



JÖNKÖPING UNIVERSITY  
*International Business School*

# Dental Laboratory Crisis: How is Chinese competition affecting the Swedish dental industry?

Are Swedish dental laboratories aware of the current market changes and what are they doing to maintain their competitive advantage against foreign competitors from China?

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# Master Thesis in General Management

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## Abstract

**Background:** With the appearance of the fourth industrial revolution a lot of industries had to change and adapt to computer integrated manufacturing, the ‘Internet of things’, cloud computing, machine to machine communication, additive manufacturing and ‘big data’. Overall, this industrial transformation is driven by digitalization. The Swedish dental laboratory industry is of special interest for our research due to the lack of adaption to the new technological changes, decreasing market share in Sweden and the threats from cheap Chinese production.

**Purpose:** The purpose of this thesis is to understand the current situation the Swedish small and medium sized dental laboratories are facing because of the threats from the Chinese competition. Therefore, we analyze the Swedish dental laboratory industry and map the situation. Moreover, we show what the laboratories are currently doing to defend their market position in a highly competitive environment.

**Method:** The data was gathered from semi structured and open interviews of dental technicians, dentists and industry experts. This empirical data was analyzed in an abductive thematic approach. Additionally, this theory driven approach combines the research question and the propositions with the empirical findings to create a precise research report.

**Conclusion:** Up to recently, China was a big threat for the domestic dental laboratories but this threat is decreasing nowadays. Due to the demand of high quality products with precise services, dentists require a close collaboration with the dental laboratories. In order to survive as an SME in the Swedish dental industry, collaborating in networks among local competitors can help to lift investments for new equipment in the transforming environment. With state of the art technology and shared competences Swedish dental laboratories can sustain their competitive advantage in global competition.

## Table of Content

<b>1</b>	<b>Introduction .....</b>	<b>1</b>
1.1	Dental laboratories affected by the fourth industrial transformation .....	1
1.2	Problem .....	3
1.3	Purpose .....	3
<b>2</b>	<b>Previous research .....</b>	<b>4</b>
2.1	Fourth industrial revolution.....	4
2.2	Industrial transformation in economies of scope.....	6
2.3	Dental industry .....	7
2.3.1	How do laboratories work? .....	7
2.3.2	Barriers against new technology .....	8
2.3.3	Communication between the dentist and the dental technician .....	9
2.4	Swedish dental market.....	10
2.4.1	Swedish market situation .....	10
2.4.2	Outsourcing the production to China .....	10
2.4.3	Challenging situation for Sweden .....	11
2.5	Dental technician industry analysis.....	11
2.5.1	Threats of new entrance .....	11
2.5.2	Bargain power of customer .....	11
2.5.3	Threats of substitutes .....	12
2.5.4	Bargain power of suppliers.....	12
2.5.5	Rivalry among existing competitors .....	12
2.6	Research question.....	13
2.7	Research model.....	14
2.7.1	Competition on a global scale .....	14
2.7.2	Dental industry transformation .....	15
2.7.3	Networking as an opportunity .....	15
<b>3</b>	<b>Research methodology .....</b>	<b>16</b>
3.1	Research Approach.....	16
3.2	Research Design .....	16
3.3	Data collection.....	18
3.3.1	Semi-structured interviews .....	18
3.3.2	Case selection .....	19
3.4	Data Analysis .....	19
3.5	Ethical Considerations.....	21
3.6	Trustworthiness .....	22
3.6.1	Credibility.....	22
3.6.2	Dependability.....	23
3.6.3	Transferability.....	23
3.6.4	Confirmability.....	23

<b>4</b>	<b>Findings .....</b>	<b>24</b>
4.1	Interviews with dental technicians.....	24
4.1.1	Company C1 .....	24
4.1.2	Company C2.....	25
4.1.3	Company C3.....	27
4.1.4	Company C4.....	28
4.2	Interviews with dental industry experts .....	29
4.2.1	Expert E1.....	29
4.2.2	Expert E2.....	30
4.3	Interviews with dentists.....	31
4.3.1	Dentist D1 .....	31
4.3.2	Dentist D2 .....	32
<b>5</b>	<b>Analysis of data .....</b>	<b>33</b>
5.1	Competition on a global scale .....	34
5.1.1	Threats.....	34
5.1.2	Competitiveness .....	34
5.2	Dental industry transformation.....	36
5.2.1	Awareness of the changing environment .....	36
5.2.2	Changes in the transforming market.....	37
5.2.3	Future considerations .....	39
5.3	Networking as an opportunity .....	39
5.3.1	Collaboration between the dental technician and the dentist.....	39
5.3.2	Collaboration among dental technicians .....	41
5.3.3	Collaboration between the dental technician and their suppliers .....	42
5.4	Conclusions.....	42
<b>6</b>	<b>Discussion.....</b>	<b>45</b>
6.1	Managerial implications.....	46
6.2	Future research .....	47
6.3	Limitations.....	48
<b>7</b>	<b>References .....</b>	<b>49</b>
<b>8</b>	<b>Appendix .....</b>	<b>53</b>
8.1	Interview guide .....	53
8.2	Informed consent.....	55

**Figures**

Figure 2.1: Research model.....14  
Figure 3.1: Research process.....17  
Figure 5.1: Map of the themes and categories.....33

**Table**

Table 3.1: Case selection .....19

# 1 Introduction

In 2011, Acatech (Germany's National Academy of Science and Engineering) were the first to introduce the concept of the fourth industrial revolution, the so-called 'Industry 4.0', within the German market. This was part of a future-oriented project to prepare the manufacturing sector for the upcoming challenges a rapidly evolving industry (Industrie 4.0, 2017). They stated that this future would be characterized by flexible mass production and high individualization of the produced goods. This production is linked to high quality services, where the client can customize the product and both the client and the manufacturer can monitor the whole value chain to steer and optimize the production in real-time. Blau (2014, p. 2) added that 'Industry 4.0' is not only about computer integrated manufacturing techniques but it also includes the currently trending computer developments 'Internet of things', cloud computing, machine to machine communication, additive manufacturing (AM) and 'big data'. Gebhardt (2011, p. 2) describes the most important part, saying that, "*Additive Manufacturing' (AM) is a layer-based automated fabrication process for making scaled 3-dimensional physical objects directly from 3D-CAD data without using part-dependent tools. It was originally called '3D Printing' and is still frequently called that.*" The Chinese answer to this middle European start is 'Made in China 2025', which was issued by the Chinese State council and should show the world that China intends to outpace all other countries. They want to be a manufacturing giant until 2025, improving quality, enhancing creativity and productivity and integrating industrialization (Jin, 2015).

