LUND UNIVERSITY
School of Economics and Management

Master's Programme in Innovation and Global Sustainable Development

# Drivers of innovation in the automotive regime in the Stuttgart Region

by

Mara Sophie Steinbrenner
ma2134st-s@student.lu.se

**Abstract:** This thesis examines drivers of innovation within the automotive industry of the Stuttgart Region, Germany. Geels' concept of a Multi-Level-Perspective is applied to the industry and its environment, when investigating positive and negative drivers. The research design of this thesis follows an exploratory case study of innovation, that includes semi-structured interviews with experts of the industry and startup founders that invented a novelty that is somehow interconnected with the automotive industry. This qualitative data reveals relevant drivers of innovation, interdependencies between actors and the level of origin and stimulation of the investigated drivers. Relevant drivers, such as technological change, in the form of digitalisation that pressures the sociotechnical car regime and stimulates tensions between actors and within corporations are revealed. This landscape pressure enables innovations to arise from a niche, discover market chances and place themselves in "windows of opportunity" of the sociotechnical regime.

**Keywords:** Innovation, Multi-Level-Perspective, Drivers of Innovation, Automotive Sociotechnical Regime, Technological Change, Automotive Industry in Stuttgart

EKHS34
Master Thesis- Independent Research Spring 2020
Supervisor: Josef Taalbi
Examinor: Jonas Ljungberg
Word Count: 17,759

# Acknowledgements

I want to thank all people, who were involved and contributed to making this study possible. I will be forever grateful to all interview partners who took their time to make this research possible and provided me with valuable insights.

First, I would like to express my deep gratitude to my supervisor Josef Taalbi, for his patient guidance and enthusiastic encouragement. His former work inspired me and enlightened the general research direction of this thesis.

Further, I would like to thank my friends in Lund and elsewhere for encouraging me to stay motivated and see the light at the horizon. Especially, I would like to mention my dearest friend Federica. Even though the Covid-19 crisis separated us in terms of our living situation, we continued to study together via video call every day and finished our theses with the support of one another.

Last, but by no means least, I am most grateful towards my family and my partner for always supporting and believing in me over all stages of life.

# Table of Contents

# Abbreviations

**AI** Artificial Intelligence

**CCI** Chamber of Commerce and Industry

**EE** Evolutionary Economics

**HR** Human Resources

**MLP** Multi-Level-Perspective

**SI** Startup Interviewee

**SSI** Sectoral System of Innovation

**VR** Virtual Reality

**WLTP** Worldwide harmonised Light vehicles Test Procedure

# List of Tables

# List of Figures

# 1

# Introduction

Stuttgart is home to the world's first automotive propelled by an internal combustion engine, the "Benz Patent-Motorwagen", built in 1885 (Benz, 2012). The region is shaped by the automotive industry like hardly any other region in Germany or even worldwide. The technical development of engines and vehicles began there, and even today the Stuttgart Region is one of the world's leading automotive ecosystems (Benz, 2012). Car manufacturers, suppliers and service providers as well as research institutes concentrate their automotive expertise there. As a result, many innovations of the automotive industry and the entire mobility industry come from the Stuttgart Region. A summary of innovations that are connected with the automotive industry is depicted in Figure 1.1.

Nevertheless, Stuttgart's automotive industry is affected by current transitions in which firms struggle to maintain their position and new companies emerge. The entire automotive industry is facing an enormous transformation process. Jannsen et al. (2019) distinguish between three main areas of change: (1) Climate protection and electric mobility, (2) Digitalisation, networking and automated driving, and (3) Globalisation, trade and increasing protectionism.

To understand these drivers and changes more detailed, this study investigates potential exogenous triggers and drivers of innovation as well as their level of origin and stimulation and discusses them in the light of previous literature. Geels' (2002) concept of a Multi-level-perspective (MLP) is applied and frames the interpretation of the uncovered drivers, making it possible to pinpoint the drivers to a specific level of origin and stimulation.

The thesis chooses an exploratory qualitative research approach by conducting a case study on drivers of innovation in the automotive sector of the Stuttgart Region. This approach is appropriate to uncover transformation pressures and assigning them a level of origin and stimulation. Quantitative data on the automotive sector as a whole is used to describe the sector and track macro level drivers, such as regulations and legislations.

*Figure 1.1: Innovations from the Stuttgart Region*

| | |
|---|---|
| 1885 | Karl Benz: Benz Patent-Motorwagen |
| 1885/1886 | Gottlieb Daimler and Wilhelm Maybach: First motorbike with a combustion engine, and a four-wheeled vehicle |
| 1887 | Robert Bosch: Magneto ignition for combustion engines |
| 1906 | Robert Bosch: Spark plug for explosion engines |
| 1927 | Robert Bosch: Injection pump for diesel engines |
| 1935 | Ferdinand Porsche: VW Beatle |
| 1952 | Bela Barenyi: Stable passenger cell |
| 1971 | Mercedes-Benz: Airbag |
| 1979 | Heinz Leiber: ABS |
| 1984 | Porsche: Tiptronic |
| 1988 | IBM Germany: Mainframe chip in CMOS-Technology |
| 1996 | Mercedes-Benz: Distance control and Cruise control |
| 1998 | CAA: Car PC |
| 1999 | DaimlerChrysler: Active Body Control |
| 2001 | Robert Bosch: Electronically controlled gasoline direct injection |
| 2003 | DaimlerChrysler: World's first fleet of fuel cell vehicles |
| 2005 | DaimlerChrysler: Night Vision Assistant |
| 2006 | Robert Bosch: CAPS Combined and Active Passive Safety |
| 2007 | DaimlerChrysler: Mercedes-Benz Citaro city bus with diesel-electric-hybrid engine |
| 2008 | Car2go starts in Ulm |
| 2010 | Huber Automotive AG: Virtual Nitric oxide sensor |
| 2011 | Mercedes-Benz: With hydrogentanks around the globe |
| 2014 | Mercedes-Benz: Automotive Innovation Award for the "Most Innovative Automotive Brand Worldwide |

*Source: Stuttgart Wirtschaftsförderung (2014)*

## 1.1 Research Problem

The automotive industry is made up around one key product and technology: the car. However, since the invention of the first car in 1885, an enormous amount of innovations has shaped the original technology and its industry to what it is today. Nevertheless, the automotive industry is facing great transformation processes, therefore, technological change and progress seem to be necessities to keep up with the industry, especially with the great competition car manufacturers are facing (Jannsen et al., 2019).

Turning to academia, Dahmén (1991) asserts *transformation pressure* and describes it as the driving force behind transformational processes an industry is facing. The author distinguishes between positive and negative transformation pressure, where the former one is characterised by opportunities and technological progress, whereas the latter one is determined by monetary pressure, such as declining profits. This approach is inspired by Naymier (1913); Schumpeter (1947) who introduces the concept of *creative and adaptive response*. Adaptive response refers to measures that take place within embedded practices and norms of an economy, whereas creative response is characterised by measures that are taken outside of original practices of the economy.
Further literature stresses the importance of firms' access to various inputs in order

to develop a successful novelty that increases their competitive position in the market (i.e. Nelson and Winter, 1982; Cohen and Malerba, 2001).
Most previous studies on innovation and change only focus on either positive (i.e. Malerba, 2002; Perez, 2010) or negative (i.e. Hicks, 1963; Dahmén, 1988) transformation pressure. Nevertheless, Dahmén (1988) argues that the process of transformation has its roots somewhere between positive and negative driving forces, hence an inclusive research is necessary to cover the whole picture. Even though Taalbi (2017b) follows an inclusive approach and evaluates negative forces, such as economic, environmental and organisational challenges as well as positive drivers, such as technological windows of opportunity and technological bottlenecks, he only identifies the main driver according to innovation bibliographies.
To understand the dynamics between actors and drivers better, Nelson and Winter (1982) introduce the concept of *technological regimes* and therefore frame part of Geels' (2002) MLP on innovation. It is a valuable model to understand the interactions and interlinkages of the micro, meso and macro level. However, the missing emphasis on the combination of the various drivers and the different levels are lacking in terms of research.
In order to identify potential exogenous triggers for different kinds of search and innovation, one must evaluate the entire search process of innovation and uncover transformation pressure. This provides valuable insights on the level of origin and the place of stimulation of transformation pressure.

## 1.2 Research Aim and Scope

This thesis presents a descriptive analysis of the sociotechnical structure of the automotive industry in the Stuttgart Region (Germany), and elaborate on drivers of innovation in this context. The data used in this thesis is self collected and of qualitative nature, thus providing valuable insights on shape-mechanisms of innovation. Nonetheless, to understand the sociotechnical structure and tensions, secondary quantitative data is taken into account as well. The empirical data will be interpreted in pre-established innovation theories, where the main focus is on the MLP introduced by Geels (2002, 2005, 2006). The following research questions are evaluated:

1. How are innovations shaped in the automotive industry of the Stuttgart Region?
   (a) To what extent are the innovations responses to opportunities, and to what extent are they driven by problems?
   (b) How are innovation activities shaped by external collaborations and linkages between actors?

## 1.3 Academic Contribution

Following an inclusive approach, this study shows that innovation activity is determined by both positive and negative driving forces. This approach allows an evaluation regarding the importance of specific drivers and discloses dynamics that

are stimulated by respective driver. This study further reveals the origin of the driving force and whether it stimulates tensions and triggers innovation activity on a micro, meso or macro level. Researchers investigated a wide range of determinants and previous streams of studies focus mainly on economic changes a firm is exposed to (i.e. Greve et al., 2003; Penrose, 2009). Other research focuses on changes in the industry environment (i.e. Breschi et al., 2000; Malerba and Mani, 2009), whereas Taalbi (2014) emphasises principal drivers and product patterns of innovations that are produced over time.
The unique aspect of this paper is that it investigates and uncovers both negative and positive drivers, and assigns them levels of origin and stimulation, by framing the drivers from a MLP. It evaluates the whole search process and development of the innovation in depth. This contributes to Geels' MLP and investigates details that are revealed during the practical application of his model.
In addition to this, the study also contributes to empirical research on innovation drivers of the automotive industry in the Stuttgart Region. Few studies concentrate on the automotive sector, such as Zijlstra and Avelino (2011) that interpret the car regime from a socio-spatial perspective and also base their investigation on Geels' MLP theory. Respectively, Smith and Crotty (2008) and Burton (2003) investigate, how environmental regulations drive the ecological design in the UK automotive industry, and the innovation drivers for a specific innovation (electric power-assisted steering). Various other research about the German automotive innovation activities are conducted (i.e. Triebswetter and Wackerbauer, 2008; Buchmann and Pyka, 2015; Rese et al., 2015), however, none of them are researching both, negative and positive driving forces while matching them to their level of origin and level of stimulation. Hence, this research contributes to the empirical picture of drivers of innovation in the automotive industry of the Stuttgart Region.

## 1.4 Outline of the Thesis

This thesis is initiated with a discussion of current tensions and pressures for innovation in the automotive industry in the Stuttgart Region as well as the outline of the research questions.
Chapter 1 highlights the need for the study to evaluate drivers of innovation and reflect them in light of previous models and theory. Furthermore, it details the contribution to the academic discussion. Chapter 2 depicts the theory of the study, which consists of the current state of research and analytical frameworks, where the latter one combines the state of literature with the automotive industry in the Stuttgart Region and evaluates it in line with the MLP. Hereafter, chapter 3 describes the exploratory case study as the methodology used for this research and presents limitations of the study. Chapter 4 reports the findings of the case study by framing it in line with the theoretical background. Chapter 5 covers a discussion and compares findings to prevalent streams of literature and concluding comments, as well as future research recommendations and policy implications.

# 2

# Theory

This chapter discusses earlier literature on the MLP and driving forces of innovation to detail the state of research and frame the findings of the case study. Furthermore, it details the automotive industry in the Stuttgart Region in the light of prevalent theories. This chapter argues that Evolutionary Economics is the foundation to explain how external forces trigger innovation and change. By using the MLP as a key concept throughout the thesis, negative and positive transformation pressures can be identified and distinguished. Lastly, previous literature is framed around data of the automotive industry to provide an analytical framework for the empirical research and detail an overview of the sociotechnical structures.

## 2.1 Literature Review

### 2.1.1 Evolutionary Economics

Both, Neoclassical theory and Evolutionary Economic (EE) theory acknowledge the importance of innovation and technological change for economic growth. Further, both theories agree on the crucial role a government plays regarding policies for science and technology (Verspagen, 2005, pp.489). Nevertheless, Verspagen (2005) argues that neoclassical theories disregard the real process of innovation, in return of higher consistency of its quantitative approach, whereas, EE embraces a focus on the micro level, hence applies a rather eclectic approach.
Since neoclassical growth theory has been criticised for its weakness when it comes to analysing technical change and its effect on economic growth, especially the missing micro level perspective (Nelson and Winter, 1982, pp. 206), EE theory is chosen as a base model for this thesis. EE is beneficial since it evaluates firms as possessing capabilities, and procedures, thus following specific decision rules that shape the action of a firm according to the market environment and changes (Nelson and Winter, 1982, pp. 206). Thus, firms that follow rules that lead to profitability, given external conditions, will grow. Moreover, EE focuses on complex interactions and interdependencies between actors and competition, growth, and structural change (Hodgson, 1996)
This provides the base for the MLP and allows to integrate findings from prevalent literature as an appreciative theory (Nelson and Winter, 1982). EE can be divided into two approaches, such as the "*process of variation, selection and retention*" (Geels, 2002, p.1258), which is shaped by Nelson and Winter (1982) outline of

technological regimes. Second, Schumpeter (1947) stresses the view on evolution as a *process of creative destruction*, thus establishing new combinations, which results in path dependencies and trajectories.
Rip and Kemp (1998) combine the presented perspectives and develop a MLP, which leads to a separate focus on the micro, meso and macro perspective and how innovations form. This complex model is greatly shaped and further established by Geels, providing an analytical and heuristic concept to comprehend complex dynamics and transitions of sociotechnical regimes (Geels, 2002).

### 2.1.2 Multi-Level-Perspective

The MLP emphasises a longitudinal view on elements such as user and markets, technology, science institutions, political regulations, as well as society and its culture by using a heuristic concept that aims to explain complex transition and change (Geels et al., 2011, Ch. 3). Figure 2.1 depicts the dynamics between actors of the framework and aims to integrate both approaches of EE theory.
The MLP is divided into three different levels, such as the micro, meso and macro perspective, thus the concept distinguishes between *(1) Sociotechnical landscapes, (2) Sociotechnical regimes,* and *(3) Niche innovations* (Rip and Kemp, 1998). Nevertheless, the levels cannot be interpreted as an ontological representation of reality, but rather provide researchers with a concept to investigate dynamics and change of sociotechnical regimes (Geels, 2002).

#### Sociotechnical landscapes

The expression *sociotechnical landscape* describes the environment and framework of sociotechnical regimes, such as economic growth, laws and regulations, political coalitions, cultural norms as well as environmental issues. Hence, it describes external factors that are deeply embedded and not easily changeable (Geels, 2002). However, the sociotechnical landscape can put pressure on sociotechnological regimes and niche innovations, by offering or changing deeply embedded structures and gradients that favour some actions over others. This can cause change within regimes or open windows of opportunities for niche innovations (Geels and Schot, 2007).

#### Sociotechnical regimes

A *sociotechnical regime* forms the core of the MLP-theory and is based on Nelson and Winter (1982) concept of technological regimes. The authors claim that it refers to common routines and rules within an engineering society and thus explains development paths. They argue that a technological regime is aligned to a problem that firms solve with a new technology or innovation activities. It shapes the learning curve, the incentives of innovation activity and restricts to given behavioural patterns and organisations.
This view was broadened by Bijker (1995) through his argumentation, that scientists, policymakers, users and further groups also shape trajectories significantly. Therefore, these actors are integrated in Geels' MLP and form the core of the sociotechnical regime. A sociotechnical regime creates stability due to linkages and interactions between heterogeneous groups and shared cognitive routines, thus mainly

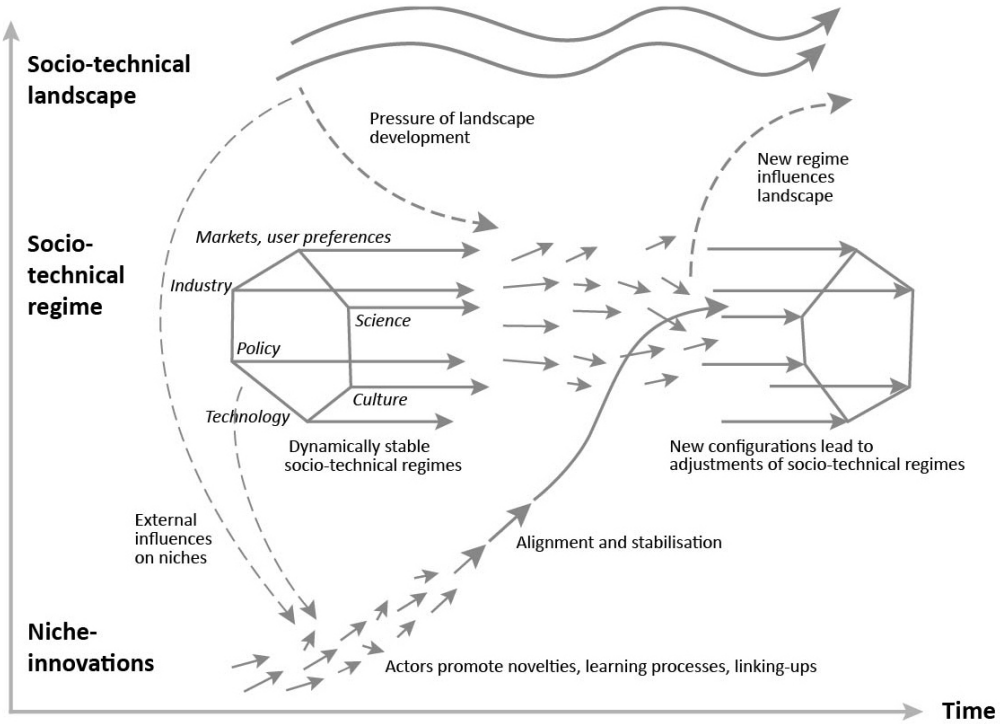
incremental improvements are recognised along technological trajectories (Geels, 2002).

### Niche innovations

*Niche innovations* are shaped by actors working on innovations that are generated in niches, thus an incubation room (Geels, 2002). Hence, niches provide space for radical innovations and novelties that are shaped by regimes and the overall landscape. Together with the landscape level, niches can challenge current regimes and, if successful, lead to transitions and changes within the regime.

Geels' presentation of the MLP emphasises the nested arrangement of the levels, meaning that niches are embedded within regimes, and regimes are integrated within landscapes (Geels, 2002). The dynamics are displayed in Figure 2.1. It displays six dimensions within the sociotechnical regime: technology, culture, policy, science, industry as well as markets and user preferences. Stable and regularly ongoing processes are presented with long arrows. Although the dimensions are all interlinked with one another and co-develop, these linkages can also lead to tensions and uncertainty. The tensions are represented with smaller arrows that evolve in different directions. As Figure 2.1 displays, this is further encouraged by pressures originally arising from the sociotechnical landscape level. On landscape level, changes occur much slower than within the regime. These slowly developing changes are presented with very long arrows.

