develop

itself as a producer of high-performance yarns in the industrial scale (SKS, n.d.). Urban Olsson, the CEO of SKS Sweden, (personal communication, 26 April 2018), explains the core business of the company as the supply of engineered products where they have some business activity in smart textiles. SKS appears several times in the list of ST company-driven projects mainly related to conductive fibers and yarn treatment (Bresky, 2013a).

Abovementioned companies have been referred by several institutions including ST as case studies which stand in the forefront for the adaptation to new technological circumstances. Even, SKS has taken part in the former Steering Group of ST to strengthen the industry-academia interactions. Both companies conducted several projects in a close collaboration with the university, ST and other research organizations. Involvement of scientific knowledge generating institutions to the innovation network of companies puts forward clear evidence for the infusion of the analytical knowledge base. Moreover, the innovation creation process for smart textiles which has been detailed in earlier sub-sections requires knowledge transfer between different disciplines and starts as a scientific research project. Therefore, engagement with smart textiles is highly interrelated with the increased collaboration with universities and research organizations. Nevertheless, Venhagen (2016) states that transformation of old companies into smart textiles is very limited in terms of both the number of companies and the share of smart textile in total business activity. Therefore, it is of crucial importance to develop the wherewithal to support routes to market for research-driven projects by increasing the number of new companies which notion is in line with recommendations from 2015 report of Vinnova.

4.2.5 Further Discussion and Results

As it has been approved by several studies, the innovation character of old industrial regions is incremental and innovation activities often progress along mature technological trajectories where the dominant form of innovation is process improvement rather than systematic efforts to develop (radically) new products for the commercialization (Trippl & Tödtling, 2008). Nelson and Winter (1977) by analyzing the development of the DC3 aircraft programme during the 1930s which has been incremental and long-term progress put forward evidence for that the problem-solving activities of engineers were not able to create changes and were remarkably stable over time. Engineers were oriented to solve particular problems and notified by certain ideas that could be a solution to the problem. Thus, the behavior of firm consists of a combined set of technological routines which they have defined as a technological regime and a barrier to new path creation (Nelson & Winter, 1977).

To Zukauskaite and Moodysson (2016), firms that rely on the combination of analytic and synthetic knowledge bases are more promising to create radical innovations and thus to trigger new path creation. An environment supported by the institutional incentives will facilitate them to collaborate with a university, apply science to traditional industry and introduce value-added products (Zukauskaite & Moodysson, 2016). In their analysis, Zukauskaite and Moodysson (2016) examine the development of the food production industry in Southern Sweden as being an example of new path creation by referring to high value-added products with health benefits. Their main argument on functional food relies on the infusion of analytical knowledge into the synthetic knowledge base which has been regarded

as the main driver of development within the new path (Zukauskaite & Moodysson, 2016). Food industry shares some commonalities with textile industry as being an example of a traditionally strong but declining industry. Moreover, both industries have been experiencing a phase of renewal. Another well-known case for the combination of knowledge bases is the automobile industry (Boschma, 2018). The industry has been traditionally dominated by synthetic and symbolic knowledge bases referring to the engineering activities and design of cars. But the technological developments in the fields of computer-led mechanization (robotics) and the self-driving cars (sensor-based safety systems. communications systems, high-resolution mapping) indicate a clear shift to the analytical knowledge base (Boschma, 2018).

Building on this explanation, smart textile opens a new era before the textile industry where scientific knowledge flows gain dominance for the product development. Analytical knowledge base underpins the creation of high value-added products while creating a new path to overcome the challenges posed by the old traditional textile production. Vinnova, by referring the other clusters in Europe, regards the Smart Textiles as a potential for the renewal of the industry and highlights the need to smart-up the textile cluster (Propris et al., 2011). Thus, a transformation to high tech and high value-added textiles is crucial for the survival of industry in the future (Propris et al., 2011) which requires the infusion of analytical forms of knowledge to the synthetic knowledge base of the textile industry.

Despite the fact that the importance of synthetic, analytical and symbolic reasoning, principles and evaluation criteria differs for specific business domains such as research, production, marketing etc., Manniche (2012) throws attention on that knowledge bases cannot be adhered to specific knowledge domains or institutions. To be defined as "analytical" for the knowledge dynamics, it is important to follow (more or less strictly) scientific principles regardless of the location where knowledge is generated if it is within the body of a university or R&D department of a company. Furthermore, the character of knowledge can change several times within the course of innovation (Manniche, 2012). Departing from that point, this study analyzed the activities and the structure of Smart Textiles Initiative which strongly reflects the knowledge generation characteristics of smart textiles.