## 1.1 Dental laboratories affected by the fourth industrial transformation

European small and medium sized companies<sup>1</sup> (SME) are aware of the upcoming revolution but most of the firms that are concerned do not feel prepared for that (Sommer, 2015, pp. 1526-1528). On the other hand, there is evidence from Chinese enterprises that they are already heavily investing in automatization. They started the first 'unmanned' company, where they replaced all their 600 employees by robots, resulting in an increase of their productivity of 250 percent (Lydon, 2016, p. 15). This shows that there is competition between the two regions and China appears to have the more advantageous trend.

The overarching projects 'Industry 4.0' and the Asian pendant 'Made in China 2025' demonstrate the rivalry in the overall production sector, but there are some major variances between different industry sectors. For example, in the car industry European manufacturers lost market share to the Chinese in the years 2007 to 2010, but since then they were able to adapt to the rapidly changing environment and the European car sales levelled out (Passenger Cars World, 2017).

Consequentially, this article focuses on the specific industry with the NACE Rev. 2 code (European Classification of Economic Activities) '32.502' which are *Manufacturers of medical*

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<sup>1</sup> SMEs are classified according to the EU's definition (European Commission, 2003).

*and dental instruments and supplies / Dental technician.* These firms produce prosthodontics<sup>2</sup>. In other words, they manufacture replacement teeth, crowns, bridges and dental braces. Forensic dentistry has proven that a person's jaw is unique and can be used for the identification of human beings. Therefore, every single tooth is unique and every patient needs individual treatment. Here, one of the benefits of the fourth industrial revolution needs to be considered: most industries see the main advantage in connectivity and automatization, but the dental industry relies on the possibility to create new designs that were either not producible with conventional methods or not economically efficient. With conventional methods, single batch production was connected to high cost; only large production batches could reduce the per-piece-cost to a minimum. Since teeth cannot be produced in large numbers, the downside of AM turns into a benefit – for large similar designed production AM is expensive, but for highly individual and customizable products like teeth the comparison of subtractive to additive technology shows that the latter is preferable. With the degree of individualization that comes with adapting to 'Industry 4.0', the unit cost can be reduced and product quality can increase (Geissenbauer, Vedso, & Schrauf, 2017, p. 4). However, the dental technicians in Sweden tend to be a slow-moving industry and is, therefore, especially interesting for our research. According to Covin and Miles (2005, p. 47), it is essential to have a competitive advantage when running a business. Due to that, all industry sectors, and especially the dental technicians are forced to keep up with the times and pace. During the last industrial revolution, many established companies adapted to the changes to keep their business running. In return, when looking at those who ignored the changes it can be seen that they lost their market position (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014).

Considering the changes of the fourth industrial revolution, the phenomena of digitalization is already taking place in many different industries. Thus, the major mass-industry sectors are by now adopting to these modifications, whereas specific industries and sectors have troubles to react. In Sweden, almost no adaptations to the changes of the fourth industrial revolution have been done. According to a market analysis, the forecast of growth for the dental laboratory market is positive (Dental Laboratory Market Analysis, Growth, Industry Outlook To 2022, 2015). In contrast, the net sales and number of employees has been decreasing since 2007 (Statistics Sweden, 2017).

In China, labor cost is dramatically lower than in Europe and especially Sweden. The Chinese are able to establish large production plants with assembly-line work and over more than 2,000 employees (Avery, 2012, pp. 80-81). These large enterprises have enough budgeted to invest in new technology and adapt to AM fast. All this leads to cheap production, but with two major flaws. First, the employees are not treated well in the factories and second, western-world standards do not apply in China resulting in bad quality control and sometimes dangerous material is used for production (Pigliacelli, 2015, p. 19).

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<sup>2</sup> Prosthodontics are dental prostheses like orthodontic appliances, crowns and bridges, complete dentures, partial dentures, or ceramics.

To sum up, it can be said that the lack of adaption to the new technological changes, the decreasing market share in Sweden and the threats from Chinese cheap production make the dental laboratory sector a topic of special interest for our research.

## **1.2 Problem**

The current status of information for the strategic positioning of dental laboratories only exists in a global context for the biggest market players. Therefore, it is difficult for SMEs in the dental sector to gather information about how to stay ahead of the cheaper foreign production. When comparing manufacturing cost and loans in Asia with European countries it is easy to see that production in Asian countries is economically better and therefore cheaper (Dental Laboratory Market Analysis, Growth, Industry Outlook To 2022, 2015). This trend can also be seen in statistical data: between 2007 and 2014 both the numbers of companies and net sales in European countries went down dramatically although the number of patients and prosthodontics needed were increasing slightly. The outcome is that Chinese countries are currently taking over market share which leads to a poor market position for concerned European manufactures (Dental Laboratory Market Analysis, Growth, Industry Outlook To 2022, 2015; Allabolag, 2017). This even impacts the whole European economy as moving production to China, particularly in specialized industry sectors, causes a decrease in the number of workstations and jobs in Europe. SMEs which have a negligible amount of orders compared to the large global players are currently facing a market change in which they are involved. Zheng et al. (2013, p. 345) reflect that China's orders are increasing and that at the same time the export of dental products is rising This is possible because of their increasing personal capabilities. In addition to the difficulty to invest money on the expensive modern technology for SMEs due to high risk, the limited budget and the lack of knowledge is a high barrier to compete against Chinese mass producers.

Due to the fact that dentists are mostly traditional, the dental sector is a very slowly reacting sector which is even effecting the dental technicians who, in turn, are neither capable of adjusting quickly to new developments. Therefore, changes and new upcoming competition are realized relatively late and established companies are often not able to react or adjust quickly enough.

## **1.3 Purpose**

The purpose of this thesis is to understand the current situation the Swedish small and medium sized dental laboratories are facing because of the threats from the Chinese competition. Therefore, we analyze the Swedish dental laboratory industry and map the situation. Moreover, we show what the laboratories are currently doing to defend their market position in a highly competitive environment.



## 2 Previous research

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*The theoretical frame of reference sheds light on the existing literature about the fourth industrial revolution, the dental technician industry and how the revolution affects the industry. A dental technician industry analysis summarizes the current situation the industry is facing. It starts with a broad review of the industrial changes and concludes in a conceptual model, which is based on our research questions and the resulting propositions.*

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### 2.1 Fourth industrial revolution

After the last industrial revolution in the 1970s the industry has been transformed again. The fourth industrial revolution is the most recent trend of automation, digitalization and data exchange in manufacturing technologies. This revolution connects automated manufacturing chains with the Internet of Things (IoT). Creating cyber physical systems while using cloud computing is the key characteristic of this transformation (Georgakopoulos, Jayaraman, Fazia, Villari, & Ranjan, 2016).