*Figure 2.1: Dynamic MLP*




*Source: Adapted from Geels (2002)*

The tension in the sociotechnical regime can also be triggered or stimulated by

novelties occurring on the niche level. The arrows arising from the niche level are not sorted or in line, which displays that a dominant innovation has not evolved yet. Nonetheless, actors promote novelties and some arrows become bigger, moving towards the sociotechnical regime level. This represents the alignment and stabilisation of an innovation that arises from the niche level and challenges the current sociotechnical regime. Arising niche innovations can either challenge a relatively stable regime by triggering tensions or make use of windows of opportunities that have opened up due to previous tensions and challenges the regime was facing.
As displayed in Figure 2.1, the tensions of the regime are stabilising again and new configurations lead to adjustments of the sociotechnical regime. Once the new regime is stable, it can shape the landscape level.
Geels' (2002) presentation of the MLP emphasises the nested arrangement of the levels and interconnected dynamics. It pictures the sociotechnical landscape as an exogenous context which puts pressure on existing regimes, thereby opening up and enabling windows of opportunities for new combinations and radical innovations. The sociotechnical regime appears to be stable with dynamic processes happening. Niches are characterised by small networks of actors that support innovation as well as learning processes on various dimensions. The effort to combine and link elements in a seamless web is supported by co-construction. Both regimes and landscape influence niches via networks, norms and expectations. Novelties become aligned and break into previous enabled windows of opportunities, challenging existing regimes. Hence, adjustment of existing regimes is crucial and new regimes form a core, which also influences the landscape further. Nevertheless, innovations can also fail to enter the market, hence not being influential enough to challenge existing regimes.
This approach, especially the dynamics, are based on Rip and Kemp (1998) and are summarised in Table 2.1.

*Table 2.1: Macro-Meso-Micro Perspective*

*Source: Adapted from Rip and Kemp (1998)*

| | Identifiable configurations that work | Merge | Seamless webs |
|---|---|---|---|
| Macro | All collective processes | Evolving sociotechnical landscapes | Patterns of transformation |
| Meso | Technical systems and knowledge | Patchwork of regimes | Sectoral structures and strategies |
| Micro | Artifacts/ New knowledge | New combinations | Artifacts as channels of society |

### 2.1.3 Drivers of Innovation

As the concept of the MLP depicts, innovation and transition dynamics are answers to certain triggers and stimulation. In order to understand the dynamics of sociotechnical change and distinguish individual drivers and transformation pressure, prevalent literature is presented and framed by the MLP.
Schmookler (1962) stresses the importance of demand in stimulating innovation activities. One can refer to a situation of increasing demand, as *demand pull*. The term demand pull refers to the demand for a new product or solution to a problem that

arises from within a market (Schmookler, 1962). Hence, a demand pull situation can be stimulated by potential customers that demand improvements of existing products (Godin and Lane, 2013). Oppositely, the term of *technology push* characterises a situation, where research drives the establishment of innovation (Dosi, 1988). Complementary to these findings is Schumpeter's (1947) theory on *creative and adaptive response*. He claims that adaptive response happens within current practices, whereas a creative response takes place outside of current practices and is determined by new combinations. Hence, a creative response can be interpreted as an event of technology push, whereas the adaptive response rather defines the reaction to a specific need, thus arises out of demand pull.
Furthermore, Arthur (2007) argues that the process of innovation is defined by finding the right combination while operating under great uncertainty. It is a process of combining requirements to effects, thus, developing innovations is about finding the right combination to solve complex problems (Arthur, 2007). Taalbi (2014) stresses that technological transformation and innovations are significantly shaped by changes within the economy. He distinguishes between positive and negative drivers, where *positive driving forces* encourage innovation by stimulating opportunities and *negative driving forces* result from pressure, thereby, focusing on problems. Negative driving forces pressure regimes and agents by challenging the dimensions of sustainability of a regime, such as the environmental, social or financial stability and acceptance of regimes. This fosters problem-solving innovations which are responses to economic, environmental or organisational problems; whereas positive driving forces account for opportunities such as technological change and improvements (Taalbi, 2014).
This interpretation is in line with Dahmén (1988) and his argument, that the process of transformation has its roots in the midst of positive and negative transformation pressure, hence it is driven by both forces.

The following subsections detail negative and positive driving forces while framing them into the levels of the MLP. It must be remembered that there is no perfectly accurate mapping of drivers and a single driver can entail both negative and positive transformation pressures.

### Negative driving forces

One of the major negative driving forces appears to be of economic origins, such as declining profits or increasing market competition. Research on negative transformation pressure reveals drivers that embody monetary incentives such as factor-price inducements (Hicks, 1963), and declines in profits (Greve et al., 2003). Hicks (1963) argues that changes in relative prices of elements of production cause innovation by using the factors, that have become more expensive, more efficiently and maximise their utility. This driver spurs innovation on a micro level and challenges firms with monetary pressure. Furthermore, he states that price induced innovation can lead to process and product innovation. Taalbi (2017b) concludes that on a micro level, negative drivers are on the one hand characterised by failure to achieve goals, and on the other hand by increasing factor prices.
Dahmén (1988) and Rosenberg (1969), stress the importance of problem solving activity and that overcoming technical or organisational obstacles, such as bottlenecks, are a crucial driver. Especially on an industry level, competitive pressure and

sectoral challenges are major driving factors (Malerba, 2002). Moreover, Rosenberg (1969) suggests that imbalances on a sociotechnical level induce inventions. Thus, the attempt to correct imbalances leads to innovation. Imbalances are characterised as situations with technological barriers, or environmental, social or economic issues that stream down from the landscape level or arise at the level of sociotechnical regimes (Taalbi, 2017a).
Moreover, negative externalities that appear on the macro level, such as environmental pollution or social costs seem to make up for an increasing share in negative driving pressure, which also leads to innovative responses (Taalbi, 2014). This challenges stagnating industries with negative transformation pressure and can increase competition around incremental improvements (Dahmén, 1988).
One may conclude that negative transformation forces exert pressure on actors and regimes and enforce change by challenging actors.

### Positive driving forces

Windows of opportunities or changes in consumer behaviour are examples for positive transformation pressure and can stimulate innovation (Naymier, 1913). These windows of opportunity usually arise on the level of the sociotechnical regime and are triggered by external forces. According to the canonical economic model, technological change and innovation are driven by expected profits to innovation, which is ensured by regulations, such as property rights (Nordhaus, 1969; Scotchmer, 1991). Furthermore, positive transformation pressure can occur in the role of technological change, arising at the macro level and affecting various actors and regimes. Due to the interdependencies of industries, technological progress requires the alignment of other components and technologies (Taalbi, 2017a). If such components are missing, technological imbalances may arise and spur innovation processes (Taalbi, 2017a).

On a meso level situation of technology push and demand pull are the main positive driving forces (Malerba, 2002). The first phenomenon is defined by technological opportunities, whereas the latter one accounts for changing demand and market conditions (Malerba, 2002). Nonetheless, Perez (2010) insists that great innovations induce further inventions by demanding complementary novelties and new combinations. This takes place in a manner of upstream and downstream; thus, innovation search is a collective process that happens in complex networks by constantly establishing new linkages, and developing dynamic clusters (Schumpeter, 1947).
According to Penrose (2009), innovation can be promoted by external or internal stimulation. External stimulation refers to changes in technology that suggest a larger scale of production; these arise from discoveries that open up opportunities to exploit new markets or the likelihood of a better market position.
Penrose (2009) refers to internal inducement as resources that exist on a micro level such as special knowledge, or productive services that have been unexploited within a firm so far. Taalbi (2017b) argues that positive driving forces on a micro level are characterised by discovering new market opportunities and utilising unused resources. The expected return may also increase by changes in market demand or user behaviour (Schmookler, 1962).

### 2.1.4 Levels of Drivers

Table 2.2 presents an overview of positive and negative driving forces that stimulate innovation while assigning their level of origin. The drivers are evaluated and interpreted in their context of research. These drivers need to be regarded in conjunction with one another and across the levels. One needs to consider that the levels of the MLP are not stringent and rigidly fixed. It is a dynamic concept with drivers that evolve and stimulate different actors on various levels.
The macro level depicts that imbalances emerging from various sources are the main drivers of both categories, positive and negative. Whether to interpret them as a negative or positive driver, depends on their place of stimulation. Taalbi (2017b) argues that imbalances from technological change are positive, whereas imbalances emerging from economic, environmental and societal effects are mainly of negative nature. This classification is further evaluated in the discussion section. Malerba (2002) argues that technological progress and opportunities are positive drivers of innovation which take place on a meso level, hence, can be interpreted in the context of a sociotechnical regime. Perez (2010) suggests that within the framework of a sociotechnical regime, new combinations and complementaries will be invented. Negative transformation pressures arising at the sociotechnical regime are imbalances (Rosenberg, 1969), competition and sectoral challenges (Malerba, 2002; Taalbi, 2017a). These drivers are likely to stimulate the initiation of windows of opportunity, that can be used by niche actors to find a solution-fit for the opening market chance.
Positive drivers that arise on the micro level are the exploitation of unused resources and the exploration of new market opportunities and technologies (Penrose, 2009). Increasing factor prices and declining profits are known factors that spur micro-actors to innovate (Hicks, 1963) and are classified as negative drivers, due to the enforced monetary pressure. Dahmén (1988) insists on the "necessity to adjust and adapt", that is stimulating firms to innovate and change.
This assignment of drivers to specific levels is only a hypothesis and will be further evaluated in the discussion section.

*Table 2.2: Summary of negative and positive forces that drive innovation*

| | Positive | Negative |
|---|---|---|
| Macro level of landscape | Imbalances emerging from technological change (Taalbi, 2017a) | Imbalances emerging from economic, environmental and societal effects (Taalbi, 2017a) |
| Meso level of sociotechnical regimes | Technological progress and opportunities (Malerba, 2002); new combinations and complementaries (Perez, 2010) | Imbalances (Rosenberg, 1969); Competition and sectoral challenges (Malerba, 2002; Taalbi, 2017b) |
| Micro level | Exploit unused resources and explore new market opportunities & technologies (Penrose, 2009) | Increasing factor-prices and declining profits (Hicks, 1963); "necessity to adjust and adapt" (Dahmén, 1988, p.138) |

## 2.2 Research Framework and the Role of Stuttgart

This section puts prevalent streams of literature in context of the Stuttgart region. It further frames the MLP around the automotive sector and presents first insights on transformation pressure that the region is currently facing.

### 2.2.1 Description of the Automotive Sector in the Stuttgart Region

Innovation develops differently across sectors and over time. It also shapes the sector around it significantly and is on the contrary shaped by the sector. To analyse the role of innovation and how it is shaped, the sector has to be analysed and evaluated first.
One distinction of sectors arises from Schumpeter Mark I and II, where Schumpeter Mark I sectors are defined by *creative destruction* (Schumpeter, 1947), whereas Schumpeter Mark II sectors are indicated by *creative accumulation* (in Keith Pavitt's words) (Schumpeter, 1947). Schumpeter Mark I sectors are characterised by entrepreneurs and high dynamics with many new firms, due to relatively easy technological access. Schumpeter Mark II sectors are typically shaped by large and powerful companies that promote a stagnant environment, which complicates the entry for new, small innovative firms. This sector can also be interpreted as a sociotechnical regime that is marked by a stable core of few, but large firms that dominate the market. Schumpeterian's classification and regime clustering is a dynamic concept and can evolve over time (Klepper, 1996). Hence, the pattern of a Schumpeterian Mark I sector can develop into the trajectory of a Schumpeterian Mark II sector. This is in line with the view of an industry-life-cycle (Malerba and Mani, 2009). When an industry is in its early stages, innovation activities are high and dynamic. This is due to rapid changes, high uncertainty and a high number of new firms as key actors (Malerba and Mani, 2009). When an industry matures, it develops around a key technology and evolves trajectories alongside economies of scale, knowledge accumulation curves, market barriers, and monetary resources. All these characteristics increase in importance and are crucial for the competition of the industry, hence companies with monopolistic power become the main innovators (Klepper, 1996).
In order to gain a deeper knowledge about the processes within a sector, Malerba (2005) constructs a concept of a Sectoral System of Innovation (SSI), that is based on EE. He emphasises the dynamics of learning and knowledge that shapes the nature and resilience of sectoral borders. Moreover, he includes innovation theory that focuses on relationships and networks of heterogeneous actors, as well as market and non-market interactions. Lastly, he states that interactions and cognitive behaviour within the SSI are embedded in authoritative institutions and norms. According to the author, this scheme is a key determinant of innovation. Gradually, an SSI is shaped over time and adjusts in line with inherent dynamics and co-evolution processes, thus an SSI is never static (Malerba, 2005).

An example of a well established and specialised SSI is the Stuttgart Region. As one of the world's most important automotive clusters, the Stuttgart Region is also the dominant automotive region within the German federal state Baden-

Württemberg. The majority of the state-wide turnover of the automotive industry is generated within the wider Stuttgart Region. 60.6 billion Euros out of a state-wide total turnover of 107.1 billion Euros in 2018 correspond to a regional share of 56.5 % (Dispan et al., 2019). The Stuttgart Region is a globally important cluster of interdependent companies and institutions of the automotive industry that consist of manufacturers as well as system and component suppliers. Also, service and IT companies, engineering offices and numerous research institutes pool their competence around automobiles. Companies like Daimler, Porsche, Bosch, Mahle, Behr, Bertrandt, Eberspächer, Mann+Hummel, Vector Informatik and affiliates of the largest suppliers worldwide like BorgWarner Ludwigsburg, TRW, Lear Corporation, BOS, Valeo or Benecke-Kaliko AG are examples for the main spatial focus of the automotive industry in Germany (Strambach and Klement, 2013). Besides, more than 500 highly innovative small and medium-sized supplier companies are located in the same area (Strambach and Klement, 2013). The Audi AG also operates one of its most important production sites in the country in the immediate surrounding area of Stuttgart (Strambach and Klement, 2013). The mechanical engineering sector, which is strongly oriented to the automotive industry, strengthens the region's central position Stuttgart (Dispan et al., 2019).
However, interdependencies and linkages are further promoted by operationalizing innovation as co-evolution. Co-evolution is a valuable concept to comprehend the complexity of innovation search and processes, since it entails constant interactions and interdependencies (Kilelu et al., 2013). Innovation platforms that engage with various actors are noted as important interventions to establish a space that allows interaction, communication and co-working in order to develop innovation (Venkatraman et al., 2014). The platforms stimulate change and adjustment among the actors and will eventually benefit the broader environment in which the actors operate (Venkatraman et al., 2014). The concept of innovation platforms is applied in forms of innovation competitions and incubators that are operated by agents of the sociotechnical regime, such as Porsche, Daimler and Festo. These platforms may follow different goals and appear to be structured in individual ways. Porsche's Open Innovation Competition usually focusses on a key technology or a certain aim, i.e. 2019, the focus was on "Autonomous Transport of Assembled Sports Cars within Production". By committing to such challenges, the car manufacturer becomes more transparent and strengthens linkages with the car ecosystem around it (Venkatraman et al., 2014). Nevertheless, innovation collaborations do not emerge autonomously but need to be encouraged, therefore, connections between actors must be forged and coordinated (Consoli and Patrucco, 2008). Venkatraman et al. (2014) stress that there is a necessity for so-called *innovation intermediaries* that coordinate, structure and mediate at the interfaces of complex configurations of actors. A potential intermediator in the Stuttgart Region is StartupAutobahn. Although StartupAutobahn is an innovation platform itself, its concept is to connect startups with large corporations to pilot niche innovations and encourage collaboration (StartupAutobahn, 2020). It was founded in 2016, in the Stuttgart Region but has expanded to locations like Beijing, Bangalore and Singapore (StartupAutobahn, 2020). The two large car manufacturers, Porsche and Daimler, both work together with StartupAutobahn.

In conclusion, the Stuttgart Region can be classified as a Schumpeter Mark II

sector, since it is developing around a key technology and the knowledge accumulation is happening along this trajectory. It is dominated by large and well-known firms, however, medium- and small- sized firms are clustered around the large firms and serve as suppliers or deliver other kinds of services. A hypothesis that can be drawn from this is that innovations are mainly shaped by the dominating core of the sociotechnical regime. However, due to the interdependencies and strong linkages, another hypothesis that has to be further evaluated is that collaborations, like innovation competitions that are organised by large firms, increase co-innovation and strengthen the chances for innovation to leave their niche.

### 2.2.2 MLP of the Automotive Sector in the Stuttgart Region

An overview of previous literature and empirical data is presented to gain an insight into the automotive sector in the Stuttgart Region. This overview presents transformation pressure that occurs mainly on the level of landscape and sociotechnical regimes and stresses on the significance of problem oriented drivers.
Due to the prevalent crisis in time of this study, caused by Covid-19, data from 2020 is neglected and only data and literature from 2019 and earlier is used to present a sectoral overview.

#### Current situation and prospects

The current development and prospects of the "manufacture of motor vehicles and components" sector are examined by the turnover index and new orders index, which are not available for the Stuttgart Region but for Baden-Württemberg as a whole. The turnover index and the new orders index are among the central and most up-to-date indicators of economic development. Table 2.3 presents the incoming orders index, which can be interpreted as an early indicator of economic development. When comparing 2019 and 2018 a significant slowdown of -4.1% is revealed. According to Dispan et al. (2019), this is a result that is primarily driven by a significant decline in the automotive industry's foreign business. In the two previous years 2017 and 2018, incoming orders from abroad were still significantly higher than domestic orders (Dispan et al., 2019). Furthermore, Table 2.3 presents that sales are increasing at a small rate, however, December 2019 shows a significant low in turnovers.

*Table 2.3: New orders index and turnover index for manufacturing of motor vehicles and components in Baden-Württemberg (Base year: 2015=100)*

New orders index

| 2016 | 2017 | 2018 | 12/2019 | 12/2019 vs.12/2018 | 2019 vs. 2018 |
|---|---|---|---|---|---|
| 99.5 | 103.7 | 107.7 | 93.7 | -15.0 % | -4.1 % |

Turnover index

| 2016 | 2017 | 2018 | 12/2019 | 12/2019 vs. 12/2018 | 2019 vs. 2018 |
|---|---|---|---|---|---|
| 97.0 | 99.2 | 102.1 | 80.0 | + 3.7 % | +0.8% |

*Source: Statistisches Landesamt (2020) Baden-Württemberg*

A weaker business climate can also be observed throughout Germany. According to Ademmer et al. (2019), the business expectations in the automotive industry fell to its lowest level in almost six years but remained above the long-term average. The significant decline is also due to the problems of German car manufacturers in the transition to the new *Worldwide harmonised Light vehicles Test Procedure* (WLTP) standard (Ademmer et al., 2019). Since many model variants could not pass the new test procedure in time, the manufacturers restricted their production. Nevertheless, these problems are a rather temporary hindrance to production, so that one could expect production to recover quickly and that - given sufficient capacity reserves - the temporary production shortfalls can be compensated (Ademmer et al., 2019). Nevertheless, the continuing weakness in car manufacturing and the poor economic outlook raises concerns that the recovery could be weaker than what was foreseeable a few months ago (Ademmer et al., 2019). For the further course, the question arises as to whether production will return to its previous trend and whether there will be significant catch-up effects regarding the production. Recently, increasing concerns that German car manufacturers, or the automotive industry in general, will have to suffer a noticeable loss of confidence from the emission scandal are voiced (Ademmer et al., 2019).

