1 The growth of service-driven businesses of industry 4.0

The German manufacturing industry represents 25% of the German gross domestic product (GDP) which is higher than for any other European countries between the years of 2009 and 2011 (Bauer et al. 2015; Brettel et al. 2014; Matthiae and Richter 2018). This high industry percentage convinces German institutions to invest into the implementation of industry 4.0. The reason is that the "German gross value can be boosted by a cumulative 267 billion euros by 2025 after introducing Industry 4.0" (Bagheri et al. 2015, p. 1622; Lee et al. 2015, p. 18) and "by estimating that until 2025 the benefits of Industry 4.0 will have contributed as much as 78 billion euros to Germany's GDP" (Amaral et al. 2019, p. 1104). Especially, between 80% to 100% of manufacturing will apply connected devices until 2025 and thereby, productivity will increase between 2.5% to 5% and revenue will increase by the introduction of new business models (Monostori et al. 2016). All in all, cost savings per year of 900 billion dollars to 2.3 trillion dollars will be expected by 2025 (Monostori et al. 2016). Due to these financial potentials, industries and governmental institutions invest into the implementation and execution of industry 4.0.

The goal of industry 4.0 shall increase profitability and competitiveness of the manufacturing industry (Madsen 2019; Mitsuyama 2019). Further, the concept of industry 4.0 shall help the productivity of workforces to balance between the growth of elderly people and the decrease of birth rates (Mitsuyama 2019). The focus is set on establishing digitalization and automatization of production processes in the manufacturing industry (Li et al. 2019; Rejikumar et al. 2019) while having an "extensive integration of information systems, digital services, and Internet-based technologies" (Geißler et al. 2019, p. 1). This results in a change on how products and services will be produced, delivered, served, and reused (Koh et al. 2019).

This further has influence on the supply chain management (SCM) as current supply chains still focus on pure standardized production processes (ten Hompel and Henke 2014). Additionally, new business models and new services will be developed which will implicate changes in the life cycle and in the value chain of industry 4.0 (Monostori 2014; Monostori et al. 2016; Posada et al. 2015; Shafiq et al. 2015; Stock and Seliger 2016a; Tantik and Anderl 2017). Especially, high flexibility and high amount of data will affect the demand for new business models and new services (Roy et al. 2016). Hereby, the products will become service-oriented products by which customers will have influence on the development and manufacturing process to increase the degree of customization (Stock and Seliger 2016a). As a result, the economic will change from production of goods to services (Demirkan et al. 2008; Juntumaa et al. 2009a). Therefore, the economy will be increasingly growing by services (Lê 2011). In fact, "projected economic and job growth through the 21st century is expected to be dominated by services" (Botta-Genoulaz and Millet 2006, p. 202). Due to the influence of high-valued services (from the development, production, sales up to the end of consumer marketing for diverse products and branches), services will become the main focus of industry 4.0 (Brentani 2003).

1.1 Motivation and problem statement

A new structure of SCM and moreover, an increase of services within various business models and processes will be expected by the development of industry 4.0. Approaches and implementations for developing towards industry 4.0 have been initiated by research and companies (Gabriel and Pessl 2016; Kreilkamp et al. 2016). For example, the concept of industry 4.0 was one of the most important topics of the World Economic Forum in Davos in 2016 (Hamdi et al. 2019; Madsen 2019).

However, “until full implementation, it will probably take a long time. Experts disagree and talk about a period of up to 20 years” (Gabriel and Pessl 2016, p. 136). Industry-related research identifies that there is a slow progression towards industry 4.0 (Rennung et al. 2016). Reasons like isolated systems and machines (Toro et al. 2015), unclear financial achievements or missing educated experts (Mohamed 2018) cause such a slow progression towards industry 4.0. Even if German companies are informed of industry 4.0 (Tupa et al. 2017), “the examination of organizational and management aspects of Industry 4.0 is still in its infancy” (Horvat et al. 2018, p. 129).

To counteract such uncertainties and to support the growth of industry 4.0, politics and industrial partners launch the platform industry 4.0[3] to develop and to provide recommendations for introducing, implementing, and executing functionalities of industry 4.0 products, processes, and services.