While talking about an industrial revolution in another generation the Germans came up with a description for that specific phenomenon. The concept of 'Industry 4.0' describes exactly the changes in the manufacturing technologies. Factories are about to get significantly smarter and more flexible while the production costs are being minimized. This change is not a revolution but rather a transformation because of the large number of development steps needed (Blau, 2014). Technological progress is as old as humanity. Therefore humans tend to interpret the future as a huge leap forward in evolution while forgetting that all these things are already existing and are just being connected (Weber, 2015, p. 1).

At the end of this so-called transformation, all successful firms will become digital companies. These enterprises are producing physical products inside while having digital interfaces and data based services to the outside. When implementing this change, digital enterprises will be able to work together with suppliers and customers in a digital industrial ecosystem. According to predictions, the annual revenue is about to increase for these firms by 2.9 percent while the costs are reduced by 3.6 percent (Geissenbauer et al., 2017, p. 4).

This 'Industry 4.0' is not a futuristic trend anymore. Big companies base their strategic decisions and their innovation processes on this phenomenon. The key benefit from this digitalization is lower cost. This results from big data analysis, flexible production concepts as well as system based real time monitoring of the manufacturing centers. This industrial transformation also comes with drawbacks. First-movers are forced to take big investments to convert their game changing idea into profit. Geissenbauer et al. (2017) reflect on companies which have not taken the step to invest in these digitalized technologies yet. Companies who did not invested strategically in the past are going to lose their competitive advantage in the future. Creating the needed networks and implementing the new communication tools is a big challenge for firms. A second challenge is capturing and analyzing the created data from different heterogeneous devices and systems. It becomes

more difficult because of the increased lack of software, different communication protocols and diverse software architectures (Wan et al., 2016).

When managing all these challenges, the potential success can be huge (Geissenbauer et al., 2017). The expected return-on-invest of 'Industry 4.0' investments within two years is 55 percent. Until 2020, the level of digitalization will be doubled. As stated, the impact in a global context of this transformation is enormous. The Chinese equivalent to 'Industry 4.0' is the 'Made in China 2025' strategy (Jin, 2015, p. 1). Even before this revolution started, China had already started to investigate the European economy with their expertise in investing (Bruton & Ahlstrom, 2003, p. 236). With this strategy China will, within the next eight years, improve their overall manufacturing quality, create more variability and productivity as well as integrate new information systems (Jin, 2015, p. 1). In contrast to that, Geissenbauer et al. present that China will gain the most from this digitalization process due to the high flexibility of Chinese companies as well as their openness to digital change.

When reflecting the previously mentioned on the current industrial change, it becomes clear to see that China will stay competitive in the future. The rise of the Eastern Asian countries, especially China, has a big impact on the central forces of globalization in the world economy. This rise also significantly affects the competitiveness of the concerned firms in the Western economy and the labor market. In the last 30 years, China could grow their trade volume by 1600 percent which led to a rise of 50 billion euros in 2008 only. While China was able to increase their trade volumes by such a high amount the Western market was only able to gain half of this growth (Dauth, Findeisen, & Suedekum, 2014, p. 1644). This rise and the changes of the economy can be seen in various industries.

In the car industry, the changes of the Chinese market position also become challenging for European companies. In the past, China could not keep up with the Europeans because of their inner policy. Since the key marketing changed, China is able to increase the pressure on the European car manufactures due to their adjustments in their whole marketing and selling strategy (Jiang, Kleer, & Piller, 2017, p. 1). Also because of the Chinese changes in their R&D approach they can integrate modular concepts in their products to increase productivity as well as revenue. Their changes of governmental support and the supply chain in the past years had a huge impact on their car industry (Thoma & O'Sullivan, 2011, p. 216). However, these changes of the economy are visible not only in the car industry. McGuire and Islam (2015, p. 742) point out the significant industrial changes in the air craft industry, stating that China dramatically increased their innovation capacities in that industry sector.

All these alterations in the global economy indicate that China will become a bigger adversary for the European and Western companies. Even if the European economy had started earlier with the fourth industrial transformation, China will continue to exert pressure in the future and it will get more and more difficult for European firms to not lose their competitive advantage in that industrial change (Jin, 2015, p. 1).

## 2.2 Industrial transformation in economies of scope

When doing a make or buy decision, the most important factors to look at are the vendor's production input and their economies of scope (Xu, Lu, Huang, & Zhang, 2013, p. 345). AM as well as the individualized production for every customer, have been becoming more and more interesting for years. The upcoming technology is also affected by the fourth transformation of the industry. Those new technologies are about to influence not only the production but also the supply chain design, the logistics, the product-life-cycle planning as well as the consumer behavior. The main two characteristics of this technology are, firstly, that it enables the production of physical objects from digital designed data, secondly, it allows private persons and industrial users to design and produce their own goods (Jiang et al., 2017, p. 2).

This specific technology facilitates the implementation of different business models. On an operational and on the strategic level processes and structures can be adjusted in a different way. This possibility of change can be either implemented to add value for the customer or to reduce the effort for the creation of value (Lutter-Günther, Seidel, Kamps, & Reinhart, 2015, p. 548). The past industrial revolution gave rise to new methods of mass production and allowed for the use of machines to replace labor. The competitive advantages moved towards the companies which can produce at the highest quality with the lowest costs. Back then costs were separated into fixed and variable cost. In economy of scale production, a high volume of products reduces the fixed costs of a product. When looking at economies of scope, the customer as well as the professional expertise of the work have central roles. The two economies differ in various specific parameters such as volume, customization, linear production cycles, transportation costs as well as the unique design and the changing set of competition (Petrick & Simpson, 2013, p. 13). In order to keep up with the trend of customization and individualization, new manufacturing technologies such as AM, and a different business model approach are needed. A company's ability to embed this new disruptive manufacturing technology is a big step towards a new industrial service (Schröder, Falk, & Schmitt, 2015, p. 312).

This change of how things are manufactured have a transformative impact on many different industries. AM technologies create products in a different way. While before, a physical product was created by molding material or subtracting material from a raw piece, AM-methods create products by layer construction. This process starts either with a 3D scan of a real object or a representative digitally generated model. All this information is then transferred to a specified file format and is afterwards crafted by a machine in one piece. This allows a high customization for the companies as well as for the customer. In the early 2000s this manufacturing methods gained a wider acceptance by firms and customers because the manufacturing industry was able to handle this digitalized production. As stated above, these new manufacturing methods impact various industries. They facilitate the mass production of highly customized products while reducing the inventory cost to a minimum. The biggest impact on the traditional production channels is that with these AM-technologies a decentralization of the production is coupled with the possibility to integrate customer-tailored product design. The challenges arising from this revolutionary manufacturing

methods for companies are the costs of an industrial 3D printer as well as the different materials used in each industry (Bechtold, 2016, pp. 519-520).