### Stuttgart Region

The economic situation in the automotive industry in the Stuttgart Region is expected to slow down in the early summer of 2019, according to a survey by the CCI (IHK, 2019). 45% of the companies in the vehicle manufacturing sector assessed the current business situation as positive and 13% as negative (42% assessed the current situation as neutral). The business expectations for the coming months are less positive: 21% of companies expect an improvement, 37% expect the business to decline. The poor outlook is also reflected in the expected development of employment: In 21% of the companies in the regional vehicle manufacturing sector, a decline in employment is expected; none of the companies surveyed are planning to hire more people. The remaining 79% assume that the number of employees in the Stuttgart Region will remain constant.

### Long-term transformation processes of the automotive industry

Jannsen et al. (2019) argue that the entire automotive industry is undergoing an enormous transformation process. They distinguish between main areas of change: (1) Climate protection and electric mobility, (2) Digitalisation, networking and automated driving, as well as (3) Globalisation, trade and increasing protectionism.

1. In the coming years, the focus of the transformation will be on electric mobility, purely battery electric and as plug-in hybrid (Jannsen et al., 2019). To achieve the ambitious EU $CO_2$ fleet limits for 2030, the rapid market penetration of e-vehicles is necessary.

2. The authors state digitalisation as a second major driver of innovation.The goal is to achieve more safety, efficiency, sustainability and convenience (Jannsen et al., 2019). Digitisation of cars and their production and networking will make a decisive contribution to this.

3. According to Jannsen et al. (2019), free trade is increasingly being undermined worldwide, leaving car manufacturers and its suppliers in uncertainty. Actively shaping globalisation is a determining factor for the German automotive industry, since three out of every four cars that are produced in Germany are exported, most of them to Great Britain and the USA (Jannsen et al., 2019). The authors also state that the conditions for innovations worldwide are not strong enough. This includes the protection of investments and intellectual property.

The previous literature and presented arguments disclose the transformation and innovation pressure the automotive industry is currently facing. It depicts that the sociotechnical regime of car manufacturers and its suppliers are challenged by sectoral imbalances and cost pressure. This leads to ruptures in the structure of the sociotechnical regime, hence windows of opportunities are opening for niche innovation. This is supported by increasing pressure of landscape development due to globalisation and digitalisation. As Jannsen et al. (2019) argue, society is changing its preferences to digitalised products. Hence, the original requirements for cars are changing and due to globalisation competition is high while worldwide markets demand innovative and digitised products.
To summarise, most of the above stated drivers of transformation can be interpreted as negative drivers for the sociotechnical regime, since they increase pressure and sectoral challenges for car manufacturers. However, digitalisation may also lead to technological imbalances, therefore, be a positive driver. When taking a micro level perspective, these landscape pressures can also be categorised as positive drivers, since they enable technological progress, support novelties, help to exploit unused resources and therefore, open windows of opportunities for new combinations and innovations. A hypothesis that can be drawn from this is that due to the challenges, such as the environmental concerns and regulations, the automotive sector's innovation are mainly problem driven. This is analysed and evaluated with an exploratory qualitative methodology, that is further evaluated in the next chapter.

# 3

# Methodology

## 3.1 Research Design

This thesis uses an exploratory qualitative approach of case studies to investigate the drivers of innovation and evaluate the formerly mentioned research questions. In this section, the empirical approach is explained, as well as the subsequent steps of data collection and analysis.

### Nature of the Research

A review of the existing literature on the topic of innovation dynamics that emerge in a market and challenge current regimes highlights the thin empirical understanding about the level that drivers emerge from and their impact on innovation. This has not been studied in the context of the Stuttgart automotive sector.
When a study or theory aims for a better comprehension of processes or problems over time by investigating motives and drivers, exploratory qualitative research is most beneficial (Yin, 2017).

### Case Study

Yin (2017) suggests to conduct an exploratory case study, if the main research questions aim to answer a "how" or "why" question (Hedrick et al., 1993), if there is no or only limited control over behavioural events, and if the focus of the study is contemporary. In the case of the automotive industry of the Stuttgart Region, relevant behaviour cannot be influenced or manipulated, and processes and events are of contemporary nature. Hence, a qualitative case study with semi-structured interviews is appropriate to explore the complex social, organisational and economic framework. Thereby, answers to the how and why as well as its underlying processes can be revealed (Yin, 2017). Case studies have the unique advantage of dealing with various data sources, such as interviews and direct observations, as well as documents and artefacts (Yin, 2017). On the contrary, quantitative research is limited in its capacities to account for such data and could, therefore, lead to conclusions that do not capture the contextual framework (Eisenhardt and Graebner, 2007). By conducting a case study, the researcher aims to disclose a set of decisions as well as intends to understand how and why they were taken and implemented (Schramm, 1971). Due to the fact that a real-world situation is investigated, it is likely that

contextual conditions are relevant and need to be placed in the appropriate framework of theory; furthermore, "in-depth" descriptions of certain phenomena may be required (Yin, 2017). As Yin (2003) states, multiple sources of evidence are more likely to build towards a robust framework. Therefore, if more interviews confirm similar results, the external validity of the research is higher (Dooley, 2002).

### Main Research Method

The main research method follows a case study of *drivers of innovation*. Therefore, interviews with startup representatives which operate within the automotive sector in the Stuttgart Region are conducted until a point of saturation is reached to identify cross-case patterns. Furthermore, a research associate from an economic research institution and an innovation manager from a car manufacturer are interviewed.
This interview approach is selected due to the research questions' nature and insufficient previous research (Eisenhardt and Graebner, 2007). As existing studies have not yet reached an agreement on the various levels of drivers of innovation, conducting a case study is a suitable approach to develop theoretical and pragmatic insights based on exploratory empirical insights.
In addition to the suitability of the chosen approach with regards to the state of research, exploratory case studies are especially suited for fulfilling this particular research aim, as it seeks an understanding of the context while monitoring ongoing processes that enable successful innovation (Yin, 2017).
As stated above, including multiple sources adds to the external validity of research, which is why several "startup-cases" are included in this case study.
Primary data is collected in semi-structured interviews. This method provides the possibility of digging deeper and offers more flexibility, while simultaneously ensuring comparability (Robson, 2002). This way, unpredictable, interesting aspects may be revealed as well (Robson, 2002). Secondary data, such as turnovers of the automotive industry in the Stuttgart Region are accessed from the web page of the Regional Statistical Office (Landesamt, 2020) and evaluated in the context of this study. This quantitative data is of importance to understand and outline the current challenges the automotive sector is facing.

## 3.2 Data Collection

### Sampling of Cases

The selection process for firms to participate in this research is based on several criteria. This includes the size and age of the firm, as well as, their current market phase. However, the emphasis lies on the diversity of cases regarding their niche environment and novelty. This is in line with the understanding of Geels' MLP, various cracks of the regime and the exploratory nature of this research. An outline of the inclusion criteria can be found in Appendix A.
The initial scanning for appropriate cases is based on the Chamber of Commerce and Industry (CCI) of the Stuttgart Region. The CCI provides an overview of innovation prices and the nominated firms (CCI, 2020). Since this includes firms of any size, the list is further scanned for startups. Within this list, the focus lies on innovations

that have been founded in the Stuttgart Region. However, the acquisition of cases appears to be difficult which is the reason for a snow-ball system being put in place. Hence, interviewees are introduced to the sampling criteria and asked to refer to their contacts in the startup scene. The precise term for this collection method is *exponential discriminative snowball sampling* (Noy, 2008). It means that an interviewee provides multiple referrals but only a few new subjects are recruited among them. The choice is shaped by the aim of the study and the sampling criteria (Noy, 2008). Hence, referral startups had to provide some connection or potential linkage to the car manufacturing industry in Stuttgart and meet the expectation to have been founded in the Stuttgart Region. Snowball-sampling enables this study to acquire "hidden startups" and provides a primary data collection that is cost-effective and appropriate due to the short time period (Noy, 2008) and the current Covid-19 situation.

### Interviews

A total of six interviews are conducted to gain a better comprehension of how market transitions, dynamics and innovation develop.
Each interview lasts between 45 and 60 minutes and is conducted via video calls, due to the restrictions that resulted from Covid-19 . The interviews are of in-depth and semi-structured nature. This is a particular fit for a case study since it provides enough room to ask new questions while operating in a structured environment that enables cross-case analysis (Eisenhardt and Graebner, 2007).
All interviews are recorded and transcribed post-conversation to ensure accuracy and completeness. The interviews are transcribed according to the simple transcription rules of Dresing and Pehl (2013). The interviews are originally conducted in German, therefore, the questionnaires (see Appendix B) and the coded sections are translated from German to English. It is assured that the questions and quotes are translated as close and neutral as possible, by using Deepl as a translation software and only correcting for obvious grammar or language mistakes.
In order to frame the semi-structured questionnaire of the startups optimally and gain further insights into the structure of the sector and experience of a large firm, two expert interviews are conducted. The first interview is conducted with a research associate, who headed the 2019 Structural Report for the Stuttgart Region. Since the focus of the Structural Report is on mobility services (Dispan et al., 2019) and the interviewee's expert view on the dynamics of the automotive sector in the Stuttgart Region underlines the current challenges regimes are facing in the right manner, the interview with him has an appropriate scope with regards to the research questions. Thus, his expert opinion supports the interpretation of the innovation activity in a bigger picture.
The second interview is conducted with an innovation manager of a large and influential car manufacturer of the Stuttgart Region. He works at the connection department between the car manufacturer and young startups, and manages events like the "Open Innovation Competition". His different point of view is valuable and supports the categorisation of the dynamics of startups and rising innovation.
The remaining four interviews are with Co-founders or CEOs of startups that are somehow connected with the automotive industry.
The role of the interviewees and their linkage to the automotive industry is presented in Table 3.1.

*Table 3.1: Interview*

| Interviewee | Motivation of interview |
|---|---|
| 1. Research Associate | Head of Structural Report for the Stuttgart Region |
| 2. Innovation Manager | Works at the interface with startups and manages an innovation competition |
| 3. CEO and Founder (Startup 1) | Startup started as an in-house innovation in collaboration with a car manufacturer |
| 4. Co-founder (Startup 2) | Startup is involved in AI production processes of car manufacturers and its suppliers |
| 5. Co-founder (Startup 3) | Startup provides an automated information distribution in production processes of car manufacturers and its suppliers |
| 6. CEO (Startup 4) | Startup develops AI robots that support production of car manufacturers or could possibly be produced by car manufacturers in the future |

The basic characteristics of the startups can be found in Table 3.2.

*Table 3.2: Interviewed startups*

| Company | Founding Year | Market(s) served | Focus | Marketphase |
|---|---|---|---|---|
| Startup 1 | 2018 | B2B | Internal communication tool | Established and growing at fast pace |
| Startup 2 | 2019 | B2B | AI production assistants | Searching for market-solution fit, while establishing right scale and channels of the company |
| Startup 3 | 2018 | B2B | Automated and intelligent distribution of information in production | Developing channels in order to validate product and scale the company |
| Startup 4 | 2015 | B2B/B2C | AI and AI robotics | Finding the right product-market fit |

## 3.3 Analysis of Qualitative Data

The collected data is qualitative, hence it consists of non-numerical and unstructured data. *Framework analysis* is used as a tool to analyse the collected data. In the 1980s, the British National Center for Social Research developed the concept of framework analysis as a systematised data evaluation method (Dunger and Schnell, 2018). The structured organisation of the data, as well as their analysis in the framework, is based on the desired traceability and thus contradicts an often formulated criticism of qualitative research (Lamnek, 2005). In its systematics, it has some similarities with methods of content analysis (Mayring, 2010) and thematic analysis (Smith and Firth, 2011). However, Ritchie et al. (2013) argue that framework analysis emphasises the transparency of data analysis and presents the linkage between the steps of the analysis better than simple thematic analysis.
The framework analysis is of great value since it is applicable to written data, such as transcripts of interviews (Ritchie et al., 2013). Ritchie et al. (2013) divide the process into six steps: (1) familiarisation, (2) identify recurring and important themes, (3) indexing, (4) structured charting, (5) analysing, and (6) interpretation.

1. The first step of the analysis aims to become familiar with the data. To achieve this, the material is read repeatedly. This step provides the base for the entire analysis.

*Table 3.3: Key-themes and sub-themes of data organisation*

| Key-themes | Sub-themes |
|---|---|
| Cooperation | a) Innovation platforms<br>b) Linkages to car manufacturers<br>c) StartupAutobahn |
| Market phase | a) Searching for a problem-solution fit<br>b) Searching for a product-market-fit<br>c) Searching for channels<br>d) Pour on the resources for growth<br>e) Maturity- growth through acquisition and internal expansion |
| Negative Drivers | a) Macro level<br>b) Meso level<br>c) Micro level |
| Positive Drivers | a) Macro level<br>b) Meso level<br>c) Micro level |
| Personal Drivers | a) Dissatisfaction with previous work<br>b) Enthusiastic and hardworking |
| Obstacles | a) Budget restrictions<br>b) Company internal obstacles<br>c) Political complexities |

2. In addition, key- themes and sub-themes are derived from recurring themes,

each of which can be assigned to one another as categories and characteristics. The chosen categories are presented in Table 3.3.

3. In this step of the analysis, the identified topics or categories and subcategories of the topic matrix are stored with original citations. For this purpose, all transcripts are scanned and citations are assigned. A double assignment of text passages and also the adjustment of the topic matrix is possible. Part of this step is presented in Table C.1, C.2 and Table D.1 in the Appendix.

4. The goal of this step is to create the final framework. The procedure is divided into three substeps:

   (a) The topics for the tabular summary are defined. The topics of the further evaluation are taken from the already created topic guide (Table 3.3) and are further refined. This serves as a basis for creating the thematic charts.

   (b) In order to design the case charts, a table is created for each startup case. The subtopics are assigned from the created topics and quotes are assigned in a row. The outcome of this step is respectively represented in Figure 4.1, 4.2, 4.3 and 4.4.

   (c) In the next step, all charts are combined into one central chart. Hence, the development of the charts results in the central chart. In this chart, following the same structure, the summaries of the individual participants from the case charts are considered for all categories. Thus, the central chart represents a summary of the previous theme-based category development. This is a necessary step that is a prerequisite to develop the final Figure 4.6.

   Finally, the entire framework consists of the thematic charts and a central chart. It completes the data organisation in terms of reduction and structuring.

5. The thematic analysis and group analysis takes place in the sense of further abstraction. Classifications beyond the individual case are identified, connections between occurring topics described and the dimensions of the categories presented. In addition to the summaries in the central chart, the present study collects "terms and topics" that occur during the analysis process. These are used in the analysis phase as a point of reference to compile overarching aspects of the question. This conceptual work using the framework, charts or graphics is the preparation for the interpretation that is explained in step 6. At the same time, these steps merge into each other.

6. In the last step of interpretation, phenomena and typologies are generated and justified. For this purpose, comparisons between the participants and what they state are drawn, but also theoretical basic assumptions are included. During this process, the participants' descriptions are reassessed after identifying links and themes are. Connections are confirmed and new ones are found and recorded. This step is repeated until no new connections are detected. This process indicates the necessity for a separate figure regarding the dynamics between startups, car manufacturers and StartupAutobahn (see Figure 4.7).

## 3.4 Limitations

Yin (2017) argues that case studies are often disdained due to inaccuracy of procedure and lacking system. Furthermore, external validity, hence applying findings outside of the context of that study is a common concern regarding case studies (Yin, 2017). However, case studies are useful to expand, confirm or generalise theory rather than generalise assumptions to entire populations (Yin, 2017).
Moreover, snowball-sampling may lead to a potential bias. It is not possible to determine the sampling error or conclude statistical inferences due to the lack of random sampling (Biernacki and Waldorf, 1981). Furthermore, it is not possible to identify an actual pattern since the sample is not guaranteed to be representative of the population (Noy, 2008).
However, it is ensured that the startups originate from diverse backgrounds, are not interconnected by any business linkages and follow different launching approaches and are facing different phases of establishment to determine a broad frame. Additionally, restricted business activities due to Covid-19 and thereby, usual point of contacts, such as fairs con currently not take place, results in limitations to acquire startups in other ways than the conducted snowball-sampling.
Moreover, it is challenging to distinguish the transformation pressure into positive and negative drivers. Since drivers can stimulate on various levels and also trigger different effects, it may not be conclusive whether it can be determined as a positive or a negative driver. It can stimulate negative drivers to arise on one level, whereas it promotes positive transformation pressure on another level. The determination of the indication needs to be done thoughtfully and some drivers cannot be exclusively identified as one or the other. The interpretation of the drivers is performed within their context and from various perspectives.
Furthermore, Yin (2017) suggests three factors to evaluate the quality of case studies: (1) construct validity, (2) external validity, and (3) reliability. These instructions are followed by (1) using multiple sources of evidence and conducting a case study with startups from various backgrounds that still have certain characteristics in common. Second (2), external validity is increased by using Geels' MLP as a theoretical framework. Due to a restricted number of sources, internal and external validity are covered sufficiently when having followed the former two steps. Lastly, (3) by transparently presenting each step of the study with protocols as well as recording and transcribing the conducted interviews, reliability is ensured.

### 3.4.1 Participant Bias

A bias can stem from the participants responding to interview questions based on what feels like the right or appropriate answer (Chenail, 2011). Hence, participants may aim for socially acceptable answers rather than the truth and just agree with the researcher. Therefore, questions are framed in an open and neutral manner without judgement (Chenail, 2011). The questions are phrased in a way that allows the interviewee to feel accepted. This is further supported by indirect questions that refer to a third party, thereby allow the participants to project their opinion.
Another potential bias can occur when the interviewee becomes less engaged due to similarly-phrased questions (Chenail, 2011). Therefore, questions are worded in different ways and encourage engagement throughout the whole interview.

### 3.4.2 Researcher Bias

According to Oleinik et al. (2014), qualitative studies performed by a single researcher may be subjective in terms of coding and the general analysis of the data. It can be concluded that a researcher introduces bias to a study, however, the systematic approach and methodology this study follows may alleviate some of the bias. Furthermore, Creswell (2002) argues that the researcher's bias is shaped by gender, culture and socioeconomic background.
Due to her upbringing in the Stuttgart Region and working in an economic research institute that focuses partly on the structural development of the Region, the researcher naturally identifies with the subject of study. Being born in 1995, the researcher is part of "Generation Y", that is the first generation that grew up with the internet, online communication and constant change (Hopkins et al., 2014). This generation is also known to show changing patterns of mobility behaviours, moving away from cars to rather sustainable alternatives (Hopkins et al., 2014). This background may contribute to incorporate preconceived notions to the research. The bias is minimised by working with a coding scheme and a systematic methodology.