For smart textiles, the innovation process can start at university with researchers or at a company. Here, the basic rationale is that, research institutions and companies should accompany each other for the creation of new knowledge where both analytical and synthetic knowledge bases are crucial. But, a new idea which will lead a product in the market emerges from analytical knowledge base activities to answer questions related to the nature and applicability of materials (the science of materials) or the functioning of information-based technologies (the science of technology) which is embedded within textile substances. The main driver for the idea development, as highlighted by project examples, is mainly sourced from technological and scientific advancements to create better solutions for diversified application areas. Synthetic knowledge becomes important in the phase of searching for the relevant product structure which is more acceptable for manufacturing techniques. In that case, the initial aim is to develop a new product at the intersection of science and industry (Moodysson et al., 2008a). Furthermore, the design of the product which offers increased ease-of-use for the customers provides the symbolic knowledge base.

Referring to the classification of Isaksen and Trippl (2017), the textile industry in Borås has been developing a combination of different characteristics from three main ways to emerge a new industrial path. First, university and research organizations enhance the flow of analytical knowledge and create ripple effects. Here, also the support of exogenous factors such as Vinnova is crucial to foster and strengthen the institutional building. Nevertheless, contrary to the Isaksen and Trippl (2017), university settlement dates back, so the main driver is not the arrival of the university but the establishment of collaborative organizations such as the Smart Textiles Initiative. Second, another factor that indicates a pattern of development based on the analytical knowledge is the emergence of spin-offs from knowledge organizations (universities, research institutes) and new analytical firms. As stated by Venhagen (2016), the transformation of the textile industry in the region is mainly underpinned by the formation of new companies that rely on smart textiles.

Finally, and third, renewal of traditional, old synthetic firms in the region through more R&D effort is noteworthy. Companies that have been founded almost more than one century ago are performing to integrate with the production of smart textiles where they involve in innovation projects with the participation of different shareholders from analytical institutions. Even, they undertake the role of project manager and generate the idea to create new products. Nevertheless, despite the far-reaching number of research-driven projects, the transformation of the industrial side can be regarded as slow and is still in its initial phase. The share of smart textiles products in total production capacity is limited. Moreover, given the structural change in the 1970s textile industry is dominated by small-sized companies and the manufacturing infrastructure mainly moved out of the country. Based on that reason, production is organized in small sizes.

On the other hand, results are, to some extent, in line with the theoretical expectations where the interaction between analytical and synthetic forms of knowledge leads to the rise of new industrial paths. Therefore it also puts evidence for the importance of importation and diffusion of new organizational forms, radical new technologies, industries, firms or institutional arrangements as stated by Martin and Sunley (2006). But with a difference that, for the case of Borås, instead of direct importation from outside, the capacity to generate and foster the scientific knowledge base has been supported by endogenous endowments. Venhagen (2016) also states that the formation of the Smart Textiles has been triggered by a team inside the university, it was later when exogenous sources have acted to flourish the new path creation in the form of financial and visional support such as the one from Vinnova where the development is enforced heavily by public funding. Thus, the upgrade of local institutional setting for the knowledge generation in the light of technological and market requirements has driven the evolution of the textile industry in Borås. The above-mentioned triggering events that can be classified as either endogenous or exogenous have led the shift between two knowledge bases and summarized in Table 2.

Table 2 Summary of new path creation (from synthetic to analytical phase)

Key Actors	Triggering events	
	Endogenous	Exogenous
The University of Borås Smart Textiles Initiative Science Park Borås Borås Incubator Old companies Vinnova	Change of policy focus and new vision adopted by University of Borås Initiation of Smart Textiles Inflow of science-based knowledge generated within the body of ST and University Establishment of Science Park Borås and Borås Incubator for new company formation Transformation of old traditional companies into smart textiles	Public Funding from Vinnova Integration to policy framework of Vinnväxt

Taken together, the region of Borås today is at the forefront of smart textiles given the advanced research facilities and the strong institutional setting that lay the ground for the collaboration among regional, national and international wide shareholders. New path creation is substantially supported by regional policy framework and local institutions take possession of the progress. Nevertheless, the development of smart textiles is an ongoing process and especially from the industrial point of view, it is an early phase to define this new path as the main characteristic of the textile industry in the region.