In the future, many different possible applications for AM can be imagined. But when looking to what Jiang et al. (2017) say, the biggest impact in the future is going to be on the production of spare parts, depending on if they are defined as critical or not. They also mention that intellectual property will get a bigger threat in the future. When a firm producing with AM-methods wants to stay competitive they have to find a solution for regulating the file sharing platforms. Mass production parts will be produced globally but customized production will occur locally (Jiang et al., 2017, p. 2).

For companies which cannot afford the initial costs of AM-machines or services the implementation of AM business models will get very difficult. A decision-making strategy on the operational as well as on the strategic level is necessary to add value to the company. Nevertheless when a firm want to implement AM processes, different adjustments regarding the process chain and the organization have to be made (Lutter-Günther et al., 2015, p. 1).

## **2.3 Dental industry**

### *2.3.1 How do laboratories work?*

As the industry is changing from their third stage to a new highly technological and connected fourth stage, so is the dental sector evolving from an analogue way of working to a more digital version. Torbica and Krstev (2006, p. 145) outline how the analogue production works: patients either see their dentist periodically or if they have problems with their teeth. When dentists find major complications and they decide that the patient needs treatment with prosthodontics, an impression<sup>3</sup> of the patient's mouth is taken. The impression is then used as the mold to cast a model of the lower and the upper jaw. Placed on an apparatus to simulate the bite and movement of the jaw both parts join as the whole model, the set of teeth. Together with a written specification the set of teeth is sent to the dental laboratory. According to those descriptions the dental technician shapes a wax model by hand and later uses this to cast the missing teeth and, if needed, the metal framework. The semi-manufactured piece's surface is processed so that a final shell, a porcelain layer, can bond to it. With this outer layer, the final shape is defined and after the coloring the piece is burned in an oven for a few hours to harden the porcelain till the prosthodontic is finished. The better the quality of the product, the closer the shape and look match the original teeth.

In the last 30 years, the way dental laboratories work has been changing continuously. Computer-aided design and computer-aided manufacturing (CAD/CAM) developments as well as new dental material have affected the dental sector (Uzun, 2008, p. 530). Uzun states that even the first step in the collaboration between the dentist and the laboratories changed. The data capture got a new possibility added - digital scanning. Either the impression is taken the traditional way and then the model is scanned in a stationary scanner or the whole part

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<sup>3</sup> A dental impression is a imprint or cast of the patient's set of teeth.

is skipped and intraoral scanning is done. Intraoral scanning is the direct scanning of the patient's mouth. The scanning can be done with or without contact to the examined object (Chang, Lee, & Wang, 2006, p. 42). The older and more unpopular version involves a touching probe moving around the surface. Today non-contact scanning via laser or other rays is more common. According to Uzun (2008, p. 533), the communication has changed from sending the model and the written specification in hard copy to computerized data sent online.

Continuing the path of the value chain, the next step is the restoration design. Uzun continues that prosthodontics are designed virtually in 3-D dental restoration CAD programs. The share of human work needed to design the product varies between the programs from almost nothing to complete user operation. After finishing the design, the file is sent to a CAM compatible milling machine. The software of the mill generates the tool path to cut out the product. When material is subtracted from a block or disc to get the final product the approach is called subtractive fabrication (Hinterschr, 1994). Here a lot of costly material is wasted. Another method, without wasting raw material, is AM, where the computer-generated path does not cut through the material but instead, laser treatment solidifies loose powder or liquids. Additionally, there are some combinations of the two ways: with a simple version of AM, called 3D Printing, wax is printed almost similar to an ink-jet printer. The built model can be used the same way as traditionally casted models.

Bilgin et al. (2016, p. 288) summarize the same thoughts in their review and add a few newly developed AM technologies. Furthermore, they state the advantages and disadvantages of digital fabrication of prosthodontics: the most important negative effects are the high cost of material and machines needed compared to conventional processes, and the absence of the possibility to try the prosthodontic on the patient before the final production. On the other hand, the positive effects are the decreased number of appointments the patient has to make, the risk of microorganism colonization and infections is reduced, and parts can be reproduced with ease and good quality control by the dental laboratory. Al-Mussawi and Farid (2016, p. 220) go one step further and add augmented reality (AR) to the task of dentists and dental technicians. With AR, implant placement can be diagnosed and treatment can be planned. They also state that at the moment this technology is still too expensive, but development goes on and there is progress all the time.

### *2.3.2 Barriers against new technology*

Van der Zande et al. (2013, pp. 2–3) used semi-structured interviews to examine the barriers why dental practices adopt digital technologies. Their results are split into six parts. The first is 'digitalization in dentistry': current and future technologies, showing that modern technology like intraoral scanning is hardly used in dental practices due to a lack of know-how and how they could benefit by those systems. In the second part, 'Benefits and drawbacks of digital technologies', they state that the main reason towards or against new technologies is the relative advantage compared to conventional methods. Even if those temporal, financial or clinical advantages preponderate, some still postpone adapting new technologies because they hope the machines will be cheaper in the future. In 'Quality, standardization and evidence', representing the third part, it is stated that the clinical

advantages (precision and accuracy) are important developments that came with digitalization. The main 'Barriers to change' were being afraid that the user does not have the skills to use the technology. This applies more to those people who learned in a non-technological environment. Other barriers are that the mostly small dental practices do not have a budget to invest in the costly technology and that it can be used in a limited number of cases only. Fifth, 'professional orientation and innovativeness' comprises that some technical, artisanal people just do not want to try out new technology because they like the way they work. This works the other way around as well, if someone is open for new things they might invest although they cannot see a real benefit. The sixth part, 'social influence' shows that hearing from the others' experiences can influence someone to use or not to use digital technology. Apart from face-to-face communication, government policies and incentives of the industry can affect potential users.