# 4

# Empirical Analysis

The empirical findings are presented and analysed, to answer the research question of **how innovations are shaped in the automotive sector in the Stuttgart Region**. Furthermore, the two sub questions on **to what extent are the innovations creative responses to opportunities, or driven by problems** and **how innovation activities are shaped by innovation competitions** are investigated.
First, Section 4.1 presents and frames the results of the startup-interviews within the MLP. Furthermore, positive and negative drivers of startups are outlined and evaluated. An inclusive approach is chosen in the empirical part, in order to analyse driving factors of innovation in the automotive regime in the Stuttgart Region. Hence, external driving forces and internal drivers that have impacted the innovation are investigated and interpreted in their correct historical setting within the frame of a MLP.
Moreover, Section 4.6 presents the identified main drivers and explains them in their context. This supports the indication of drivers to the respective levels (see Figure 4.7) and enables mapping into positive and negative transformation pressures. Nevertheless, it must be remembered that the nature of a driver depends on where the stimulated agent is located and may be of negative nature for the situation of one agent while positively influencing another agent.
Lastly, subsection 4.2.2 presents and elaborates the dynamics that are stimulated by linkages and collaborations between startups and embedded actors of the sociotechnical regime.

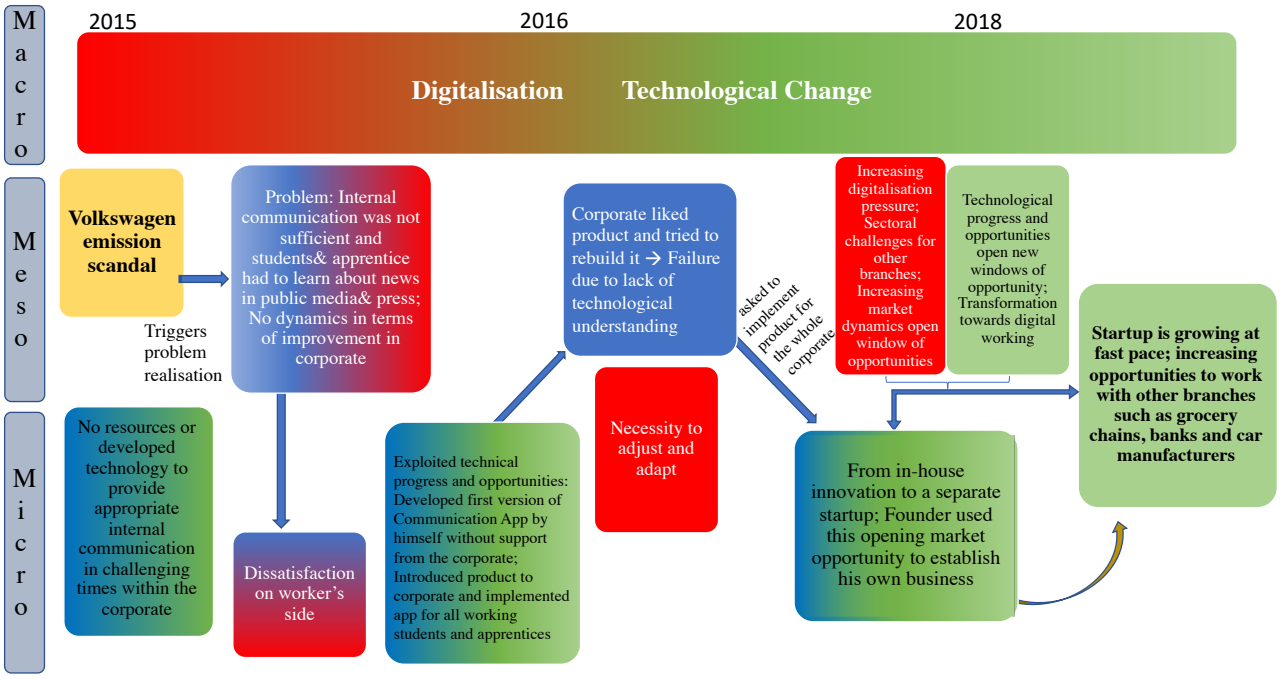
## 4.1 Startup Cases in the Analytical Framework of the MLP

The following subsections explain the development process of each startup and present driving forces, categorised into the macro, meso, and micro level. Both large car manufacturers from the Stuttgart Region, Daimler and Porsche, hold innovation competitions in which startups can participate. This is also a common practice for other large firms that are part of the automotive regime in the Stuttgart Region. These interconnections are outlined and further evaluated. Figure 4.1, 4.2, 4.3 and 4.4 present a MLP-framed description of findings with regard to the origin and development of the innovation and its drivers in a temporal context. The respective

starting point or original trigger is highlighted in yellow. Direct linkages, sequences and ongoing processes are represented in blue. Transformation pressure or events that can be categorised as a driver are indicated in red (negative drivers) or green (positive drivers). General tendencies of growing in the market or leaving the market are presented with yellow arrows. The macro, meso, and micro levels are emphasised on the left-hand side. Nonetheless, one has to keep in mind that this is a fluid transition that does not have strict borders and the figures show only tendencies of the respective levels. The respective interviewee is abbreviated with SI (Startup Interviewee)

### 4.1.1 Startup 1

*Figure 4.1: MLP of Startup 1*




*(Explanation of colours can be found in the introduction of this section.)*

#### Background

Startup 1 was referred from the innovation manager of the car manufacturer and started as an in-house innovation of the respective company. Its innovation is an application that enables workers and employers to communicate and resolve human resource (HR) processes such as applying for holidays. It follows a similar concept as Facebook but the application is adjusted and limited to the client firm. Hence, this innovation is a new combination of technology and complements traditional ways of communicating. Figure 4.1 represents the findings framed within a MLP.
The interviewee was working with a car manufacturing corporate at the time when the Volkswagen emission scandal took place which left him feeling highly dissatisfied by the limited information the corporate provided the employees, especially working students and apprentices with. However, after approaching the IT-manager,

no consequences were drawn as the corporate claimed not to own enough resources to change anything. This triggered the interviewee to develop a product himself, establishing the first version of the innovation. This was a communication application adjusted for working students and apprentices that helped to stay up to date with dynamics of the firm, news, internal communication, and enabled simple HR-processes. After presenting it to the board of directors, he was allowed to implement the application for the stated target group. However, the management board decided to develop its own internal communication application. The attempts to reproduce the innovation failed and the board approached him to develop and implement the application for the whole company. He decided to take the offer starting and developing his own business as well as the innovation itself further. The business was officially founded in 2018 and has gained 30 employees until now, which it intends to double by the end of this year.

**Analysis**

Startup 1 is triggered by a concrete problem: insufficient internal communication. The macro level plays an important role in this context. Digitalisation and technological change cover both, negative transformation pressure and positive, enabling drivers. Hence, digitalisation pressures corporations to change to digital solutions and improve working equipment and resources. Nowadays, media, press and news are independent of printing and, thanks to connectivity and digitalisation, allow a minute-accurate update of information. Therefore, employees, especially from big corporations might learn about news and happenings regarding their employer from the media rather than from the corporate itself. This signs a lack of internal communication and too long communication ways. Hence, resources to provide appropriate internal communication are either not available, unused or the necessary technology is not sufficiently developed.
The interviewee develops a novelty to improve communication, which is enabled by the positive sides of digitalisation, hence technical progress and opportunities. After implementing this innovation for working students and apprentices, the corporate feels the necessity to adjust and adapt, hence experiences further pressures to seek technological progress concerning their company communication. However, due to a lack of knowledge regarding digital solutions and technology, rebuilding the product fails. This opens up a window of opportunity for the niche innovation that has only been implemented for a limited amount of employees yet. Furthermore, increasing digitalisation pressure that also enables various niche innovations that challenge the current sociotechnical regime trigger sectoral challenges for different branches and increase market dynamics (Dispan et al., 2017). These dynamics, together with technological progress and opportunities, open new windows of opportunities and drive a transformation towards digital solutions. Startup 1 grows rapidly due to increasing demand and sectoral imbalances, which are not only observed in the automotive industry.
The ranking presented in Figure 4.5 is in line with this analysis. It depicts that *finding a solution for a problem* is ranked as the main driver of Startup 1, followed by *technological progress* that enables the innovation. *Market opportunities* take the third rank, whereas *institutionalised search for improvements* takes the last place. The interviewee stresses that problem-oriented working is necessary in order to develop a successful innovation that can leave the niche-market and provide solutions

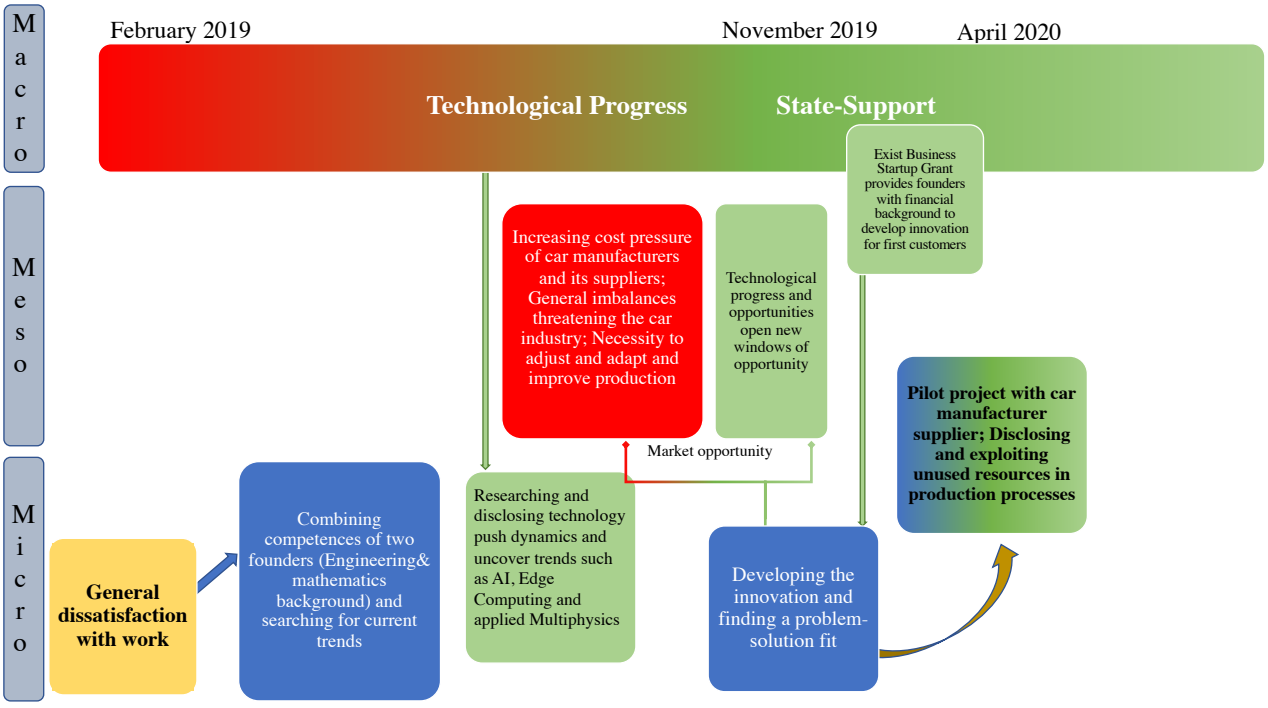
for various customers. He also underlines the lacking knowledge for digital solutions and technological progress of car manufacturers. Therefore, technological progress is ranked higher than market opportunities.

### 4.1.2 Startup 2

#### Background

Startup 2 realised an innovation that develops intelligent data collection and evaluation. This novelty creates new insights in so far unknown conditions of material and machines during the manufacturing process. The data insights are used by employees for optimal material processing results and are therefore used in a complementary manner to existing production processes and seek to improve them.
This business idea was personally motivated due to dissatisfaction of previous employments. The founders brainstormed within their combined knowledge field of engineering and mathematics and analysed technological trends and progress, which led them to the field of Edge Computing, Artificial Intelligence (AI) and Applied Multiphysics. After developing the novelty and finding market opportunities, the founders were awarded the EXIST Business Startup Grant and were supplied with financial aid and consulting support. This enabled the founders to develop the innovation further and find the right problem-solution fit. Currently, they are successfully running their first pilot project with a car manufacturer supplier.

*Figure 4.2: MLP of Startup 2*




*(Explanation of colours can be found in the introduction of this section.)*

#### Analysis

As Figure 4.2 displays, Startup 2 differs in its original trigger and progression of events, compared to Startup 1. The founders were generally dissatisfied with their

employment situation and systematically searched for trends and analysed the market situation. By disclosing niche innovations that are currently developing and growing at a fast pace, such as AI, Edge Computing and Applied Multiphysics, the founders combined their different knowledge and developing a novelty. Meanwhile, the automotive industry is facing increasing cost pressure and increasing sectoral competition, which forces the manufacturers and suppliers to adjust and adapt its processes and improve the efficiency of their production. Hence, a market opportunity for incremental and complementary innovation is opening. However, this is only possible due to technological progress and therefore, *technological change* is ranked as the main driver of this novelty. Followed by *market opportunities* that enable the innovators to uncover problems, manufacturers are facing and find a problem-solution fit for them.
The landscape pressure is hereby mainly of positive nature. As mentioned before, technological progress and change is the overall enabler of the novelty. By supporting founders with an EXIST Business Startup Grant, the state enables innovators to develop their product thoughtfully and with enough resources, while being financially independent. Hence, this can be categorised as a positive driver that is somewhere between the macro-, and meso level and pushes niche innovation positively.

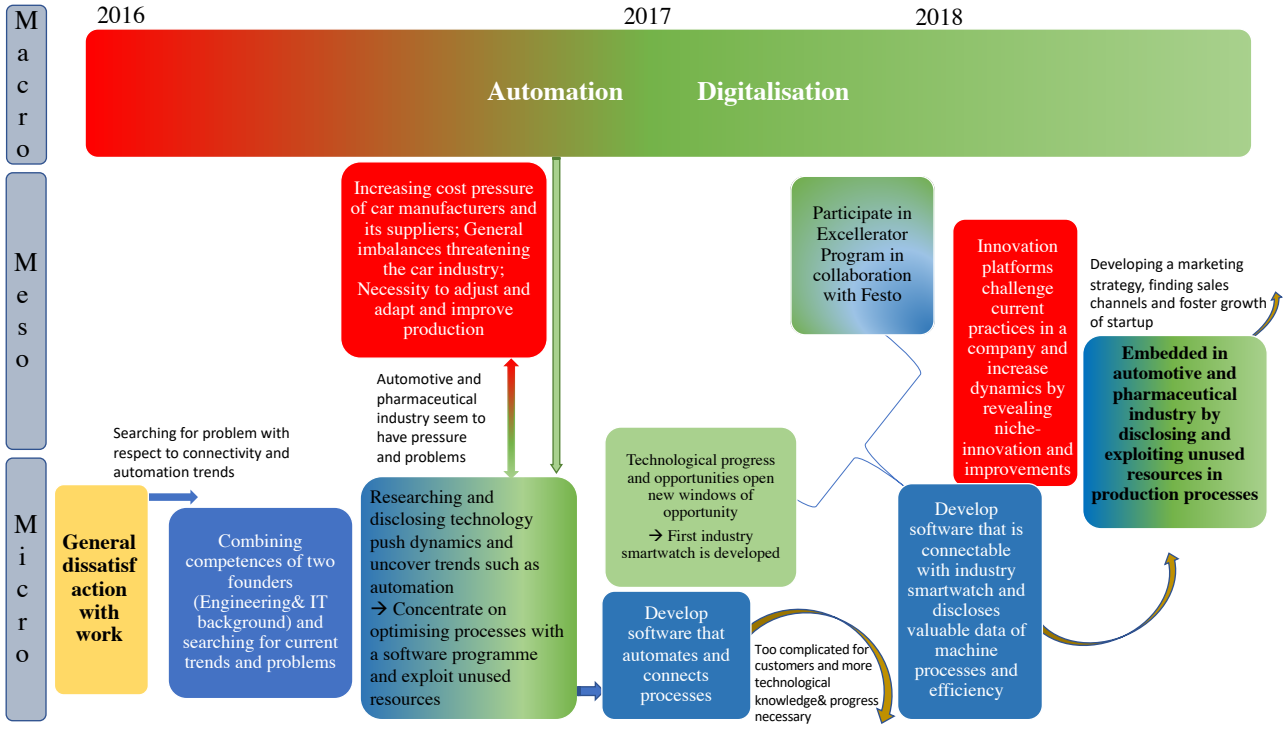
### 4.1.3 Startup 3

#### Background

Startup 3 introduced an intelligent organisation solution that decentralises communication on a shop floor and delivers summarised information to the right place. The novelty accounts for a system that optimises the human-machine interaction, prevents silos, enables automated prioritisation and delivers real-time data for decision-making processes. Furthermore, Startup 3 combined its software with the corresponding hardware, an industry smartwatch. This novelty is not only a new combination of technologies, it also complements existing production processes and aims to improve their efficiency.
Originally, the two founders of Startup 3 were not satisfied with their previous workplace and urged to become self-employed with a technological novelty. By combining their competences, engineering and IT management, the founders searched for challenges, problems and trends concerning automation as well as connectivity. They uncovered the increasing cost pressure car manufacturers are facing and investigated the need for efficiency improvements regarding the production processes. They found similar needs in the pharmaceutical industry. The founders developed software that automates and connect processes and machinery. However, due to the lack of technological knowledge and the complexity of the software's first version, the innovation is not successful and is pushed out of the market. The founders continued with their idea and participated in the *Advanced Innovation Competition* that is held by Festo, a German engineering-driven company that is based in the Stuttgart region and focuses on pneumatic, as well as electrical control and drive technology for factories or process automation. The Advanced Innovation Competition was a successful experience and they were supported by an innovation counsellor and started concentrating on combining their software with actual hardware. This is enabled by the first industry smartwatch that appeared on the market in 2017. This concept of the industry smartwatch was focused on the needs a watch needs

to fulfil in an industrial environment, such as dust and water resistance. At the innovation competition, the concept of the industry smartwatch was further elaborated and the founders developed a complementary software that discloses valuable data of machine processes and efficiency. The interviewee states that the innovation is greatly embedded in the automotive and pharmaceutical industry and supports production processes by exploiting unused resources and increasing connectivity of machinery and employees. They scanned other industries such as the hotel industry and hospitals for further market opportunities. Nevertheless, since the developed software concentrates mainly on machinery communication and connectivity, these branches do not seem to fit yet.

*Figure 4.3: MLP of Startup 3*




*(Explanation of colours can be found in the introduction of this section.)*

## Analysis

Again, personal dissatisfaction and ambitions are the main trigger of the targeted search for innovation. The cost pressure and sectoral imbalances, the automotive industry is facing, is opening various opportunities for process optimisation innovation. By revealing this problem on one hand, while understanding current technological developments, both negative and positive drivers shape the development of this novelty significantly. After developing a software that is still too complex and needs more technological understanding and prerequisites on the side of the customer, Startup 3 is using synergies from a corporate by participating in an innovation competition. There, they are provided with counselling, financial aid and a first opportunity to test their novelty. Just before, technological progress in form of a niche innovation, an industry smartwatch, is developed and enables a complimentary usage of the previously developed automation software with the newly developed industry smartwatch and therefore shapes the innovation significantly.

This leads to a new combination and a complementary novelty that is successful. Market opportunities are opened by formerly mentioned cost pressure the industry is currently facing and the necessity to adjust and adapt production processes.
In the ranking of major drivers, the interviewee explicitly states that *finding a problem* that needs to be solved is a crucial driver to find customers in the end. He further states that a *market opportunity* is necessary as well, since one needs to solve problems for various actors or customers to place itself on a market. However, even though without *technological progress* his novelty would not exist, he indicates it as an enabler and not as a driver that pushed the innovation forward.