Especially, the identification of essential requirements to aim (working and living in) an industry 4.0 oriented environment with a strong increase of services in supply chains needs support. For example, manufacturing companies will change from offering products, to service-products, and to only services’ solutions (Gebauer et al. 2013) but they will have less capabilities in developing such services (Saccani et al. 2014). Companies are not used to develop a unique model of services that is independent of organizational limitations and silo mentality within companies (Chesbrough and Spohrer 2006).

In detail, “the goal is to supply a digital service to the customer that is attuned to the customer benefit. This new way of creating new business models and additional services to the physical product should be minted by a digitalization and a development which is organized in an intelligent network” (Stöhr et al. 2018, p. 194).

Although literature already discusses possible technical production innovations for industry 4.0, literature confirms that a foundation of method is needed for optimizing the service of information for the production chain (Poetter et al. 2014; Schlick et al. 2014). The reason is that it is challenging to measure services and services lack of research in standardization and industrial commonalities (W. Liu et al. 2019). Therefore, research and practical insights shall be commonly addressed for outlining guidance on services in supply chains (W. Liu et al. 2019).

[3] https://www.plattform-i40.de/IP/Navigation/EN/Home/home.html

Hereby, the thesis research pursues to answer the following research questions:

- How are services in supply chains developed to support the progression and operationalization of industry 4.0?
- What elements of SCM have influence on the development of services in supply chains to support the progression and operationalization of industry 4.0?
- Which principles affect the participants of the value chain network while they develop services in supply chains to progress and to operationalize industry 4.0?

1.2 Structure of the thesis

The goal is to define a Service oriented Supply Chain Management (SoSCM) framework that fulfills the requirements of industry 4.0 and that shall enable companies to develop services in supply chains to progress towards industry 4.0, to operationalize industry 4.0, and to stay competitive in an industry 4.0 oriented environment (Figure 1).

Firstly, the thesis conducts literature reviews to analyze the interrelations of industry 4.0, SCM, and services for identifying common requirements and approaches for the SoSCM framework. Hereby, a research gap is identified and research propositions are outlined (chapter 2).

Secondly, the thesis analyzes case studies to close the research gap and to redefine the research propositions. Hereby, the case studies focus on the blockchain technology as a tool to develop services in supply chains and that represents important characteristics to progress towards industry 4.0. Based on these case studies' findings, five research propositions are defined (chapter 3).

Thirdly, the SoSCM framework is described based on five research propositions. Additionally, models and phases of the SoSCM framework are discussed and managerial guidelines are provided (chapter 4).

Finally, the thesis closes by highlighting limitations of the thesis research and by proposing additional ideas for future research to develop services in supply chains for industry 4.0 (chapter 5).