### *2.3.3 Communication between the dentist and the dental technician*

Davenport et al. (2000, p. 471) emphasize that communication is crucial for a successful collaboration between the dentist and the dental laboratory and therefore the patients' satisfaction. In 2000, there was practically no 3-D data communication between the two mentioned parties apart from the taken physical impressions. Everyone needed to rely on the dentist's ability to describe the patient's mouth two-dimensionally and the technician's ability to create a three-dimensional object out of the written specification and the provided impression tray. Afsharzand et al. (2006, pp. 203, 206) add that the written communication, called laboratory work authorization, is lacking. In their study, they showed that technicians needed to call the dentist to clarify details in up to 66 percent of the cases. Another study corroborates this trend: only 30 percent of the dental technicians who the survey was sent to replied that the written prescriptions were 'clear' and completely understandable to produce a good quality product (Dentist–dental technician communication, 2010, p. 240). Schoenbaum and Chang (2011, pp. 561-564) add the next step to make the communication outcome more successful, namely, digital photography and CAD/CAM. When done with the correct settings the difficult color matching becomes easier. In 2010, Touchstone et al. (2010, pp. 16-19) already proved that the CAD/CAM communication gateway works successfully with a case report of a 63-year-old woman who got a milled CAD/CAM all-ceramic prosthodontic with a good quality result in an even shorter time than if it would be with conventional manufacturing methods. A very new version of communication was introduced by Rusanen et al. (2014, pp. 36, 40) when they made a first-case study about recording the dentists' work with a high definition camera mounted to the dentist's head. They highlighted that a more efficient way of communicating in the dental sector is needed. Their solution was video material combined with the verbal communication supporting those that had hitherto been used. Furthermore, this close connection lifts the co-operation to a higher level, finally resulting in better product quality. Changing from written work authorizations to the usage of web content management systems will save time, improve the prosthodontics quality and is highly recommended (Alshiddi, 2014, p. 558).

## 2.4 Swedish dental market

### 2.4.1 *Swedish market situation*

In Europe, the dental sector usually is defined by small and medium sized laboratories. In Sweden, 85 percent of all dental laboratories have zero to five employees. There are only three companies with more than 200 employees (Allabolag, 2017). Pigliacelli (2015, p. 18) argues that small laboratories do not have the buying power to get good conditions when investing in new equipment and therefore, cannot afford new machines. This poses serious difficulties because without new technology it is hard to compete with highly technologized foreign competition. In the years between 2007 and 2011 net sales of the dental technician sector dropped from 5 billion SEK down to 2 billion SEK where they levelled out and are almost stable till today (Statistics Sweden, 2017). In contrast to that, the dental laboratory market is expected to grow till 2022 (Dental Laboratory Market Analysis, Growth, Industry Outlook To 2022, 2015). Taking those two developments into consideration, the question arises where the sales have gone.

### 2.4.2 *Outsourcing the production to China*

Outsourcing the production of prosthodontics is becoming more common due to cost savings compared to in-house manufacturing (Outsourcing dental laboratory work, 2007, p. 29). China has become one of the main exporting nations. The Chinese government grants a three-year tax free period for new dental laboratories. Additionally, the increasing worldwide shipping made it easy to deliver prosthodontics cheap and fast (Dental laboratory industry, 2013, p. 240). There are two connected main reason why Chinese production is cheaper than in Europe: the first one is labor. In China, there are laboratories employing more than 1,500 technicians in one factory. US and European labor laws do not apply there and thus, working conditions are terrible (Pigliacelli, 2015, p. 19). Avery (2012, p. 81) supports this statement with the example of a manufacturing location with over 2,000 employees on a 20,000 m<sup>2</sup> campus with their major customer base in Europe. Because of the exploitation of labor, the production in China can be done much more cheaply than in European countries (Outsourcing dental laboratory work, 2007, p. 30). According to Regina and Winings (2010, p. 27), the one who is importing has an ethical responsibility to check if the products are manufactured under good working conditions. Apart from the mentioned ethical aspects another problem is that China's certificates and material descriptions cannot be taken for granted. Pigliacelli (2015, p. 19) compares the dental sector to other consumer good products where dangerous substances like lead were found in toys and many other products – one cannot be sure that this will not happen for prosthodontics as well.

The second reason for the cheap production is the economy of scope. As mentioned in the introduction, every prosthodontic is unique. This explains why a dental technician's work was handmade art. In the early days, every tooth way modelled by hand. Nowadays, technology makes it possible to produce those single pieces by machine. By using CAD/CAM technology and AM they can produce highly individualized pieces in large batches at low cost.

### 2.4.3 *Challenging situation for Sweden*

Those changes in the industry lead to a decline in both the number of people training and the already working technicians (Killian, 2011; Statistics Sweden, 2017). Giovannone (2015, p. 48) summarizes the current situation the dental laboratories in Sweden are facing: the whole industry will have to change in an ‘adapt or die’ environment due to the rapidly changing technology. Without adapting to the fourth industrial revolution, smaller dental laboratories will not be able to withstand the price pressure that is pushing from China’s large production plants.

## 2.5 **Dental technician industry analysis**

To summarize the previously mentioned phenomena, an industry analysis is done. Often this is only done by understanding and coping with direct competition – this is mostly too narrow, so four more dimensions need to be added to get a clear view of the whole industry (Porter, 2008, p. 79). In the following, the analysis of the dental technician industry is structured according to Porters five forces (Porter, 2008, p. 80).

### 2.5.1 *Threats of new entrance*

The manufacturing of prosthodontics is almost an art because it is very hard to perform. One of the hardest parts is the color matching of the visible teeth to make them look like real ones and fit seamlessly into the set of teeth (Derbabian, Marzola, Donovan, & Arcidiacono, 2001, p. 161). Therefore, additionally to the compulsory education a sense of art is needed to succeed. This makes it hard for new entrees to join the existing market.

For small start-ups or self-employed technicians, the investment in the needed technical equipment can be a high barrier. Since the fourth industrial revolution, even larger investments need to be done for CAD/CAM machines or intraoral scanners. Before doing so, one needs to make careful calculations, leading to the result that it might not be profitable to buy such an expensive machine (Erickson, 2012, p. 57).

We propose that customers are old fashioned in the way they search for new business partners, that is, they hardly do so. Similarly, when dentists are satisfied with their suppliers they will not change even if the price might be a little higher than at other providers. They do not like uncertainty, therefore they do not want to try out new sources that they do not trust.

### 2.5.2 *Bargain power of customer*

As we think, the customers have little bargain power in the dental industry due to the once a year happening public price bidding and negotiating. Every year the whole industry negotiates about the price the different health services cost for the public population. All the parties to the deal are skillful negotiators and therefore, the prices always end up in a similar segment. Moreover, the power of the customer is cut down to a minimum resulting in stable conditions for the dental laboratories.



### *2.5.3 Threats of substitutes*

Total health will never be possible and an industry outlook predicts the dental laboratory market to rise till 2022 (Dental Laboratory Market Analysis, Growth, Industry Outlook To 2022, 2015). The only substitute for healthcare is other healthcare, for the dental technician sector this is the dentist itself. If technology will move the challenge of high quality manufacturing from crafting by hand to only changing the settings of a machine, the dentist will be able to produce with chairside<sup>4</sup> solutions.