### 4.1.4 Startup 4

#### Background

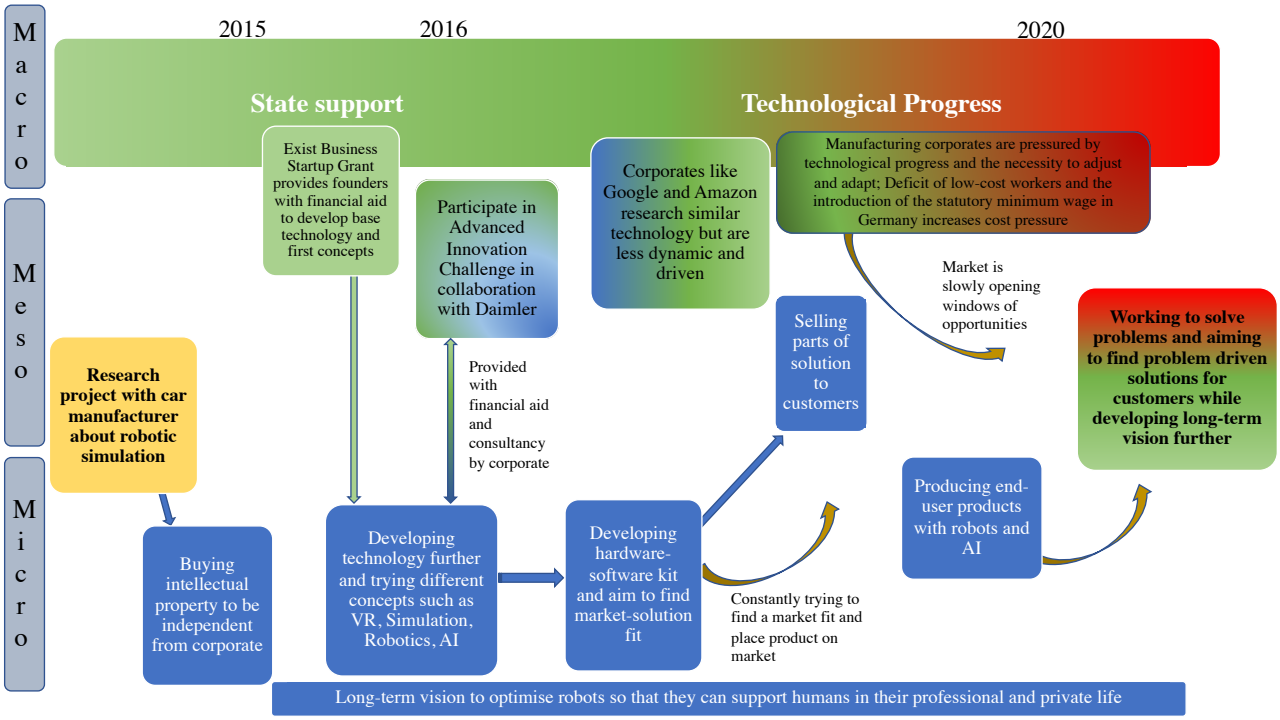
This innovation finds its origin in a research project with a car manufacturer from the Stuttgart Region. Initially, the project focused on the simulation of robotics technology. However, after becoming independent from the corporate, the founders focused on actual robots and their features. Financially supported by the EXIST Business Startup Grant, the technology and business plans were further developed. After participating in the Advanced Innovation Competition, held by Daimler, the founders developed a hardware-software-kit of robotic solutions. However, the interviewee states that there is no market for robots yet. Few corporations like Amazon and Google research in this direction, but there are no developed products on the market yet. Therefore, it is complicated for Startup 4 to find a market fit, and place its innovation on a market. Since the startup also developed technologies like Virtual Reality (VR), simulations and AI, it is able to sell these technologies as parts of a 'complete product'. Furthermore, the founders are using their robots and hardware to produce end-user products themselves, e.g. during the Covid-19 crisis they were able to change their production to masks with a protection shield within a few days. In addition, they were producing faster and cheaper than the human workforce was able to. The founder's long-term vision is the optimisation of robots, so they can support humans in their professional and private everyday life.

#### Analysis

Since the innovation was established as an in-house novelty and research project of a car manufacturer, the linkage to the automotive industry is obvious and further strengthened by participating in an innovation competition, held by Daimler. Especially at the start of the innovation's life-cycle, the macro level is of positive nature for the startup, due to technological progress and financial aid, that is provided by the EXIST Business Startup Grant. These drivers encourage the founders to create a solid technology before entering the market. Therefore, the interviewee ranked *institutionalised search* as the original main driver of the product. Due to a long research process, the innovation is relatively far developed and the founders are able to sell parts of it already. However, especially at the time of the foundation, there is no market for robots in Germany yet. The founders try to find a window of opportunity and analyse the market thoughtfully. The interviewee states that due to increasing cost pressure manufacturers are facing and the fast changing technological standards, the market for robots are slowly opening and corporations become

more interested in the innovation. He further states that by using robots instead of production workers, Germany could save its place as an important production and business location worldwide.

*Figure 4.4: MLP of Startup 4*



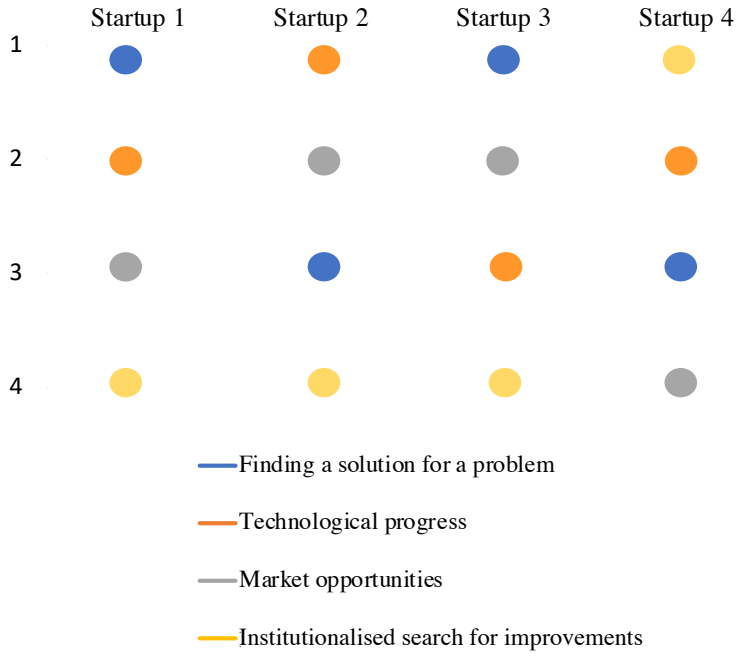

*(Explanation of colours can be found in the introduction of this section.)*

*Technological progress* is stated as another important driver that enables the development of this specific novelty. It is followed by *finding solutions for a problem*. Moreover, the interviewee states that this is currently becoming a more important driver in shaping their products and may overtake the other two drivers in the future. Last, he ranked *market opportunities*, since no established market for robots exists yet.
The founders' long-term vision is the optimisation of robots, so they can support humans in their professional and private everyday life. Even though there is no established market for it, manufacturing corporations are financially pressured by technological progress and feel the necessity to adjust and adapt.

## 4.2 Main Drivers

To uncover the main drivers of innovation, the SIs are asked to evaluate and rank four main drivers of innovation. Moreover, in the last interview-question, all interviewees are asked to construct an innovation equation with all drivers that are necessary to obtain a successful innovation at the end (results can be found in Appendix C.2). By asking this as the last question of the interview, it allows the interviewees to reflect and emphasise the main message they wanted to send during the interview. Furthermore, the general tendency of the interview is included in the evaluation of

*Figure 4.5: Ranking of drivers*




this question.
Figure 4.5 presents the ranking of the four drivers: (1) Finding a solution for a problem, (2) Technological progress, (3) Market opportunities, and (4) Institutionalised search for improvements. The graph shows a diverse picture, therefore it is necessary to interpret the results in the context of the specific case. Drivers that are outlined by the interviewees are presented in Table C.1 and Table C.2. They are categorised in positive and negative drivers, according to the context of the quote and are further assigned to their respective level of action. Furthermore, Figure 4.6 outlines the MLP of the investigated mechanisms.
Figure 4.5 shows that *finding a solution for a problem* is ranked as the main driver twice. In contrast, *institutionalised search* is ranked as the last driver in three out of four cases. According to the interviewees *institutionalised search* seems to be more suitable for large enterprises and not startups that develop a novelty with a restricted budget. Furthermore, SI 4 states that their drivers are different now, but due to a very scarce developed technology and financial support of the EXIST Business Startup Grant, it was necessary to systematically research the technology and novelty first, therefore, institutionalised search is ranked as number one, whereas these days they are mainly driven by solving problems with their product.
It stands out that *technological progress* is only once ranked on place three, otherwise it is ranked on second place twice and even as the main driver in case of Startup 2. All interviewees agree with the fact that technology was a necessary enabler for their innovation and without technological progress, there would neither be an existing market for their product, nor a product itself.
*Market opportunities* always lack behind other main drivers but are still ranked as somewhere medium-to less important. Startup 2 and 3 even rank it in second place. SI 1 states, that "when someone is solving a problem, that is a big pain to someone

else, then there will always be a market for this solution". SI 4 argues that "market opportunities are fluid and markets are changing rapidly", therefore, he does not believe in it as a major driver. Further, he states that the product should ideally be existing by the time the market opportunity opens up.

Moreover, the innovation equations disclose that the SI 1-3 all name problems as a necessary driver in their equation. However, SI 4 states, after further enquiries, that as long as enough technological knowledge is provided, one will find a problem to solve. This underlines the different patterns startup 1-3 and 4 followed. Startup 1-3 all emphasise a problem they seek to solve, whereas Startup 4 developed the technology for years before even looking for a problem or market fit. However, when interpreting these results, one has to keep in mind that the startups all differ in their technology and development phase, thus it cannot be correctly compared. Nevertheless, SI 3 constructs a very interesting equation that underlines the relevance of a problem as a driver and that technology is only a potential driver "to speed the process of innovating up" (SI 3).

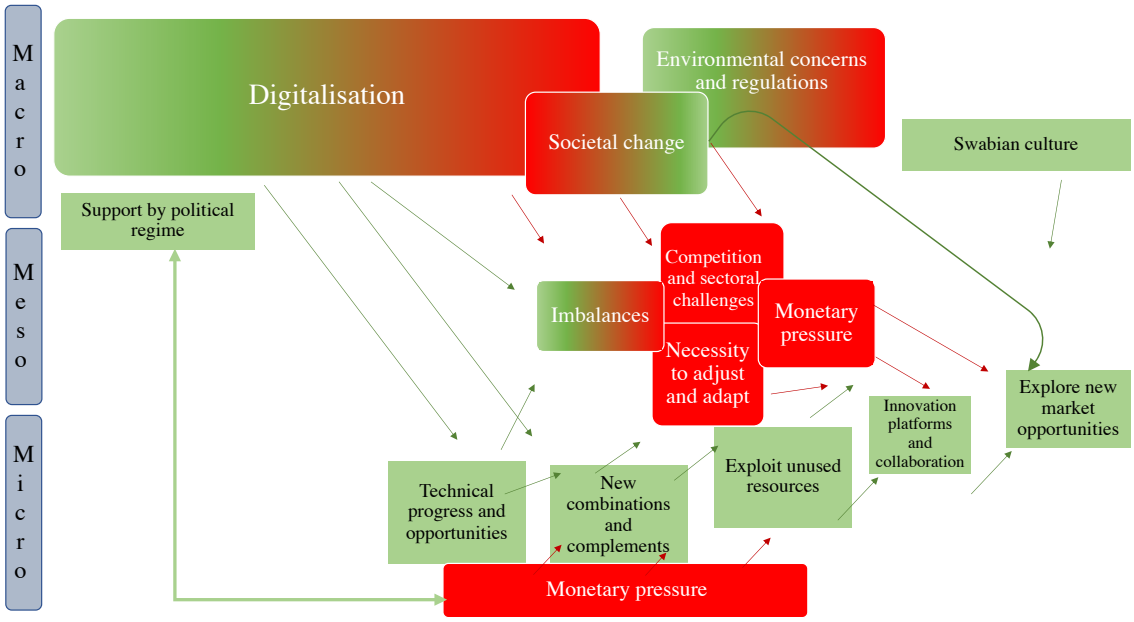
$$Innovation = (Problem\ worth\ solving + Mindset + Freedom\ to\ act) * (1 + Technology)$$

The equation stresses with the term $(1 + Technology)$ that technology is not a necessary prerequisite for innovation and even if it takes the value 0, innovation can still be created. Nonetheless, according to the interviewee, it can speed the process up or make the innovation more successful.
Other inputs, the interviewees are stressing on are personal traits and the freedom and opportunity to engage in developing an innovation and building a business structure around it. SI 1 sets up two different equations, one for corporations and one for startups. This is an interesting point due to his former experience. He stresses explicitly on innovation pressure and problems a corporate needs to face, in order to innovate. Furthermore, he states general change of the ecosystem around the corporate and speed within the company as necessary drivers.
The innovation manager stresses on openness and transparency. He also emphasises that other markets and branches should be constantly screened for new technologies. According to him, other significant inputs are "communication between actors" and "partnerships and collaboration". Since he works at the interface with startups, it seems obvious that he stresses on linkages between startups and car manufacturers. This will be further elaborated in section 4.2.2.

### 4.2.1 MLP on Drivers

Figure 4.6 categorises the drivers into negative transformation pressure (red) and positive enablers and drivers (green) while distinguishing between the macro, meso and micro level. The arrows are indicating whether the movement that is triggered is of positive (green) or negative (red) nature. It has to be kept in mind that the arrows only emphasise the direction and general ruptures, triggered by certain changes, and do not present direct linkages or sequences. Furthermore, Table C.1 and C.2 in the Appendix present the analysed quotes in context of drivers and levels.

*Figure 4.6: MLP on drivers*




*(Red: Negative driving forces*
*Green: Positive driving forces)*

### Macro level

Great emphasis is put on digitalisation throughout all interviews. It is always named as an enabler of technological progress and a prerequisite for the developed innovations. Digitalisation may be of positive nature for the micro level, hence, in this case: startups. SI 2 argues that "to a certain extent digitalisation emphasises the goal of making things more efficient and that's where our innovation comes in". As outlined in Figure 4.6, digitalisation pushes and enables technological progress and opens opportunities. This positive transformation pressure mainly stimulates the micro level. New technologies allow to exploit unused resources or find new combinations of technologies such as Startup 3 did with their combination of newly developed software and a novel hardware, industry smartwatches. Nevertheless, digitalisation also puts transformation pressure on corporations. Since corporations operate on a much larger scale and are less dynamic and flexible in their processes, the fast changing technological environment makes it difficult for large corporations to keep up with the speed and develop their processes in line with the environment. This triggers technological imbalances, as well as economic imbalances. Therefore, they are forced to progress; collaborating with other firms is one way to push progress and challenge former processes. SI 1 outlines that "[f]ear of digitalisation and technology enables cooperation" between startups and car manufacturers. Hence, it triggers a window of opportunity for niche innovation by pressuring the sociotechnical regime with technological imbalances.
Furthermore, digitalisation changes society and its preferences. To emphasise these dynamics and understand drivers emerging from the macro level better, further research on digitalisation regarding the automotive sector is put in the context of this study's findings. Digitalised and connected products are demanded more than ever and the digital preferences are also observed in cars. Viereckl et al. (2015) state

that the way people think about cars is changing fundamentally and car manufacturers are challenged to transform into mobility-service providers rather than just car manufacturers. Hence, the perception of cars is changing significantly. Moreover, the public awareness of problems associated with the automotive industry is increasing (Whitmarsh and Köhler, 2010). International climate movements like *Fridays for Future* emphasise the rising concern about climate change and stress the changing priorities of society, especially of the younger generation. Society appears to acknowledge the link between the automotive industry and climate change (King et al., 2009). The changing behaviour is spurred by various EU emission reduction policies for automobiles. Among other things, a car labelling regarding the energy efficiency impacted both, the supply and demand side of the automotive industry (Whitmarsh and Köhler, 2010). Whitmarsh and Köhler (2010) argue that the most effective policies to decouple greenhouse gas emissions from transport are those that exploit and promote competitiveness within the automotive industry. This promotes alternatives to high emission vehicles while being perceived as fair to the consumers. Interestingly, labelling new vehicles seems to have a great impact on environmental innovation on the supply side, because it stimulates competition between car manufacturers. The additional labelling information simplifies the complex decision-making process of consumers on vehicle choice (Whitmarsh and Köhler, 2010). SI 4 argues that "[i]deas and solutions will be greatly shaped by challenges such as environmental pressure. This will lead to more cooperation between startups and corporations in order to find innovation". In this context, SI 1 stresses that "market pressure and pressure on the society to change" will enable niche innovation to enter the market. SI 2 details that the "aim to increase quality and reduce waste, that is also an important step towards sustainability" (SI 2). Hence, their products embody incentives towards a sustainable change of production processes.
To summarise, environmental regulations contribute to societal preferences change and increase sectoral imbalances and competition. Therefore, negative transformation pressure is pushing the sociotechnical regime of the automotive industry.
Moreover, SI 4 argues that the Swabian culture shapes the development of niche innovation significantly. It argues that "[i]n Swabian there are actually many who first build up a foundation and create a basic technology before they enter the market and generate revenue. A real Swabian working mentality". This statement supports a stereotype that may be expressed in portraying the Swabians as frugal, clever, entrepreneurial and hard-working. Categorised as culture, therefore a landscape trait, this working culture could be a potential driving force on a personal level of entrepreneurs and be an advantage for the development of innovation.
Another positive driver is the monetary aid that is entailed by the EXIST Business Startup Grant. EXIST assists students, graduates and scientists from universities and research institutes who intend to realise their business idea in a business plan (EXIST, 2020).

### Meso level

These changes and movements on the landscape level pressure the meso level massively and lead to various problems. As stated above, car manufacturers are facing high competition and sectoral challenges. "The car manufacturers have been on unbelievable cost pressure, and accordingly they are looking for every second they

can squeeze out" (SI 3). SI 1 further argues that "car manufacturers realised 10 years ago 'okay we have to do something'[...] and suddenly you can implement a novelty into a company". Moreover, he states that "it all depends on the innovation pressure the industry is facing and also how badly the industry is threatened". This underlines the necessity to adjust and adapt to new technologies. Another weak point the sociotechnical regime is facing are imbalances of technological knowledge. SI 1 argues that the car manufacturers "know the structures well, but they know nothing about the current technology and that's a huge issue for them". This underlines the necessity to collaborate with startups and watch out for niche trends arising. Collaboration is also promoted by various innovation platforms and challenges. SI 3 argues that "if the programme is established in an appropriate way, both [startups and corporations] can benefit from it". SI 1 argues that it pushes dynamics in a corporate by "questioning the status quo in a concern". He further argues that "[f]or the first time [the CEO of a company] has to think about how valuable the things are he is doing. And he has to defend it and this process alone is of great value for the company". This is of benefit for both startups, as well as corporations. Corporations are challenged and departments have to defend current practices, thereby, running processes are examined and reviewed. By introducing innovation, current practices are challenged and may be replaced or complemented by novelties. Therefore, innovation competitions present a great platform for niche innovation to be recognised by large corporations.
Furthermore, the technological maturity of a company seems to be of importance. SI 3 argues that a corporate needs to be technologically developed to a certain extent to make it "economically profitable to implement systems like ours". Hence technological progress needs to enable opportunities within the corporate itself. SI 2 also emphasises that he was looking at current trends in the automotive sectors and then "decided to develop something in the field of data science and complex technology in context of new trends". Hence technical progress on the meso level opens opportunities and enable niche innovation to arise.
The sociotechnical regime also enables new combinations and allows for complements on their existing technology. SI 4 argues that "corporations realise that simulation technology is close to experiments these days. It adds value to current processes, but it is much cheaper to conduct a simulation than an experiment". This allows the Startup to complement processes in a corporate and leave the niche market to operate on the meso level. However, complements and new combinations can also arise from the niche level, as seen in the case of Startup 3, which combines their newly developed software with industry smartwatches to improve communication between machinery and workers. A similar example happens in case of Startup 1, where a newly developed internal communication platform complements and replaces former communication tools such as email. Since the platform itself is similar to current social media applications like Facebook, it can also be interpreted as a new combination, thus the concept of a social media platform and internal business communication, that has evolved along a technological trajectory.