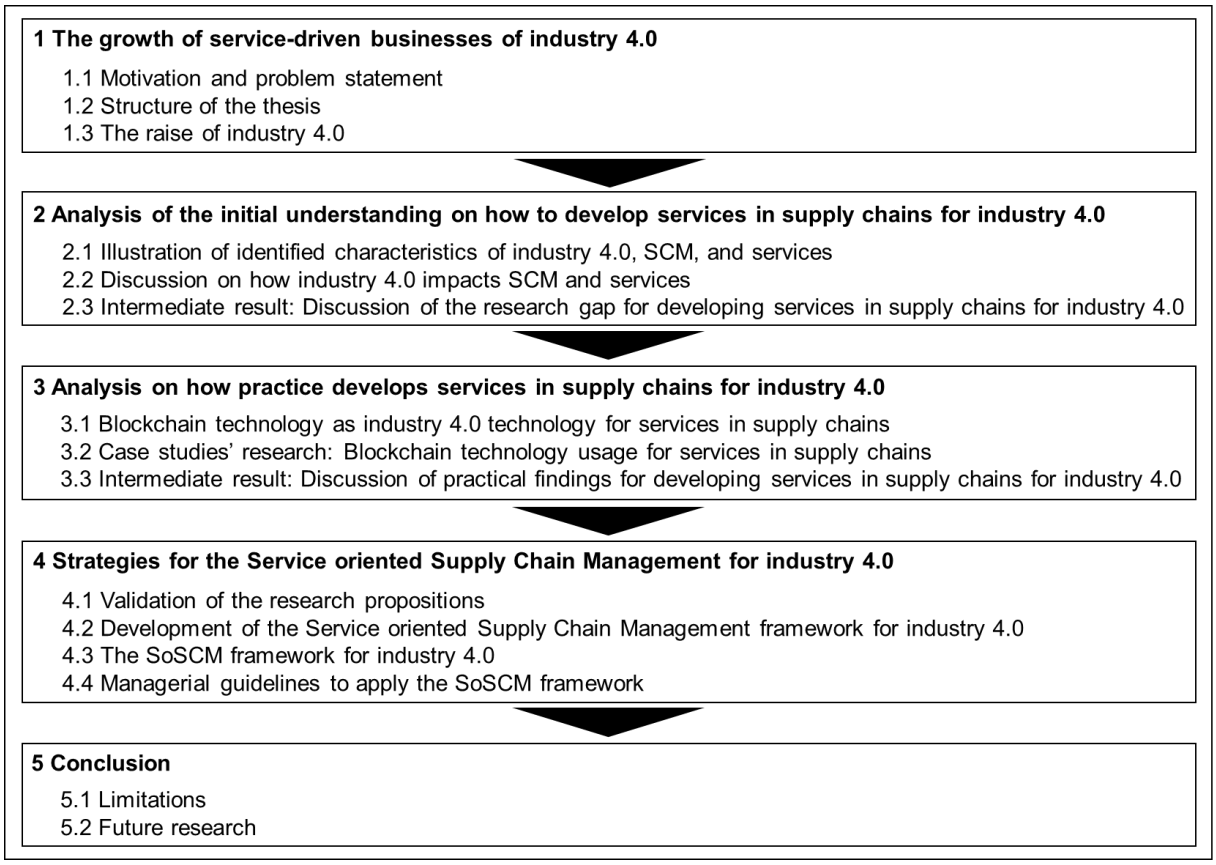

Figure 1: Schematic representation of the thesis research

1.3 The raise of industry 4.0

Industrialization has affected a growing economy because of the increasing productivity by the usage of capital equipment, manpower, and land. Due to industrialization, the world's population has been developed, new products and services have been offered, and demands and outcomes have been changed (Boelcke 1987).

As soon as information and communication technologies (ICT) have been advanced and the internet has been available in 2000, knowledge shall become one of the new growth potentials for industries worldwide (Bauernhansl 2014).

Additional benefits of personalized information and data shall satisfy individual requests of product variety and product volume. Exchange of information in real-time from customers to producers shall enable a new way of manufacturing products which is popular for the fourth industrial revolution or known as industry 4.0 (Bauernhansl 2014; Haddara and Elragal 2015; Schuh, Potente, Varandani, Hausberg, et al. 2014; Toro et al. 2015).

In August 2006, a German national-wide purpose – known as "High-Tech Strategy"[4] – was defined to combine future-oriented innovative technologies across various science, companies' sizes, and industry branches supported by each

[4] www.hightech-strategie.de

government ministry in Germany. This strategy was further developed and published by the “High-Tech Strategy 2020” in 2010 which focused on topics of climate/energy, health/nutrition, mobility, security, and communication (Hamdi et al. 2019).

In 2011, German industry partners and German government responsibilities built the foundation for a German industrial future strategy based on ICT principles and innovations at the Hannover exhibition. At this exhibition, the German umbrella term “Industrie 4.0” (in English written as industry 4.0) was created (Bal and Erkan 2019; Grabowska 2019; Lucato et al. 2019; Madsen 2019; Mohamed 2018; Pietrewicz 2019; Sader, István Husti, et al. 2019; Tupa et al. 2017; Vogel-Heuser and Hess 2016).