One substitute for the local production is the Chinese competition (Outsourcing dental laboratory work, 2007, p. 29). For dentists, it is cheap to order whole prosthodontics from Asia. For dental technicians, it is an easy solution compared to investing in expensive high-tech equipment. But still a lot of downsides, like no labor protection or little quality assurance hinder the success of supplementing the national industry (Outsourcing dental laboratory work, 2007, p. 30; Avery, 2012, p. 81; Pigliacelli, 2015, p. 19).

### *2.5.4 Bargain power of suppliers*

We propose that the suppliers have the power to exert influence on the dental laboratory industry. If the price gap expands and the difference between the Swedish price and the cheaper Chinese alternative gets bigger, it is more likely that customers will move to the low-priced substitutes. The suppliers can influence this situation by raising the price of their products for business internal dealings. The effect is that the laboratories have to change their prices too, the Chinese production will still be able to maintain their position, and customers will change their buying behavior.

In addition, it is a common practice that machine manufacturers limit the capabilities of their products. For instance, when using a specific scanner, it could only be possible to use the data type with their own software and not with others. When producing with a 3D printer the material can only be bought from the original equipment manufacturer. With this system, they can tie the customer to their products, prevent competition for material supply, and maintain reasonably high prices.

### *2.5.5 Rivalry among existing competitors*

Empirical data shows that rivalry among the existing dental technicians is a minor issue. They do have some kind of ‘gentleman’s agreement’ with their close-by competitors to not steal the others’ customers by doing extensive marketing outside their already existing circle of customers. But due to the increasing connectivity and power of the internet an online presence gets even more important. In the near future, the ‘gentleman’s agreement’ may become less effective because customers can check out the competitors online without their direct marketing.

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<sup>4</sup> A chairside solutions is when the dentist produces products or uses technology directly next to the dentist chair, in-house.

Chinese laboratories can be substitutes, but they are also existing competitors already. With their low price politics, they were able to gain market share in the Swedish market already (Outsourcing dental laboratory work, 2007, p. 29).

## **2.6 Research question**

The industry analysis and the gaps in the existing literature leave some questions unanswered. Hence, the following research questions are drafted to close the gaps and fulfil the purpose of this thesis.

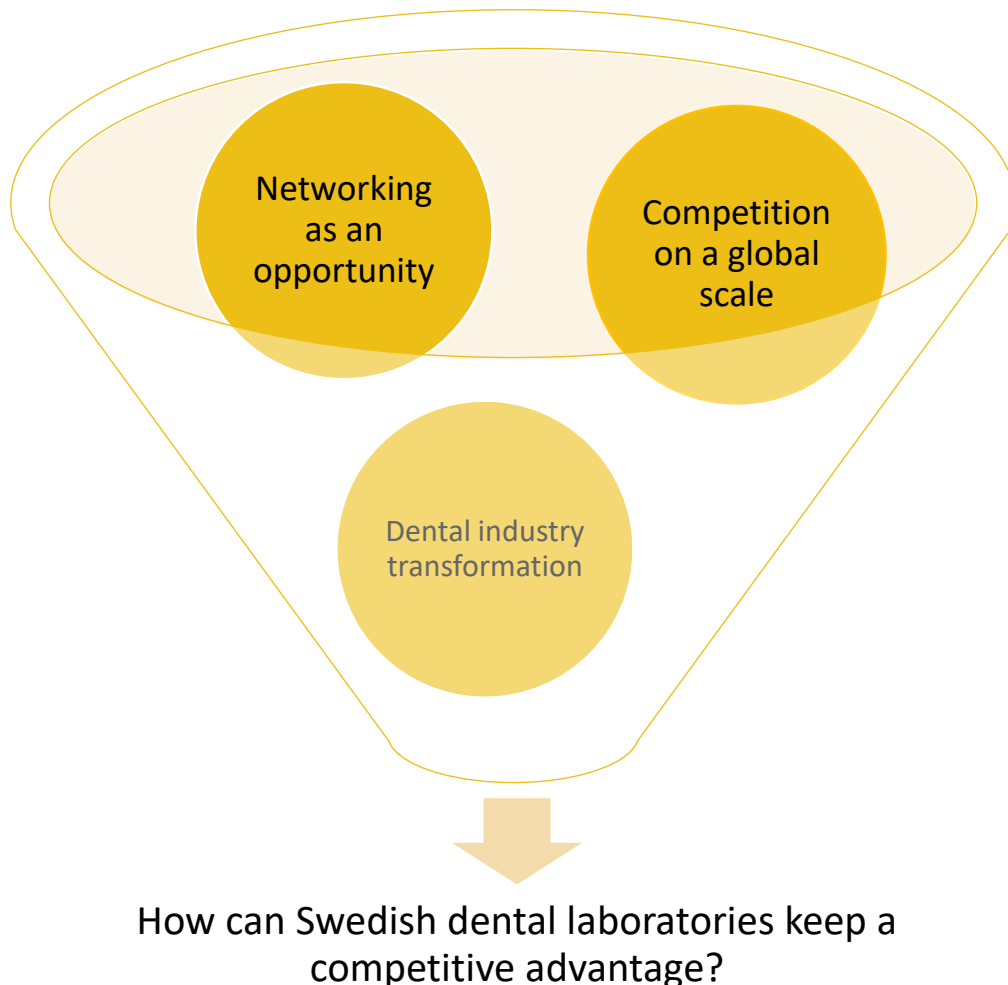
Research question 1: How is the low-cost competition from China a threat to existing dental laboratories in Sweden?

Research question 2: Which actions are Swedish dental laboratories undertaking to prevent losing market share to foreign competition?

Research question 3: How will small dental laboratories still be able to compete against both large enterprises or networks and low-cost country production in the future?

## 2.7 Research model

This model is drafted to support the research questions and the data collection. Within the analysis, the model will be either proven right and be might be adapted, or disproved and a new model will be drafted. Summing up the dental technician industry and integrating the existing literature, one major model consisting of three themes has been created to display the research questions. In Figure 2.1 it can be seen that the themes lead to the general question of this study.