### Micro level

The micro level accounts for mainly positive transformation pressure, such as the exploitation of unused resources. SI 3 stresses in this context that their innovation

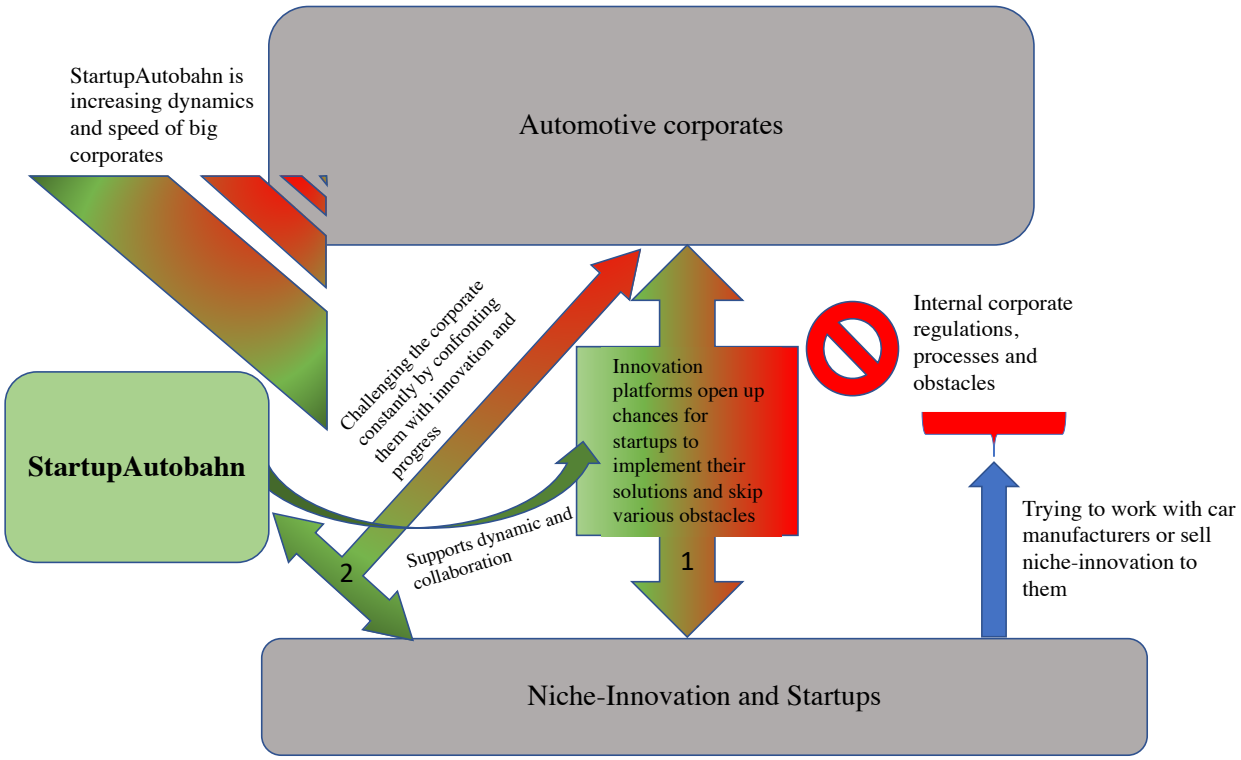
is like "an automation cookbook. One can choose a production process that you can optimise with our software". SI 2 states that "with our technology one can track the machine load and send collected information to the plant manager". With these technologies, current performance can be optimised and resource-use improved. Another positive driver that is revealed during this research is the exploration of new market opportunities. SI 2 states that their "technology did not penetrate the market yet, so it is definitely a good time for this growth to begin and to invest in this technology". SI 3 outlines the development process with their customers and the process of exploring a market opportunity together with a customer, "[o]ur original idea always developed relatively strongly towards customers. And in the end, the product we have now is significantly shaped by our customers and their feedback". However, despite these positive drivers, the micro level is also facing negative drivers. This is mainly monetary pressure, but SI 4 outlines this partly as a chance by arguing that "when you are not backed up by a corporate and infinite money, then you have higher pressure to innovate and find cheap and efficient solutions". Hence, Startup 4 stresses that monetary pressure can increase efficiency and dynamics and is, therefore, an advantage compared to the stagnant processes of a corporate. However, the EXIST Business Startup Grant supports young innovators with monetary aid and consultancy services. SI 4 argues that "[a]t that time we simply had the luck to get EXIST and there was still this project from the state, also cool, which was called 'young innovators' and because of the fact that you have such possibilities you can really [...] build up a foundation and develop a technology". Furthermore, SI 2 argues that EXIST forced them to explain their innovation in detail, "[t]hat definitely helped to develop and elaborate the idea further".

### 4.2.2 Collaborations and Linkages

Since this research concentrates on innovation drivers and how these are shaping innovation, a closer look on linkages between car manufacturers and startups is taken. It is evaluated, how they are formed and what role the innovation competitions play during the innovation process. The interviewed startups are asked to elaborate on innovation competitions as well as platforms and evaluate their previous experience. It stands out that the organisation *StartupAutobahn* is named frequently. StartupAutobahn is an innovation platform that connects startups with large corporations to pilot niche innovation. It was founded in 2016, in the Stuttgart Region but has expanded to locations like Beijing, Bangalore and Singapore. The two large car manufacturers, Porsche and Daimler, both work together with StartupAutobahn. The arguments the Interviewees state about innovation competitions are summarised in Table D.1 of Appendix D.

Figure 4.7 represents the dynamics, drivers and obstacles that arise between actors, and stresses on linkages of niche innovation and startups, and automotive corporations like big car manufacturers or their suppliers and the role of StartupAutobahn.

*Figure 4.7: Dynamics between Startups, Car manufacturers and StartupAutobahn*




*(Explanation of colours can be found in the introduction of the previous section.)*

Processes in a corporate can be quite stagnant and many internal regulations and concepts are deeply embedded. When startups introduce a newly founded technology and seek to collaborate with large corporations or sell them a product, the collaboration often fails on too many regulations and obstacles within the corporate. SI 1 elaborates on the obstacles his startup was facing when first trying to work with another corporate: "a company like that sends you a questionnaire with 4,500 questions that you have to answer [...]. You just sit there and think to yourself, my goodness, I am selling my soul here and have to assure things that no one can ever cover. It's just not possible. [A car manufacturer] has a questionnaire of 4,500 questions. [...] that was a problem at the beginning. And we knew that some things, we simply couldn't ensure, no IT service provider in Germany could do that. No one in the world could. But we had to make sure that we could somehow cover it and we just managed to get our way around it a bit. But it was already an issue. And it costs a lot of time to overcome these corporate obstacles." SI 1 also exposes his previous experience as an employee in a corporate and stresses the financial aid and opportunities these linkages can embody: "When I was building up the digital department together with a startup, we were doing pretty well, because we had really big corporate budgets. We had several million Euro as a budget, which we could roll out". However, he also states that it "can be quite dangerous for startups. [... I]f the company really wants to establish and use your solution, small budgets are just not enough. 50,000 Euro is 50 man-days, so you can employ someone for 2.5 months and then you haven't done a big project and you haven't rolled out anything

in the company. And that's already a problem. Because the startups really put high efforts in it."
Startup 3 and 4 participated in innovation competitions themselves when establishing their product. Arrow 1 of Figure 4.7 represents the connection that is established by innovation competitions between automotive corporations, and niche innovation and startups.
SI 3 emphasises that they "had a good project partner and mentor, who dealt well with innovations". However, he also states that processes and internal regulations continued to slow down working steps and hinder the innovation to develop by asking questions, such as "Who owns the intellectual property? And which property is given to whom, when, how?" Furthermore, he mentions that "competitors are completely excluded. We have actually gone through that several times and it slows down the process tremendously". Nevertheless, SI 4 argues on the dynamics these corporations have developed mainly due to StartupAutobahn and that "it was helpful to make [their] way into big corporations with this startup track".
StartupAutobahn is supporting innovation competitions held by corporations and encourages cooperation between startups and corporations. According to all interviewees, this leads to an increase in dynamics within the big corporations. "Innovation Competitions question the status quo in a concern" (SI 1) and enable startups to pitch their niche innovation in a professional environment. Therefore, "corporations [also] monitor the market with these platforms and screen for valuable ideas" (SI 4). This can lead to collaborations with startups and investments in niche innovations. However, SI 4 mentions that a large supplier of the automotive industry is trying "to copy everything and then build it themselves. [...] I don't know anything that corporate has ever done with a startup. It's one of those home-grown companies", he emphasises the issues, that can arise when working with a corporate. In this context, SI 2 mentions that one has to be careful because "corporations can market themselves with startup cooperations", hence, only use startups to present themselves as modern and innovative.
To include the view of a corporate, the innovation equation, constructed by the innovation manager (Interviewee 2) is further evaluated.

$$Innovation = Transparency + Openness + Screening\ of\ other\ markets + Communication\ with\ ecosystem\ around + Partnership\ and\ collaboration$$

It stands out that he values collaboration strongly since he does not only emphasise collaboration and partnership, but many supporting values, such as communication and openness. His innovation equation states that he does not believe in innovation that is only shaped by a car manufacturer itself but evolves out of co-creation with other actors and may even arise from other markets or branches. Such knowledge-spillovers are encouraged by the targeted screening of other markets and transparent working culture.
In summary, innovation competitions were mainly assessed as chances and opportunities for both startups and corporations. StartupAutobahn appears to play a major role in driving the dynamic within corporations and promote collaboration by supporting innovation competitions and giving its processes a clear structure. Hence, linkages and co-development of innovation are encouraged. Innovation competitions seem to speed up the establishment of collaborations between startups and

corporations and decrease the complexity of processes startups would normally need to go through when working with corporations. The collaborations of the two startups with the corporations were successful and supported the development of the innovation and its placing on the market. However, since only two out of four startups actively participated in innovation competitions, a quantitative study would be necessary to conclude further causalities of success.
Furthermore, one can interpret the dynamics that are triggered by innovation competitions as drivers that embody the necessity to adjust and adapt. Since corporations are challenged by niche innovation and startups, they are pressured to adjust their current performance and adapt to new technologies. Hence, as Arrow 2 in Figure 4.7 emphasises, collaborations between StartupAutobahn and startups are of positive nature, mainly for niche innovation and startups, since StartupAutobahn provides consultancy and a platform to connect with corporations. As stated above, this can be an advantage for corporations as well. However, the driving force can be of both negative and positive nature. It encourages corporations to exploit unused resources optimally and co-develop new combinations or complementaries to their current product line or production together with startups. Nevertheless, current practices are challenged and critically reviewed, which embodies the necessity to adjust. This may reveal further imbalances, such as technological and digital progress, or encourage competition.

# 5

# Discussion and Conclusion

## 5.1 Discussion

### Research Question 1

The first and overall research question **"How are innovations shaped in the automotive industry of the Stuttgart Region?"** can be limited to the constraints of this study, answered by evaluating the drivers of innovation and their level of origin and stimulation. Digitalisation, as technological change is the main driver that occurs on the landscape level. Nonetheless, it is further promoted by innovations that arise out of the technological opportunities and further promote digitalisation as a whole movement. Digitalisation finds its place of origin on the landscape level and pressures the sociotechnical automotive regime strongly. Taalbi (2017a) argues that imbalances from technological change are of positive nature and imbalances emerging from economic, environmental and societal changes are mainly of negative nature. Technological change stimulates tensions by forcing the regime to adjust their processes and adopt new processes and therefore resolve technological imbalances (Taalbi, 2017a). Furthermore, Jannsen et al. (2019) findings are in line with the statements the interviewed innovation manager states. He argues that "E-mobility is a very important driver, in terms of the vehicle, but also in terms of production. This partly requires innovation or transfer from other sectors, which is also conducive to innovation." (Innovation Manager, Interview 2). Furthermore, the research associate argues that "current technology changes are necessary to keep up with the demand of the society and today's globalisation" (Research Associate, Interview 1).
This study shows that technological imbalances can stimulate innovation (partly in case of Startup 1), however, it can also trigger negative drivers to arise. After assessing the collected data and including further quantitative data on the automotive sector in the Stuttgart Region, digitalisation is identified as a driver of both positive and negative nature. The data shows that digitalisation arises from the landscape level and triggers technological imbalances and stimulates tension of the sociotechnical regime. Moreover, it can pressure specific corporations on a micro level, but the collected evidence supports that it mainly stimulates adjustment and adoption on the whole meso level, hence it promotes sociotechnical change.
As presented before, digitalisation goes hand in hand with societal change and changes in consumer preferences. This spurs competition within a sector and pressures actors to adopt new technologies in order to satisfy consumer's demand. Hence,

it further pressures the need adjust previous norms on one hand and drives competition between actors on the other hand. Competition and sectoral challenges are further stimulated by environmental concerns and regulations. This complements societal change and enhances legislation and regulations towards environmentally friendlier cars. These processes increase the competition between manufacturers of a sociotechnical regime. Hence, monetary pressure occurs together with imbalances and sectoral challenges to reach the promoted regulations. After the failure of reaching the allowed $CO_2$-emission limit and the Volkswagen emission scandal, trust in the Stuttgart car manufacturers is questionable, which further stimulates societal and environmental concerns, hence the sector faces a challenge of *winning back the trust of their consumers*, while adopting technological solutions that enable the manufacturing of environmental friendlier cars. These drivers are in line with Rosenberg's, Malerba's and Taalbi's findings that economic and environmental imbalances, competition and sectoral challenges drive innovation, moreover, Taalbi classifies them as negative drivers (Rosenberg, 1969; Malerba, 2002; Taalbi, 2014, 2017a). The result of this study shows that these tensions are mainly triggered by dynamics that take place on the landscape level and develop its dynamics within a sociotechnical regime. A negative driver that is suggested by Hicks (1963) is that monetary pressure is stimulated by increasing factor prices and declining profits. The increasing competition and sectoral challenges also promote monetary pressure, however, this study shows that it does not only occur on a micro level, hence, it is not only one corporate or individual actor that is confronted with monetary pressure, it is the whole sociotechnical regime, since they are all interdependent and connected with another. Therefore, monetary pressure can stimulate tensions of a whole sociotechnical regime and does not only occur on micro level. Nevertheless, monetary pressure also spurs the micro level to innovate and find solutions to problems. The interviews revealed that startups are facing high monetary pressure as well and are, therefore, more dynamic as well as forced to adapt by finding new solutions. Hence, innovation is pressured and the environment becomes more dynamic and moves at a faster pace.

Nevertheless, digitalisation can not only take the role of negative transformation pressure, but it also shapes the niche and micro level significantly. One major driver is the technical progress that enable opportunities to arise, presenting chances for micro actors to engage in. Malerba (2002) stresses on this driver but in his framework it seems to be of importance mainly for the meso level. This research, however, emphasises the importance of technological progress and opportunities on the niche level. It is an enabler for novelties, therefore a positive driver that originates from the macro level, stimulating novelties on the niche level.

Another important driver, that is enabled by technological change arising from the landscape level is the opportunity of new combinations and complements (Perez, 2010). This study confirms that this driver is greatly shaped by the key technology of the sociotechnical regime, nevertheless, the findings of this study suggest that new combinations and complements arise also at the niche level and move their way up if successful.

Another driving force is the exploitation of unused resources as well as the exploration of new market opportunities (Penrose, 2009). It is a driver that, according to Penrose (2009), stimulates the micro level. This study shows that the technological progress to exploit unused resources may arise on the micro level, but it is developed

towards actors that dominate the sociotechnical regime and face challenges, such as monetary pressure. This positive driver works in hand with negative drivers that stimulate tensions and challenges on the meso level. Hence, this driver is enabled by overall technological progress, develops on the niche level and stimulates the adoption of this technology to exploit unused resources on the level of the sociotechnical regime. It is a driver that is especially emphasised and evaluated, since Startup 2 and 3 provide solutions that maximise the utilisation of production processes, hence support the optimal use of resources.

### Research Question 1 a)

The second research question **"To what extent are the innovations responses to opportunities, and to what extent are they driven by problems?"** is evaluated by assessing the ranking the startup interviewees provided and the last interview-question, where all interviewees are asked to construct an innovation equation (see Appendix C.2). Furthermore, the general tendency of the conversation is included in the evaluation of this question. The findings of this research are in line with Dahmén (1988) and show that the process of transformation has its roots somewhere between positive and negative transformation pressures. The interviews disclose that innovations require to solve problems in order to be successful. Concluding from this research, these are the innovations that are entering the market faster. At least, this is the case for Startup 1-3. Nevertheless, Startup 4 finds itself in a situation of technology push, where no market is existing at the time of the innovation activity but the technology is evolving fast. Hence, this data suggests that there is no clear distinction of whether the innovation is mainly stimulated by an opportunity or driven by problems. Three out of four innovations are developed with a clear problem in mind, however, all these innovations are enabled by technological progress and can, therefore, be categorised as answers to technological opportunities and technological imbalances within the sociotechnical regime. These findings are in line with the conclusion Taalbi (2017b) states, that most innovations are invented as answers to problems or imbalances arising by economic development or driven by technological opportunities. Taalbi (2017b) argues that the main driver of innovation appears to be of problematic nature, such as obstacles in production or economical challenges. This is supported by the driver ranking (see Figure 4.5), which stresses that *finding a solution for a problem* is the most named main driver. *Institutionalised search* is ranked least in three out of fours cases, which is in line with theory that states that *institutionalised search* needs to be supported by sufficient resources for Research & Development and is caused by the aim to improve characteristics of existing technology along a trajectory (Dahmén, 1988; Taalbi, 2017b). Hence it is more suitable for developed companies with a key technology at the core. This study claims that it depends on the nature of the innovation and whether it is the answer to a situation of demand pull or technology push. However, the majority of the analysed innovations is a response to a problem that was emerging from technological imbalances or sectoral challenges within the sociotechnical automotive regime.