In 2012, the German government specified ten projects within the “High-Tech Strategy 2020 Action Plan”[4] to promote essential political targets. Industry 4.0 was one of the ten projects for strengthening the influence of ICT in business processes. The interests to support the intention of industry 4.0 has been increasing in Germany since then (Bauer et al. 2015; Bierer et al. 2016; Liao et al. 2017; Wang, Wan, Li, et al. 2016).

Due to the previous industrial revolutions, literature (Amaral et al. 2019; Da Costa et al. 2019; Kreilkamp et al. 2016; Malm 2016; Naitove 2015; Stojkić et al. 2016; Stork 2015; Uriarte et al. 2018; Wang, Wan, Li, et al. 2016; Weyer et al. 2015) speaks of a revolution with the context of industry 4.0. Especially, “the fourth industrial revolution, which is also called ‘Industry 4.0’, combines all technological equipment in the manufacturing process with information networks” (Yerofeyev et al. 2015, p. 1017) and is known as the internet revolution (Kans and Ingwald 2016).

Pereira et al. (2018) also outline that for the first time, companies are aware of a revolution and therefore, they can prepare themselves for the digital transformation. In contrast, other literature (Gabriel and Pessl 2016; García and García 2019; Issa et al. 2018; Leineweber et al. 2018; Pinto et al. 2019) rather argues of an evolution by the name of industry 4.0 as most of the components have been developed and improved over years and their technological combination shall enable the implementation of industry 4.0. Amaral et al. (2019) interlink the revolution and evolution context by saying that “this revolution will influence the evolution of technologies and change significantly the business model entirely” (Amaral et al. 2019, p. 1104).

As such, multiple technological and management related concepts are discussed under the terminology of industry 4.0 (Madsen 2019). Therefore, “Industry 4.0 is an umbrella term, a vision that shows where the journey in industrial production is going” (Gabriel and Pessl 2016, p. 131).

In fact, high percentage of a producing industry is essential for growth and development within the country. Therefore, the market is interested into position value-added chains of products and processes within the country. However, the economy will not be able to satisfy the customer demands by focusing on the current value-added chains, as resources (e.g. petroleum) will run out. Due to this fact, the business complexity will increase and value-added chains shall be reorganized to fulfill customer requirements (Bauernhansl 2014).

Hereby, SCM and the related supply chain network (SCN) of stakeholders have been adapting to changes and new requirements to fulfill such business needs. For example:

- Companies work in cooperation for their plans and forecasting in procurement, production, distribution, and transportation (Nikolopoulou and Ierapetritou 2012; Tan and Shaw 1998).
- They select their partners carefully, observe other companies' network position, and know how relationships are managed (Harland 1996).
- The focus is set on the end consumer to split up financial advantages and disadvantages through the network, to constantly enhance supply chain possibilities, to spread management decisions around the network, and to apply budgeting (Smith and Lockamy 2000).
- They have a corporate strategy to align on decision-makings (Ellram et al. 1989; Elmuti et al. 2008).

All in all, companies work in SCNs to react flexible and agile to market changes (Sigala 2008) and to increase the value for the end customer by creating innovations in networks and applying present resources (Chen et al. 2017). Hereby, new services are developed and partnerships are starched (Chen et al. 2017) which lead to value systems and value chains (Smith and Lockamy 2000). Companies emphasize on adding services to products along the production of supply chains which cause an extensive increasement of services and which further influence the economic growth potential (Botta-Genoulaz and Millet 2006; Lê 2011).

As additional countries have been started the discussion of industry 4.0 by the support of the government and local institutions (Madsen 2019) and as further international terms for industry 4.0 and market related strategies have been defined to deal with the broader context of industry 4.0 (Kohnová et al. 2019; Kosacka-Olejnik and Pitakaso 2019) (Appendix II Exhibit 4), Germany is set under pressure to deal with the global competitive activities of implementing functionalities and applications of industry 4.0 (Rennung et al. 2016).

To support the German initiatives and companies, the thesis investigates research on how to develop services in supply chains that fulfill the requirements of industry 4.0 for supporting the progression towards industry 4.0, the operationalization of industry 4.0, and the competitiveness in industry 4.0.