5 Conclusion

The primary objective of this study is to understand the new industrial path creation and development by unfolding the different characteristics of development phases given to the knowledge base approach. This study aimed to enhance our understanding on how evolution process acts and what type of dynamics are influential to create a new development path for a traditionally declining regional industry, namely textile industry, in light of new challenges posed by the severe global competition and increased demand for high-tech products. The regional industrial development has been identified in two distinct phases, synthetic and analytical, where the notion of knowledge base provides us a deeper understanding regarding the functioning mechanisms that drive the change. Beyond defining the general characteristics of synthetic and analytical phases of development, the study sheds light on the endogenous and exogenous driving forces and the key actors of the evolution process by relying on a historical perspective, thus offers explanation for the questions of how a regional industry evolves from one knowledge base to another and how it built on the pre-existing structure through a new regional path.

The theoretical framework built upon the knowledge base approach and the notion of regional industrial path development has been applied to the textile industry in Borås. Borås has been home for the Swedish textile and clothing industry where the roots of the industrial development date back to the 1800s when products have been produced within the system of home crafts production. With the emergence of the modern factory system, home crafts production was superseded by factories but kept its existence after even the 1900s (Schön, 2012). The period, between the 1850s when the structural transition to factory manufacturing started and the 1970s after when a deep crisis diminished the textile production in Sweden as well as in Borås, is characterized by synthetic knowledge base which is the typical form of knowledge for the textile industry. Knowledge flows existed among the regional companies where innovation is derived from the novel combinations of existing knowledge. Mass production, efficiency increases, and cost gains were the main improvement areas in terms of product and process development. Traditional heritage of textile industry has shaped the identity of the region even after the outsourcing of production to low-cost countries.

In the last 2-3 decades, the textile and clothing industry in Borås, as well as the other regions in Europe which had traditionally organized dense industry clusters with substantial manufacturing operations, have undergone a heavy restructuring process. Manufacturing capacities have been significantly downsized and the substantial part of employment has been lost. New competences to find niches and high value-added strategies have been main agenda of companies to survive and stay competitive (Propris et al., 2011). On the other hand, exit of industries from a region may strengthen the local industrial portfolio by increasing the technological coherence between existing members (Neffke et al., 2011) where a significant skill, knowledge and technology base is needed to form the basis for the emergence of innovation clusters (Propris et al., 2011). In that environment, actors in an innovation chain

such as education, research and technology providers, industry and demanding customers which benefit from each other are necessary parts of that system.

Paths of regional industrial and technological development mainly have their roots within the old ones where the local inherited knowledge and skill base can lay the ground for the rise of related new local paths. New industries can build their competences on the knowledge resource base created by existing local industries. Ultimately, local industrial evolution is an adaptation process to changing environment and market conditions (Martin, 2010). Departing from that point, heritage of long tradition in textile production and local industrial connections to technical textiles have facilitated the initiation of smart textiles in Borås where regional industry has adjusted itself to new competitive market structure.

For the case of Borås, competences to stay competitive for a declining traditional industry have been developed by bringing the university research into the textile industry and the gap between the academia and industry has been filled by the Smart Textiles Initiative. The Initiative has created an environment for the interdisciplinary collaboration where the facilities such as tech lab, design lab and prototype factory contribute to enriching the research infrastructure. Historical background of regional industrial development reveals the sequence of accompanying triggering events to change the pre-existing structure and to induce the shift in industrial knowledge base where scientific knowledge gained dominance over time in line with the well-knitted position of Smart Textiles Initiative and the University of Borås in the regional context. While it was a firm-driven regional industry in which synthetic form of knowledge was dominant, an evolutionary process has taken place where the industry has been increasingly depended on an analytical knowledge base, and thus knowledge organizations and their scientific knowledge. Despite the fact that the structural change during the 1970s has uncovered the outdatedness of old regional industrial development path by throwing a diminishing effect on regional industry when a radical break occurred within growth pattern, the new path creation can be traced much later where it coincides with the introduction of ST and thus the inflow of analytical forms of knowledge after the 2000s. According to the findings of this study, the infusion of analytical knowledge to the synthetic form of knowledge was crucial for the new path creation within the textile industry in Borås. The basic rationale to trigger the development process into new path creation relies on the combination of different kinds of knowledge, heavily on the analytical knowledge base which is in line with the theoretical expectations.

The evolution of different knowledge bases and the dominant type of innovation (radical or incremental) are heavily conditioned by past economic structures. While the synthetic form of knowledge is more favorable for incremental innovations, the analytical knowledge base is more likely to response radical innovations (Boschma, 2018). The case study of Borås, given the competences gained through the inflow of scientific knowledge, paved the way from incremental to radical innovations with a shift in the type of dominant knowledge base. Therefore, the combination of two distinct knowledge bases has created an enabling environment for the new path creation which has been supported by the roles of key actors. This notion also delivers empirical findings for the combinatorial approach which claims that regions endowed with more than one knowledge base are apparently more qualified to prosper. Moreover, results are in line with the hypothesis by Asheim and Hansen (2009) in which they state that specific characteristics of knowledge bases matter for the ability to

change the technological trajectories, and industries that act upon analytical knowledge base operate in a more favorable environment for radical innovations to flourish.