*Figure 2.1: Research model*

### 2.7.1 *Competition on a global scale*

The major strategy to overpower global competition might be to focus on resource complementarity and competence sharing. Resource complementarity is *“the degree to which two partner firms symmetrically contribute dissimilar resources, in term of both type and amount, to an alliance.”* (Khoumbati, 2010, p. 233). In the dental sector, the two main partners are the dentist and the dental technician. If at least one of both sides is not equipped with modern technology the communication flow is done by written work instructions, which is often

problematic because of missing details or misunderstandings (Afsharzand et al., 2006, pp. 203, 206). And even for partners with high technological standards and digital communication the process is made easier but the outcome is still not perfect (Schoenbaum & Chang, 2011, pp. 561-564; Touchstone et al., 2010, pp. 16-19). Hence, the technician often needs to contact the dentist to clarify details or gather missing data. Although the technicians usually have no direct contact to the patients, sometimes the dentist sends their customers to the laboratory because taking the measures and modelling the set of teeth is impossible for them. Those shared competences result in a very close relationship between the concerned parties. A very close and personal collaboration requires short distances between the sharing partners. Therefore, the hypothesis that only regional partners can work together emerges.

Proposition 1: The threat from Chinese dental laboratories can be overpowered by laying focus on building strong personal relationships to the dentists.

### *2.7.2 Dental industry transformation*

Reasons for China being able to produce cheaper than some Swedish dental laboratories are the low labor cost and the large production facilities with the highest degree of state of the art technology (Outsourcing dental laboratory work, 2007, p. 30; Avery, 2012, p. 81). In Sweden, labor cost cannot be reduced due to high average wages. The possible solution is the technological one, modern machines need almost no human activity once they are started. The investment cost is in both areas at the same level because most machines are either imported from Germany or the United States. By investing in those machines the currently still active advance of large Chinese production facilities will shrink.

Proposition 2: Swedish dental laboratories need to invest in know-how and new technology to stay on the same technological level as the Chinese competition and stay competitive in den Swedish market.

### *2.7.3 Networking as an opportunity*

Small dental laboratories often do not have the money to invest in the needed expensive new technology or have too little power to get good conditions for loans (Pigliacelli, 2015, p. 19). By building up networks between other small players in the market or in their own supply chain all participants can share the benefits of the network. A study conducted by Marchi et al. (2016, p. 180) showed that by collaborating in networks the performance of the entire system improves. Additionally, they stated that partnership agreements on sharing financial resources to invest in new state of the art equipment helps to overcome skepticism of uncertain investments.

Proposition 3: One major opportunity for small dental laboratories to stay competitive in the future is to build up networks and benefit from synergies and combined financial power.

### 3 Research methodology

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*Within this chapter, the research approach and the research design of our study is described. Moreover, it is described how we collected and analyzed the empirical data. In the last two parts, ethical considerations and the trustworthiness of the study are presented.*

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#### 3.1 Research Approach

Since this thesis wants to obtain new information, understand people's opinions and identify certain patterns, we have chosen a qualitative approach. This approach generates new data more easily due to the openness and the less structured way of data collection. Qualitative approaches lead towards new concepts which are not part of existing literature. In our case, there is only little literature on which we could build a quantitative approach. The outcome of our thesis is to answer the research questions and the propositions on which a hypothesis can be built on. The chosen research approach is associated with recording, analyzing and uncovering humans experience, individual beliefs and their own point of view. Out of this approach we want to gain a deep understanding of people's experiences and thoughts and not much information from large groups (Easterby-Smith et al., 2015, p. 129).

This research is based on the realist point of view. This point of view relies on the idea of individuality of reality from the human mind. The realist's view is based on the approach of developing knowledge in a scientific way (Easterby-Smith, Thorpe, & Jackson, 2015). To understand the specific content of the dental industry this epistemological point of view is selected.

In order to generate a specified description of the threats to Swedish dental laboratories, we develop a report out of specific patterns and themes. Since we wanted to be more flexible in our research strategy, these patterns are not part of a hypothesis. We have chosen this approach due to the degree of freedom for our participants too. Thoughts and experiences can only be obtained if participants are in the right atmosphere. Unformal communication tends to collect information which is not described yet because of the level of freedom and comfort for the participants. No real limits are set before the data collection, therefore we can use all the information gathered from the participants and not limit our point of view before that (Gligor, Esmark, & Gölgeci, 2016, p. 93).

#### 3.2 Research Design

We want to obtain something new and combine these findings with the literature gathered before. Therefore, we decided to choose an approach which combines the gathered data with existing literature. The researcher takes a central role in this research approach. It is the judgement and the interpretation that are key tools for analyzing the coded data. Since we developed three research questions and created a conceptual model we have chosen to

analyze our data in a abductive way (Boyatzis, 1998, p. VIII). Also, to combine our explorative goal of the thesis with literature gathered before.

This theory driven approach focuses on the three main topics of our research:

- Competition on a global scale
- Dental industry transformation
- Networking as an opportunity

These themes represent the patterned response/meaning from the data which is related to our research questions. In our case, this data is the conceptual model discussed in the 'previous research' chapter. The goal of this thesis is to find out the specific threats from China for small and medium sized companies, the actions which are needed to prevent losing market share in Sweden as well as how small dental laboratories can survive in a competitive environment in the future. In order to identify these problems, we believe that an abductive approach is the right way to find a solution for this industry. For the development of solutions, interviews are coded and restructured into a new concept which is later used to provide suggestions for the Swedish SMEs in the dental laboratory industry. The way of data collection as well as the analysis is described in the next two chapters.

Our strategy for the successful outcome of this thesis is stated in Figure 3.1. After defining the research question a literature review of existing theory was made. Subsequently, a research approach was chosen and the research question was adjusted to the approach used. Analyzing the data after collecting it from interviews lead, after coding and restructuring it, to a common theory. This theory is presented as an answer to our research questions as well as our propositions.



*Figure 3.1: Research process*

### 3.3 Data collection

The data consists of primarily gathered data, we collected data first hand from participants of this study through interviews. The overarching goal of qualitative interviews is to collect information, interpret it, and use it to get an understanding of the participants 'worldview' (Kvale & Brinkmann, 2009). First, the aim of our research was to interview a group of dental technicians from different laboratories in a focus group. The advantage of collective interviewing is the interaction between the participants that leads to a special dynamic. It is most likely that more information can be gathered because one can build on the opinions of another (Castree, Kitchin, & Rogers, 2009, p. 258). But the group dynamic can result in a negative direction if the group gets stuck in one topic, they get lost and will not create new content. Another reason that made us change the type of data collection away from a focus group was that the dental laboratory industry is highly competitive and therefore confidentiality is of high interest to everyone. In a focus group this confidentiality must be abandoned to have open discussion.

Since the technicians will not open up their companies to their direct competition they will not talk freely within a group. By changing the research aim to interviewing representative technicians from different laboratories in single interviews, privacy can still be maintained. In this thesis, all participants will be anonymized and all data will be handled with the highest degree of confidentiality. In this environment, the technicians can speak freely about their industry without the fear of mistakenly talking too much of their business secrets to their competitors.