**Research Question 1b)**

The third research question **"How are innovation activities shaped by external collaboration and linkages between actors?"** is investigated by the evaluation of innovation competitions that are assessed by the interviewees and complemented by the general statements the innovation manager is making.
As Figure 4.7 represents, the dynamics between well-established firms of the car manufacturing sector and startups are greatly influenced by innovation competitions. These potential innovation platforms increase linkages and stimulate co-creation of innovation. This is in line with Malerba and Mani (2009), which argue that novelties are stimulated and shaped by linkages and communication between actors. Their concept of SSI further stresses the importance of knowledge exchange and establishments among different actors. Furthermore, it shows development patterns along certain technological trajectories (Dahmén, 1988). This study underlines that a mature industry, such as the automotive industry, is strongly developed around one key technology, in this case, the combustion engine and the car itself. The findings of this study reveal high market barriers for new firms and innovative products as well as the importance of economies of scale for corporations, especially in their production sides.
Nevertheless, StartupAutobahn appears to be of great relevance in challenging current technological trajectories as well as stimulating sociotechnical change. By participating in the StartupAutobahn program both corporations and startups aim to actively form collaborations and partnerships, while encouraging communication between one another. The choice to engage in an innovation platform depicts that the core of the sociotechnical automotive regime is under tension. Therefore, it needs to engage with other actors of the regime to stay embedded within the regime. By screening the environment for promising innovations, technological imbalances are detected fast and can be resolved by collaborating with technological advanced actors. Through the fast-changing technological progress, economical imbalances can also arise, since economies of scale are of such importance and by increasing (production) processes, a firm can gain competitive advantages.
To summarise, StartupAutobahn and innovation competitions themselves are mainly identified as actors spurring positive drivers as well as encouraging linkages and (technological) knowledge accumulation. This shapes and stimulates innovation and its process of development. These findings are in line with Malerba and Mani (2009), who emphasise that communication and shared knowledge plays a crucial role in the process of inventing.

## 5.2 Future Research

In order to increase reliability and draw conclusions about causalities and ongoing processes and their consequences, the study will need to be replicated on a larger scale. This could support the correct indication on the level of occurrence of drivers and their level of stimulation. This knowledge would be valuable to shape and develop policy measures that support sociotechnical change as well as innovation.
Furthermore, the relevance of innovation competitions and intermediators such as StartupAutobahn that enhance collaboration and partnerships between the agents

of a sociotechnical regime as well as help to reduce obstacles for niche innovation, is disclosed. Quantitative research on these dynamics are promising contributions, in order to promote such programmes, increase dynamics of the sociotechnical regime and support niche innovation.

## 5.3 Conclusion

This thesis examines how innovations are shaped in the automotive industry in the Stuttgart Region. It further assesses whether innovations are creative responses to problems or opportunities, Moreover, linkages between actors in the form of innovation competitions are evaluated. The study is making use of formerly developed constructs around innovation activities, such as Geels' notion of a MLP and Taalbi's categorisation of negative and positive driving forces. By conducting a case study with semi-structured, exploratory interviews with experts from the car manufacturing regime of the Stuttgart Region and founders of startups that promote an innovation, which is linked to the car manufacturing industry in the Stuttgart Region, the following main results occur.

### Main Results

The sociotechnical automotive regime in the Stuttgart Region is mainly challenged by dynamics that occur on the landscape level. Examples for such drivers are digitalisation and environmental regulations. These drivers trigger tensions in the sociotechnical regime and stimulate sectoral challenges, competition and monetary pressure. Therefore, these drivers can be classified as negative transformation forces. Nevertheless, digitalisation is also an enabler of innovation and spurs opportunities within the niche level of innovation as well as shapes technological imbalances within the sociotechnical regime and on a micro level. By promoting tensions within the sociotechnical regime windows of opportunities open up. Thereby, niche actors can disclose current challenges the regime is facing and invent a solution for it. This is in line with a situation of market pull and this dynamic is further promoted by innovation competitions that encourage large corporations to engage and collaborate with niche actors. This partnership and collaboration enhances communication and enables niche actors to accumulate more knowledge about relevant problems the regime is facing. However, this case study also revealed a situation of technology push, which is also promoted by the landscape driver digitalisation. It is suggested that the tensions on the level of the sociotechnical regime are required to increase further to open market opportunities for such a technology push innovation.
To sum it up, this thesis stresses the relevance of the level of the driver and distinguishes between level of origin and level of stimulation. The results further suggest that current challenges provide strong incentives for niche actors to innovate and develop problem-solving answers.

### Practical Implications

Innovation managers may draw measures from the implications of this thesis. Firstly, collaborations seem to benefit both startups and large corporations. Corporations can draw opportunities from innovation platforms and benefit from the co-innovation

process with young companies. Within the constraints of this study, it also seems to be of great aid to strengthen communication with other actors of the sociotechnical regime as well as encourage the relationship to intermediators, such as StartupAutobahn. Secondly, this study categorises innovation competitions as positive drivers that enhance the resolution of technological imbalances as well as promote technical progress. Thus, it is a driver that is partly in control of the corporate itself, therefore, can be stimulated or hindered by the corporate.
Furthermore, this study may support the development of policy measures that support innovation and encourage change of sociotechnical regimes. The findings emphasise the importance of landscape drivers such as regulations and legislation. Since both the sociotechnical regime and niche actors are embedded within the overall landscape, an innovation fostering environment is required to ensure incentives for innovation, such as appropriate intellectual property rights. Furthermore, environmental regulations cause sectoral challenges and trigger tensions within the sociotechnical regime. This may be perceived as negative for the regime, however, it encourages technical progress and enables niche innovation to explore market opportunities. Nonetheless, technological imbalances caused by overall technical change, such as digitalisation, is revealed and characterised as an important driver of innovation in the automotive industry. Therefore, digital change needs to be stimulated and novelties supported. The government provides, in collaboration with universities, the EXIST Business Startup Grant. It seeks to protect innovation activities that are happening in a niche market by providing financial aid as well as consultancy services. This opportunity protects innovation arising from niche markets and enables founders to invest in technology research and develop an innovation without the need to be profitable from the beginning.

# Bibliography


Ademmer, M., Boysen-Hogrefe, J., Fiedler, S., Groll, D., Jannsen, N., Kooths, S., Mösle, S., Potjagailo, G., and Wolters, M. H. (2019). Deutsche konjunktur im herbst 2019-deutsche wirtschaft im abwärtssog.

Arthur, W. B. (2007). The structure of invention. *Research policy*, 36(2):274–287.

Benz, C. F. (2012). *Lebensfahrt eines deutschen Erfinders*. Leipzig: Jazzybee Verlag.

Biernacki, P. and Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological methods & research*, 10(2):141–163.

Bijker, W. E. (1995). *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change*. Cambridge: MIT press.

Breschi, S., Malerba, F., and Orsenigo, L. (2000). Technological regimes and schumpeterian patterns of innovation. *The economic journal*, 110(463):388–410.

Buchmann, T. and Pyka, A. (2015). The evolution of innovation networks: the case of a publicly funded german automotive network. *Economics of Innovation and New Technology*, 24(1-2):114–139.

Burton, A. W. (2003). Innovation drivers for electric power-assisted steering. *IEEE control systems Magazine*, 23(6):30–39.

CCI (2020). Accessed at 07.05.2020.

Chenail, R. J. (2011). Interviewing the investigator: Strategies for addressing instrumentation and researcher bias concerns in qualitative research. *Qualitative Report*, 16(1):255–262.

Cohen, W. M. and Malerba, F. (2001). Is the tendency to variation a chief cause of progress? *Industrial and Corporate Change*, 10(3):587–608.

Consoli, D. and Patrucco, P. P. (2008). Innovation platforms and the governance of knowledge: Evidence from italy and the uk. *Econ. Innov. New Techn.*, 17(7-8):699–716.

Creswell, J. W. (2002). *Research design: Qualitative, quantitative, and mixed methods approaches*. New York: The Guilford Press.

Dahmén, E. (1988). 'development blocks' in industrial economics. *Scandinavian Economic History Review*, 36(1):3–14.

Dahmén, E. (1991). *Development Blocks and Industrial Transformation: The Dahménian Approach to Economic Development*. Stockholm: Industrial Institute for Economic and Social Research (IUI).

Dispan, J., Koch, A., and König, T. (2019). Strukturbericht region stuttgart 2019: Entwicklung von wirtschaft und beschäftigung; schwerpunkt: Mobilitätsdienstleistungen.

Dispan, J., Koch, A., Luitjens, P., and Seibold, B. (2017). Strukturbericht region stuttgart 2017: Entwicklung von wirtschaft und beschäftigung; schwerpunkt: Digitaler wandel.

Dooley, L. M. (2002). Case study research and theory building. *Advances in developing human resources*, 4(3):335–354.

Dosi, G. (1988). The nature of the innovative process. *Technical change and economic theory*.

Dresing, T. and Pehl, T. (2013). Praxisbuch interview, transkription & analyse. *Anleitungen und Regelsysteme für qualitativ Forschende*, 5:813–829.

Dunger, C. and Schnell, M. W. (2018). Was ist die framework analysis? In *30 Gedanken zum Tod*, pages 27–39. Springer.

Eisenhardt, K. M. and Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of management journal*, 50(1):25–32.

EXIST (2020). Exist gründerstipendium. https://www.exist.de/DE/Home/inhalt accessed at 23.05.2020.

Geels, F., Kemp, R., Dudley, G., and Lyons, G. (2011). *Automobility in transition?: A socio-technical analysis of sustainable transport*. New York: Routledge.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, 31(8-9):1257–1274.

Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological forecasting and social change*, 72(6):681–696.

Geels, F. W. (2006). Co-evolutionary and multi-level dynamics in transitions: the transformation of aviation systems and the shift from propeller to turbojet (1930–1970). *Technovation*, 26(9):999–1016.

Geels, F. W. and Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy*, 36(3):399–417.

Godin, B. and Lane, J. P. (2013). Pushes and pulls: Hi (s) tory of the demand pull model of innovation. *Science, Technology, & Human Values*, 38(5):621–654.

Greve, H. R. et al. (2003). *Organizational learning from performance feedback: A behavioral perspective on innovation and change*. Cambridge: Cambridge University Press.

Hedrick, T. E., Bickman, L., and Rog, D. J. (1993). *Applied research design: A practical guide*, volume 32. Newbury Park: Sage Publications.

Hicks, J. (1963). *The theory of wages*. London: Macmillan and company limited.

Hodgson, G. M. (1996). *Economics and evolution: bringing life back into economics*. Michigan: University of Michigan Press.

Hopkins, D., Stephenson, J., et al. (2014). Generation y mobilities through the lens of energy cultures: a preliminary exploration of mobility cultures. *Journal of Transport Geography*, 38(1):88–91.

IHK (2019). Stagnation auf hohem niveau. Technical report, Konjunkturspiegel Region Stuttgart, Stuttgart.

Jannsen, N., Dudenhöfer, F., Canzler, W., Knie, A., Schneidewind, U., Koska, T., Lah, O., and Mattes, B. (2019). Autoindustrie—auf dem richtigen weg? *Wirtschaftsdienst*, 99(7):451–469.

Kilelu, C. W., Klerkx, L., and Leeuwis, C. (2013). Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. *Agricultural systems*, 118:65–77.

King, S., Dyball, M., Webster, T., Sharpe, A., Worley, A., DeWitt, J., Marsden, G., Harwatt, H., Kimble, M., and Jopson, A. (2009). Exploring public attitudes to climate change and travel choices: Deliberative research. *Final report for Department for Transport. People Science and Policy Ltd., London*.

Klepper, S. (1996). Entry, exit, growth, and innovation over the product life cycle. *The American economic review*, pages 562–583.

Lamnek, S. (2005). Qualitative sozialforschung, 4. aufl. beltz.

Landesamt, S. (2020). Online. https://www.statistischebibliothek.de/mir/receive/BWHeft-mods-00039692 accessed at 14.05.2020.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research policy*, 31(2):247–264.

Malerba, F. (2005). Sectoral systems of innovation: a framework for linking innovation to the knowledge base, structure and dynamics of sectors. *Economics of innovation and New Technology*, 14(1-2):63–82.

Malerba, F. and Mani, S. (2009). *Sectoral systems of innovation and production in developing countries: actors, structure and evolution*. Cheltenham: Edward Elgar Publishing.

Mayring, P. (2010). Qualitative inhaltsanalyse. In *Handbuch qualitative Forschung in der Psychologie*, pages 601–613. Springer.

Naymier, L. B. (1913). Review of J. Schumpeter. Theorie der Wirtschaftlichen Entwicklung. *The Economic Journal*, 23(89):105–106.

Nelson, R. and Winter, S. (1982). An evolutionary theory of economic change. *Rochester, NY: Social Science Research Network*.

Nordhaus, W. D. (1969). An economic theory of technological change. *The American Economic Review*, 59(2):18–28.

Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. *International Journal of social research methodology*, 11(4):327–344.

Oleinik, A., Popova, I., Kirdina, S., and Shatalova, T. (2014). On the choice of measures of reliability and validity in the content-analysis of texts. *Quality & Quantity*, 48(5):2703–2718.

Penrose, E. (2009). *The Theory of the Growth of the Firm*. New York: Oxford university press.

Perez, C. (2010). Technological revolutions and techno-economic paradigms. *Cambridge journal of economics*, 34(1):185–202.

Rese, A., Sänn, A., and Homfeldt, F. (2015). Customer integration and voice–of–customer methods in the german automotive industry. *International Journal of Automotive Technology and Management*, 15(1):1–19.

Rip, A. and Kemp, R. (1998). Technological change. *Human choice and climate change*, 2(2):327–399.

Ritchie, J., Lewis, J., Nicholls, C. M., Ormston, R., et al. (2013). *Qualitative research practice: A guide for social science students and researchers*. London: Sage Publications.

Robson, C. (2002). Real world research 2nd edition. *Malden: BLACKWELL Publishing*.

Rosenberg, N. (1969). The direction of technological change: inducement mechanisms and focusing devices. *Economic development and cultural change*, 18(1, Part 1):1–24.

Schmookler, J. (1962). Economic sources of inventive activity. *The Journal of Economic History*, 22(1):1–20.

Schramm, W. (1971). Notes on case studies of instructional media projects. Technical report, Stanford University, CA. Institute for Communication Research.

Schumpeter, J. A. (1947). The creative response in economic history. *The journal of economic history*, 7(2):149–159.

Scotchmer, S. (1991). Standing on the shoulders of giants: cumulative research and the patent law. *Journal of economic perspectives*, 5(1):29–41.

Smith, J. and Firth, J. (2011). Qualitative data analysis: the framework approach. *Nurse researcher*, 18(2):52–62.

Smith, M. and Crotty, J. (2008). Environmental regulation and innovation driving ecological design in the uk automotive industry. *Business Strategy and the Environment*, 17(6):341–349.

StartupAutobahn (2020). Online. https://startup-autobahn.com/ accessed at 21.05.2020.

Strambach, S. and Klement, B. (2013). Exploring plasticity in the development path of the automotive industry in baden-württemberg: the role of combinatorial knowledge dynamics. *Zeitschrift für Wirtschaftsgeographie*, 57(1-2):67–82.

Taalbi, J. (2014). *Innovation as Creative Response. Determinants of Innovation in the Swedish Manufacturing Industry, 1970-2007*. PhD thesis, Lund University.

Taalbi, J. (2017a). Development blocks in innovation networks. *Journal of evolutionary economics*, 27(3):461–501.

Taalbi, J. (2017b). What drives innovation? evidence from economic history. *Research Policy*, 46(8):1437–1453.

Triebswetter, U. and Wackerbauer, J. (2008). Integrated environmental product innovation and impacts on company competitiveness: a case study of the automotive industry in the region of munich. *European Environment*, 18(1):30–44.

Venkatraman, N. V., El Sawy, O. A., Pavlou, P. A., and Bharadwaj, A. (2014). Theorizing digital business innovation: platforms and capabilities in ecosystems. *Fox School of Business Research Paper*, (15-080).

Verspagen, B. (2005). Innovation and economic growth. In Fagerberg, J., Mowery, D. C., Nelson, R. R., Verspagen, B., et al., editors, *The Oxford Handbook of Innovation*. New York: Routledge.

Viereckl, R., Ahlemann, D., Koster, A., and Jursch, S. (2015). Racing ahead with autonomous cars and digital innovation. *Auto Tech Review*, 4(12):18–23.

Whitmarsh, L. and Köhler, J. (2010). Climate change and cars in the eu: the roles of auto firms, consumers, and policy in responding to global environmental change. *Cambridge Journal of Regions, Economy and Society*, 3(3):427–441.

Wirtschaftsförderung (2014). Hightech-region stuttgart: Automotive.

Yin, R. (2003). Designing case studies. *Qualitative Research Methods*, pages 359–386.

Yin, R. K. (2017). *Case study research and applications: Design and methods*. London: Sage publications.

Zijlstra, T. and Avelino, T. (2011). A socio-spatial perspective on the car regime. In *Automobility in transition?: A socio-technical analysis of sustainable transport*, chapter 8, pages 160–179. New York: Routledge.

# Appendices

# Appendix A

# Startup Criteria

Since the collection of startups is based on an exponential discriminative snowball sampling, the startups have to fulfil certain criteria to be suitable for an interview.

1. They have to be founded in the Stuttgart Region.
2. They must not be older than 5 years, but have to be an official founded firm for at least one month at the time of the interview.
3. The startups's products need to be of innovative character, may it be of incremental or radical nature. It cannot be a well-established technology that is re-sold by a newly founded firm.
4. To ensure relevance and validity regarding the research question, the startups must have linkages to the car manufacturing industry. It may be during their innovation and foundation process or as end-customers, the timing or actual presence of the linkage is of non-importance.
5. To increase the variety of the startups, they cannot work on the exact same product or technology. However, it can support similar aims or solve the same problem.
6. The startups cannot be connected via business links or depend on one another.

# Appendix B

# Questionnaires

# Research Associate Questionnaire

This is a semi-structured questionnaire that provides a structure and example composition of questions that can be asked. However, it depends on the specific interviewee, his/her background, his/her linkages to the automotive industry, and the phase his/her startup/product is facing right now. This is the translation of the original German questionnaire.

*Italic font: Not to read out to the interviewee; only for interviewer*

*Blue/Italic font: Not to read out to the interviewee; helps interviewer to keep structure and keep in mind what the aim of the asked questions are.*

Blue font: Structure of introduction

## Introduction/ Welcoming the interviewee

Thank the interviewee for his/her participation in my research.

Explain the background of the study:

- I am doing my Master in Lund, Sweden and studying Innovation and global sustainable development.
- I am writing my master's thesis on innovations and how innovations enter the market. In doing so, I am now looking in particular at the players in the automotive industry in the Stuttgart region.
- The interviews are conducted to find out to what extent patterns of change can be identified in the industry. In particular, I would like to investigate how interactions and interdependencies between the actors are characterized and how innovations are shaped and driven by this.

The results of the interviews will of course be analysed anonymously, not published and deleted after submission of the thesis.

I would like to record our conversation; would that be all right with you?

Do you have any questions in advance?

### Block A- Structural change: drivers of change

*In this block I would like to find negative and positive drivers and the expert's assessment of what significant drivers of the current changes are. Furthermore, potential obstacles and brakes are asked for.*

1. In the automotive industry, especially in the Stuttgart region, one can currently see a high dynamic and a structural change driven by various things.
    1.1 In your opinion, what are the potential drivers in relation to these movements?
    1.2 Positive drivers - To what extent are there specific drivers that you would see as opportunities or pathfinders for both innovation and structural change in the automotive industry?