The development pattern of textile industry recalls the notion that "more likely today that it is the available knowledge base and institutional set-up that matter" as stated by Malmberg and Maskell (2006). Moreover, it is evident from that new growth paths have their roots in the historical economic structure of a region and study contributes to the understanding of how combinatorial knowledge bases is conducive to regional path development. Nevertheless, existing institutional configurations might be both enablers or hindrances for the emergence of new paths (Martin & Sunley, 2006). The University of Borås and the Swedish School of Textiles have located in the region for decades. But it was after the introduction of Smart Textiles Initiative since when scientific knowledge has been integrated into the innovation process of textile products. In that case, existing institutional configuration has transformed itself into a new institutional setting by adopting a policy perspective with more focus on collaboration and scientific knowledge where it has fostered the new path creation. While Isaksen and Trippl (2017) throw attention on the settlement of knowledge organizations (universities, research institutes) or the establishment of analytical firms that move from outside in their scenarios for the emergence of new industrial paths, the case elaborated in this paper, differs where the key actors that play role in reconfiguration and characterization of regional environment to create the favorable conditions for new growth path have resulted from endogenous efforts to transform the existing structures into more enabling ones. Therefore, this result confirms the view from the literature that new growth paths are more likely to come out from endogenous factors and mechanisms instead exogenous shocks as a source of new path creation.

Local institutions and human resources that have developed given to the industry's historical development in the region acted as critical causes for the creation of new path. Furthermore, the vision adopted first by Smart Textiles and then supported by Vinnova has generated the force to create the transformation of the industry in the region. By channeling public funding and drawing the main guidelines for the further development of innovation network of smart textiles, Vinnova has acted as a supplementary exogenous factor to underpin emerging regional context.

Building upon on these initial conditions, Science Park Borås and Incubator have created a more enabling environment for the growth of the smart textiles in the region by complementing the research activities. Given the far-reaching number of research projects, generation of scientific knowledge and research activities overweight where adaptation of old companies into the new path in terms of systematic R&D activities is limited to some companies. Nevertheless, smart textiles production within the body of one-century-old companies is an indicator to show the way paved for the development. In that context, new company formation and start-ups are more influential to trigger the regional industrial transformation which is to some extent expected in line with the strong position of university and ST that substantially increase the dominance of analytical knowledge.

Taken together, for the case of Borås, the evolution of the historical conditions into new technologies (high value-added products) has triggered the emergence of the new path within smart textiles where regional strength that comes from the history has laid the ground for the

new path creation. Inflow of analytical knowledge into synthetic knowledge base has formed a new path into smart textiles where three triggering factors induced the change; first, establishment of collaborative organizations such as ST, science park and the reconfiguration of institutional setting; second, spin-off processes triggered by the knowledge generating organizations as being the main origins for new industry to spawn; third, renewal of traditional, old synthetic firms in the region which is relatively late-comer compared to the other factors. Due to the low upward extension of diffusion of R&D efforts into the industrial side, the level of new path creation can be regarded as progressing in the early phase of its development. Vinnova reports also highlight the minimal impact of ST for upgrading the existing local textile production through the high value-added products and draw the guidelines on policies to facilitate start-ups and spin-offs of innovative firms and to design the channels for the hand-over of new ideas to interested entrepreneurs. To put in a nutshell, the study enhances our understanding on the different forms of regional path development in relation to knowledge bases by focusing on the role of history.

5.1 Future Research

A future study, in addition, should be conducted to include the symbolic knowledge base which will shed light on the fashion concerns of customers and how the industry works to reply these expectations regarding the limitation derived from technological possibilities. In a narrow perspective, focusing on wearable technology can enhance our understanding on the combination of three different knowledge bases for a traditionally declining industry which is in a renewal phase.

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Appendix A

Interview Questions: Smart Textiles Initiative

1. How is Smart Textiles Initiative shaped in the pre-existing structure?
2. Which actors are involved in that process?
3. How can you define the role of the university in that creation process?
4. How can you define the contribution of Vinnova in the development of smart textiles in the region?
5. Can you explain the implications of the transformation regarding the contributions from the old traditional companies and new company formations?
6. To what extent does the existing industry adapt to new products in the field of smart textiles?
7. Can you make a comparison between the company-driven and research-driven projects?
8. Can you provide information about how the cooperation is established to develop a project within the body of Smart Textiles?
9. Can you compare the share of companies inside and outside the region?