1.3 Negative drivers - To what extent are there specific drivers of innovation that you would see as pressures for both innovation and structural change in the automotive industry?
1.4 Obstacles/Braking: Do you see potential braking mechanisms in one of these drivers, which are an obstacle especially for niche innovations?

## Block B - New interdependencies within and outside technological regimes

*In this block I would like to learn more about cooperations between (former) competitors and different big players with startups. I would also like to look at the interrelationships between the technological regime, the automotive industry and services.*

2. Cooperation between competitors - Using the example of Daimler and BMW, one can observe that competitors actually join forces and in this case work on a common car sharing platform.
How would you assess or justify the dynamics of (former) competitors forming alliances? Who benefits from this?

3. Big players with start-ups - One can observe that big companies, such as Bosch or Porsche, do a lot to enter into cooperations with young start-ups - How do you assess this movement? Why now?
3.1 To what extent can this movement benefit niche innovations?
3.2 How do these alliances and partnerships change the balance of power in the automotive industry?
- Does this only give the "big players" in the automotive industry more power?

4. Automotive and services- As outlined in the structural report, the change is leading to alliances between car manufacturers and service companies. This can be seen in examples such as Duno& Porsche, (Bosch& Toom) or also Toyota& Grab.
4.1 To what extent does this change the classic role of an automobile manufacturer?
4.2 Would you say that car manufacturers can be characterised as niche companies in mobility services?

## Block C- Niche innovations

*In this paragraph I would like to find out more about potential niche innovations and discuss the role of sharing services as a potential niche. It also discusses whether sharing services can be seen as a solution to current challenges and how this can be achieved.*

People often talk about niches and that novelties are emerging in niches, i.e. in specific areas of use, new alliances of different actors and geographical areas with specific characteristics. The novelty or niche innovation can be a new practice, technology or special state intervention
5. Can you name one or more areas where potential niche innovations are currently emerging?
5.1 Do you think that existing and emerging sharing services can be characterised as niche innovations?

- Often these sharing services are not yet financially sustainable. Do you think that these niche markets should be better protected?

5.2 In the case of sharing services, to what extent can one speak of solutions, especially with regard to the environment?

- What about rebound effects?

6. Offers from, for example, PorscheinFlow, Car2Go or ShareNow create new opportunities that in theory do not necessarily make owning a car necessary.

6.1 What is your opinion on this topic? Is society ready to give up the car as private property and live in an economy of sharing?

## Block D- E-Mobility

*In this paragraph I would like to find out to what extent e-mobility can be seen as a niche innovation and is responsible for a turnaround in the automotive industry.*

All major car manufacturers are now developing in the field of electromobility. Recently, the luxury car manufacturer Porsche has launched an e-car and the other manufacturers are also doing a lot in this area.

7. Who is particularly affected by the effects of the movement towards e-mobility?

7.1 Do you think that niche innovations will be affected?

8. Do you see e-mobility as the solution to problems we are currently facing?

8.1 To what extent are aspects of sustainability addressed?

8.2 Does it solve problems that are particularly evident in the Stuttgart Region?

- Does the appearance and function of the car change (not)?
- Slow process, see emergence of the automobile- Very similar to carriages, transformation to be seen over a long period of time

## Block E- FINAL QUESTIONS

*Concluding questions and opportunity for the interviewee to ask questions or make concluding comments.*

9. Imagine the drivers of niche innovations as an equation in which we see niche innovations as a result. Finally, what would you say about this interview that are necessary inputs to get successful niche innovations as outputs?

10. Do you have any final comments or questions that you would like to ask or highlight?

# Innovation Manager Questionnaire

This is a semi-structured questionnaire that provides a structure and example composition of questions that can be asked. However, it depends on the specific interviewee, his/her background, his/her linkages to the automotive industry, and the phase his/her startup/product is facing right now. This is the translation of the original German questionnaire.

*Italic font: Not to read out to the interviewee; only for interviewer*

*Blue/Italic font: Not to read out to the interviewee; helps interviewer to keep structure and keep in mind what the aim of the asked questions are.*

Blue font: Structure of introduction

## Introduction/ Welcoming the interviewee

Thank the interviewee for his/her participation in my research.

Explain the background of the study:

- I am doing my Master in Lund, Sweden and studying Innovation and global sustainable development.
- I am writing my master's thesis on innovations and how innovations enter the market. In doing so, I am now looking in particular at the players in the automotive industry in the Stuttgart region.
- The interviews are conducted to find out to what extent patterns of change can be identified in the industry. In particular, I would like to investigate how interactions and interdependencies between the actors are characterized and how innovations are shaped and driven by this.

The results of the interviews will of course be analysed anonymously, not published and deleted after submission of the thesis.

I would like to record our conversation; would that be all right with you?

Do you have any questions in advance?

### Block A - New linkages within and outside technological regimes

*In this block I would like to learn more about cooperation of different big car manufacturers with startups. Further, I would like the startup to elaborate on innovation platforms, provided by "big players".*

1. *Big players and startups* - It can be observed that large corporations, such as Porsche, for example, do a lot to establish cooperation with startups and offer platforms, such as the "Open Innovation Competition".

a) How do you assess this movement of increasing interconnections?
b) Why are this effort happening right now?

2. Do you think that this movement is useful for innovation?

3. What do these alliances and partnerships change in the balance of power in the automotive industry?

a) The big players always claim their platforms as opportunities for start-ups. Do you think this is the case, or will the big players in the automotive industry only gain more power? *(Only as further inquiry, if previous question was not answered sufficient)*

4. Alliances between car manufacturers and service companies are increasingly being formed. This can be seen in examples such as Cluno& Porsche or the offers that are developing from them such as PorscheinFlow or PorscheDrive, Passport/ Host.

4.1 To what extent does this change the classic role of an automobile manufacturer?
4.2 Would you say that car manufacturers can be characterised as niche companies in mobility services?
4.3 What is your general assessment of this topic? Is society willing to give up the car as private property (and live in an economy of sharing)?

5. Cooperation between competitors - Using the example of Daimler and BMW one can observe that competitors actually join forces and in this case work on a common car sharing platform. How would you assess or justify the dynamics of (former) competitors forming alliances? Who benefits from this?

## Block B- Structural change: drivers of change

*In this block I would like to find negative and positive drivers and the expert's assessment of what significant drivers of the current changes are. Furthermore, potential obstacles and brakes are asked for.*

6. In the automotive industry, especially in the Stuttgart region, one can currently see a high dynamic and a structural change driven by various things.

6.1 In your opinion, what are the potential drivers in relation to these movements?
6.2 Positive drivers - To what extent are there specific drivers that you would see as opportunities or pathfinders for both innovation and structural change in the automotive industry?
6.3 Negative drivers - To what extent are there specific drivers of innovation that you would see as pressures for both innovation and structural change in the automotive industry?
6.4 Obstacles/Brakes: Do you see potential braking mechanisms in one of these drivers, which are an obstacle especially for niche innovations?

## Block C- niche innovations

*In this paragraph I would like to find out more about potential niche innovations and discuss the role of sharing services as a potential niche. It also discusses whether sharing services can be seen as a solution to current challenges and how this can be achieved.*

People often talk about niches and that novelties are emerging in niches, i.e. in specific areas of use, new alliances of different actors and geographical areas with specific characteristics.

The novelty or niche innovation can be a new practice, technology or special state intervention

7. Can you name one or more areas where potential niche innovations/novelties are currently emerging?

8. Does the movement come from innovation, from the region or from external actors?

9. Do you think that existing and emerging sharing services can be characterised as niche innovation?

9.1 Often these sharing services are not yet financially sustainable. Do you think that these niche markets should be better protected?

10. In the case of sharing services, to what extent can one speak of solutions, especially with regard to the environment?

10.1 What about rebound effects?

## Block D- E-Mobility

*In this paragraph I would like to find out to what extent e-mobility can be seen as a niche innovation and is responsible for a turnaround in the automotive industry.*

*All major car manufacturers are now developing in the field of electromobility. Recently, the luxury car manufacturer Porsche has launched an E-car and the other manufacturers are also doing a lot in this area.*

11. Do you think that e-mobility is our future?

11.1 Do you think that this will have a major impact on niche innovations, or perhaps already has?

12. Do you see e-mobility as the solution to problems we are currently facing?

12.1 To what extent are aspects of sustainability being addressed?

12.2 Does it solve problems that are particularly evident in the Stuttgart Region?

## Block E- Final Questions

*Concluding questions and opportunity for the interviewee to ask questions or make concluding comments.*

13. Imagine the drivers of niche innovations as an equation in which we see niche innovations as a result. Finally, what would you say about this interview that are necessary inputs to get successful niche innovations as outputs?

14. Finally, do you have any comments or questions that you would like to ask or highlight?

15. Can you possibly name regional start-ups that I can turn to, which are currently undergoing this process of niche novelty/innovation?

# Startup Questionnaire

This is a semi-structured questionnaire that provides a structure and example composition of questions that can be asked. However, it depends on the specific interviewee, his/her background, his/her linkages to the automotive industry, and the phase his/her startup/product is facing right now. This is the translation of the original German questionnaire.

*Italic font: Not to read out to the interviewee; only for interviewer*

*Blue/Italic font: Not to read out to the interviewee; helps interviewer to keep structure and keep in mind what the aim of the asked questions are.*

Blue font: Structure of introduction

## Introduction/ Welcoming the interviewee

Thank the interviewee for his/her participation in my research.

Explain the background of the study:

- I am doing my Master in Lund, Sweden and studying Innovation and global sustainable development.
- I am writing my master's thesis on innovations and how innovations enter the market. In doing so, I am now looking in particular at the players in the automotive industry in the Stuttgart region.
- The interviews are conducted to find out to what extent patterns of change can be identified in the industry. In particular, I would like to investigate how interactions and interdependencies between the actors are characterized and how innovations are shaped and driven by this.

The results of the interviews will of course be analysed anonymously, not published and deleted after submission of the thesis.

I would like to record our conversation; would that be all right with you?

Do you have any questions in advance?

### Block A- General information about the start-up/ product

*By asking these questions, I would like to find out more about the product, whether it is already established in a regime, or if it is still in a niche position, and to what extent it is linked to the automotive industry.*

1. Could you tell me a bit more about your company, and your product?

2. Would you say that you replace, or rather complement existing technologies/ human work/ processes? *(depended on product)*

3. How did the creation process of your product take place? Where did the idea come from?

4. In what way are you established on the market? Which phase of establishment are you facing at the moment?

5. To what extent are there connections to the automotive industry in Stuttgart? *(mention, if previous background is known, e.g." You have also worked for Porsche for a long time, to what extent are you still connected to the automotive branch?")*

## Block B - New linkages within and outside technological regimes

*In this block I would like to learn more about cooperation of different big car manufacturers with startups. Further, I would like the startup to elaborate on innovation platforms, provided by "big players".*

6. *Big players and startups* - It can be observed that large corporations, such as Porsche, for example, do a lot to establish cooperation with startups and offer platforms, such as the "Open Innovation Competition".

a) Was your startup involved in such processes/ challenges/ platforms?
b) How do you assess this movement of increasing interconnections?
c) Why are this effort happening right now?

7. Do you think that this movement is useful for innovation?

8. What do these alliances and partnerships change in the balance of power in the automotive industry?

a) The big players always claim their platforms as opportunities for start-ups. Do you think this is the case, or will the big players in the automotive industry only gain more power? *(Only as further inquiry, if previous question was not answered sufficient)*

## Block C- Drivers of innovation

*In this block I would like to investigate negative and positive drivers and the interviewee's assessment of what significant drivers of the current changes are. Furthermore, I am interrogating what potential obstacles of launching an innovation are.*

6. Innovation are enabled or even forced by different drivers. What would you say were the main reasons for the creation of your product?

7. Was it mainly opportunity, or problem driven?

8. Why is the time for this innovation right now?

9) I will now introduce four drivers and enablers and I would like you to rank them in an order from place 1, "very important" to 4, "not so important" in terms of the creation of your innovation. *(investigating most important driver)*

- Solving a problem
- Technical progress

- Market opportunities
- Institutionalized search for improved performance

I would now ask you to order these 4 points in your personal order.

a) Could you explain why you chose this order?

10. How did the process of launching the product go? Did you have to deal with many regulations or potential obstacles that slowed down the process?

11. To what extent have users or companies understood the product or adapted their behaviour and accepted it?

12. How are your innovation activities influenced by other industries?
*(knowledge/technology transfer, linkages of sales…)*

## Block D- FINAL QUESTIONS

*Concluding questions and opportunity for the interviewee to ask questions or make concluding comments*.

13. Imagine the drivers of innovation as an equation in which innovation are a result/ output. In conclusion of this interview, what would you state as necessary inputs to get a successful innovation as outputs?

14. Do you have any comments or questions that you would like to ask or highlight?

# Appendix C

# Drivers of Innovation

## C.1 Macro- Meso- Micro- level of drivers and their quotes

*Table C.1: (Negative) Drivers of Innovation*

| | (Negative) Drivers | Example-Quotes |
|---|---|---|
| Macro Level | | |
| | Digitalisation | "Fear of digitalisation and technology enables co-operation" [between startups and car manufacturers] -1 |
| | Societal change | "Market pressure and pressure on the society to change" -1 |
| | Environmental | "Ideas and solutions will be greatly shaped by challenges such as the environmental pressure. This will lead to more cooperation between startups and corporations in order to find innovation" -4 "We aim to increase quality and reduce waste, that is also an important step towards sustainability" -2 |
| Meso Level | | |
| | Competition and sectoral challenges | "The car manufacturers have been on unbelievable cost pressure, and accordingly they are looking for every second they can squeeze out" -3 " If you can improve that process by three seconds, that's a hell of a lot of time. Because for them it scales 100,000 times and then you have saved not 3 seconds, but 300,000 seconds" -3 "The car manufacturers realised 10 years ago, 'okay we have to do something' [...] and suddenly you can implement a novelty into a company. "-1 "It all depends on the innovation pressure the industry is facing and also how badly the industry is threatened"- 1" |

| | | |
|---|---|---|
| Micro Level | Imbalances | [The car manufacturers]"know the structures well, but they know nothing about the current technology and that's a huge issue for them." -1 "You can be sure, that car manufacturers know nothing about digital solutions." -1 |
| | Monetary pressure | "When you are not backed up by a corporate and infinite money you have higher pressure to innovate and find cheap and efficient solutions" -4 |

*Table C.2: (Positive) Drivers of Innovation*

| | (Positive) Drivers | Example Quotes |
|---|---|---|
| Macro Level | | |
| | Digitalisation | "to a certain extent digitalisation emphasizes the goal of making thinks more efficient and that's where our innovation comes in"- 2 |
| | Swabian culture | "In Swabian there are actually many who first build up a foundation and create a basic technology before they enter the market and generate revenue. A real Swabian working mentality."-4 |
| Meso Level | | |
| | Support by political regime | "At that time we simply had the luck to get EXIST and there was still this project from the state, also cool, which was called 'young innovators' and because of the fact that you have such possibilities you can really [...] build up a foundation and develop a technology. "- 4 "We wrote an application for an EXIST Business Startup Grant. Therefore, we were forced to explain everything in more detail and to get to the point. That definitely helped to develop and elaborate the idea further."-2 |
| | New combinations and complements | "So in 2017 there was a prototype [of an industry smart watch] introduced, which was really the first industrial smart watch with these features, which I mentioned earlier. And with that it was for the first time really possible to realize something like that."-3 "The industry realizes that simulation technology is close to experiments these days. But it is much cheaper to conduct a simulation, but adds value to previous processes" - 4 |

| | | |
|---|---|---|
| | Technical progress and opportunities | "This already means that the technology as such is technologically mature, but also that the customer already has systems that make it economically viable to use systems like ours., hence that his systems are technological developed."- 3 "There is a trend of AI. We wanted to develop something in the field of data science and complex technology in context of new trends. After defining this, we looked into the right place for us. "- 2 |
| | Innovation platforms and challenges | "If the programme is established in an appropriate way, both [, startups and corporations] can benefit from it" -3 "Innovation competitions question the status quo in a concern,. So for them, it is a great concept." -1 "For the first time [the CEO of a company] has to think about how valuable the things are, he is doing . And he has to defend it and this process alone is of great value for the company." -1 |
| Micro Level | | |
| | Exploit unused resources | "It's like an automation cook book. You can choose a process from our software that you can optimize."- 3 "With our technology you can track the machine load and send it to the plant manager, 'hey your machine has been stopped for three hours because nobody was there' " - 2 |
| | Explore new market opportunities | "The technology did not penetrate the market yet, so it is definitely a good time for this growth to begin and to invest in this technology"-2 "Our original idea always developed relatively strongly towards customers. And in the end, the product we have now is significantly shaped by our customers and their feedback."-3 |

## C.2 Innovation Equations

**Research Associate**

$Innovation = Communication + Former\ technological\ strength +$
$Political\ regulations\ and\ promotion$

**Innovation Manager**

$Innovation = Transparency + Openness + Screening\ of\ other\ markets +$
$Communication\ with\ ecosystem\ around + Partnership\ and\ collaboration$

**Startup 1**

Differentiates between corporations and startups.
Innovation in a corporate:

$Innovation = Innovation\ pressure\ and\ a\ problem + General\ change + speed$
Innovation in a startup:
$Innovation = Good\ human\ resources + Budget + problem$

**Startup 2**

$Innovation = Time + Creativity + Pressure\ or\ a\ problem + Personality$

**Startup 3**

$Innovation = (Problem\ worth\ solving + Mindset + Freedom\ to\ act) * (1 + Technology)$

**Startup 4**

$Innovation = Driving founder + Technology\ and\ knowledge\ about\ it +$
$Experience\ or\ good\ consultancy + Creativity$

# Appendix D

# Evaluation of Innovation Platforms

*Table D.1: Evaluation of Innovation Platforms*

| | Useful | Dangerous |
|---|---|---|
| Startups | "We simply had a good project partner and mentor, who dealt well with innovations." - 3 "When I was building up the digital department together with a startup, we were doing pretty well, because we had really big corporate budgets. We had several million Euro as a budget, which we could roll out." -1 "Daimler was then agile, thanks to Startup Autobahn and Porsche was quite agile as well, also thanks to Startup Autobahn. [...] I think it was helpful to make our way into big corporations with this startup track. "-4 " | "They try to copy everything and then build it themselves. It's a real tragedy. I don't know anything that corporate has ever done with a start-up. It's one of those home-grown companies."-4 "Who owns this intellectual property? And which property is given to whom, when, how? The competitors are completely excluded. We have actually gone through this several times and it slows down the process tremendously." -3 "It can be quite dangerous for startups. [...] if the company really wants to establish and use your solution, small budgets are just not enough. 50,000 Euro is 50 man-days, so you can employ someone for 2.5 months and then you haven't done a big project and you haven't rolled out anything in the company. And that's already a problem. Because the start-ups really put high efforts in it." -1 |

| | |
|---|---|
| Corporations | "Innovation Competitions question the status quo in a concern,. So for them, it is a great concept." -1 "The corporations can market themselves with startup cooperations""-2 "Some cooperates monitor the market with these platforms and screen for valuable ideas"-4 " |