#### 3.3.1 *Semi-structured interviews*

According to Charmaz (2009) both semi-structured and unstructured interviews are appropriate if: firstly, the understanding of the participants world is needed. This applies here because part of the purpose of this thesis is to understand the current situation of the threats from Chinese competition. Secondly, when the topic is highly confidential, which is already described in the previous paragraph.

In an unstructured interview the questions are more used to stimulate conversation than to guide through a specific topic. Those interviews are spontaneous and therefore difficult to prepare and handle (Easterby-Smith et al., 2015, pp. 139-140). For the main part, the dental technicians, we chose semi-structured interviews because it is an open approach that will leave space to talk about topics that are not listed in the interview guide. In this guide, the main questions are noted so that it can be checked whether all needed topics are discussed during the observation. Additionally, non-verbal communication is used to assess the participant and ask the right follow-up question (Sims, 1993). The degree of openness makes it possible to go beyond the guide and collect new data that was not considered before. For the remaining part, the dental experts and dentists, we used semi-structured interviews with very little structure to still be in control of the conversation but to not restrict ourselves to the topics we know and still be open for new thoughts.

### 3.3.2 Case selection

The main part of the data collection is about dental technicians. To get reliable results we are using a purposive sampling approach. This means that the samples are *chosen* out of a target group to fit the purpose of the study (Daniel, 2012, p. 88).

*Table 3.1: Case selection*

Sector	Name
Dental technician	Company 1, C1
	Company 2, C2
	Company 3, C3
	Company 4, C4
Dental expert	Dental expert, E1
	Dental expert, E2
Dentist	Dentist 1, D1
	Dentist 2, D2

To assure the validity of our research results and to support our analysis we use data from different types of sources. This is done by interviewing dentists too. The dentist and the dental technician have in common that they have a close relationship and need to communicate in order to pursue their daily business. Often the technicians are dependent on the dentist because latter decide what they want to order and what they do not want. This close connection and their dependency makes it possible for us to interview an additional number of dentists too. The data is used to either support or disprove the conclusions made from the technician's data. The same holds true for dental industry experts. We included interviews of those to assess the whole situation the industry is facing due to the current changes. The distribution of interviewee type can be found in Table 3.1.

### 3.4 Data Analysis

A thematic analysis is a method used to encode qualitative information. These themes are the patterns found in the information that either describe or interpret aspects of a certain phenomenon. The patterns are generated by raw information from the data collection or from theory and prior research. We have chosen this approach to capture the intricacies of meaning inside our data.

The thematic analysis is used to identify key themes in the text. This is used to build theoretical models to find a solution to real world problems (Guest, MacQueen, & Namey, 2012, p. 17). Since we want to solve an industry problem by using a theoretical model with a literature comparison this approach suits our thesis. This analysis is according to Guest et al. well-suited for a team research and the interpretation is supported by data which means that a high-quality report can be produced after completing the analysis. This abductive approach



is theory driven and focuses on the specific aspects of data determined before (DiCicco-Bloom & Crabtree, 2006, p. 318).

The field of international business is by far not saturated with theory. Gligor et al. (2016, p. 93) argue that there is a need for more theory development in that area. When reflecting on the expected outcome of our thesis it can be stated with certainty that a thematic analysis design is a suitable approach for us.

Chapter '2. Previous research' chapter includes the basic concepts or predefined ideas as solutions to the research question. Therefore, we are able to analyze the gathered data and afterwards link it to the theory and the conceptual model. This thematic approach therefore suits our case best because even while using a qualitative research design a theory driven approach is possible. With this analysis, we are able to compare the gathered data with the propositions of the conceptual model. The aim is to analyze the gathered data systematically, meaning that theory is built from themes and categories. These categories are based on the codes which were found in the transcribed interviews (Guest et al., 2012, p. 7). Moreover, thematic analysis tries to understand the meaning of data and it is also open to new discoveries (Easterby-Smith et al., 2015, p. 95). Thematic analysis is characterized by iterating and constant comparison of the coding and the analysis. This process of iteration is useful to reanalyze the data from a different angle, add or remove additional data as well as to revise the initial interpretations (Guest et al., 2012, p. 13).

In order to answer the research questions Braun and Clarke (2006, p. 87) developed several steps of analysis which are necessary to complete the research:

- **Familiarization** – This initial phase in the thematic analysis is to familiarize the researcher with the data. Reading, note taking and transcribing the gathered data are the key tasks in this phase.
- **Initial coding** – The second step of this analysis is to generate a list of items from the data set. The way of gaining and organizing the meaningful parts of the data is called coding. This process is not completed at first try. Refining, combining and splitting potential codes are key jobs in this part.
- **Searching for themes** – Braun and Clarke describe this step as an analysis of the potential codes. Deducing themes by combining codes is the goal. These themes are an analytical reflection of the codes. In this stage, present data but also missing data is described.
- **Reviewing Themes** – In this stage the researcher searches for data which supports or contradicts the literature. This phase consists of two levels of reviewing and refining the themes. In level 1 clear patterns and themes are identified and compared with the coded extracts. If they do not form distinct patterns the themes should be reconsidered. Level 2 reviewing considers the validity of the individual themes and compares the themes with the initial data. The outcome of this phase is a thematic map.
- **Defining and naming themes** – At this point of the analysis the researchers refine the specifics of each theme. Generating clear definitions is done by looking at the overall story the dataset tells. The outcome of this stage is that the researcher defines what the current themes consist of and give a concise explanation of them.

- **Producing the report** – While writing the final report of the analysis the researcher should make meaningful contributions to answer the research questions. The goal of this phase is to write a report which contains the final analysis related back to the research questions and the existing literature.

In order to get familiar with the content and data we reviewed literature and transcribed the interviews according to our interview guide. Also, reviewing the raw data helped us to get familiar with the data. After this first step we coded the raw data to find significant codes. During this step, we evaluated and combined them while comparing them with our conceptual model. Then we searched for themes within our gathered codes to actually see what content is already described and which parts are missing. At this stage, we reevaluated our themes with the literature gathered and the conceptual model. This helped us to validate the developed themes. After reviewing the chosen themes, we described them and clearly stated their content. With this setup, we are able to combine our collected data with the gathered literature to create a valuable analysis. After following the six steps the final report of the analysis is produced.

### **3.5 Ethical Considerations**

Ethical considerations have to be made through all stages of the research. The research design influences the ethical issues the researchers might face. For justification of the research it is not to harm, wrong do or risk anyone during and after the research. Management studies tend to often do something wrong rather than harming anyone. Every study in a human context requires ethical approval.

Privacy, anonymity and confidentiality are important in all stages of the research. Conversations between participants and researchers have to remain private and participants must not be discriminated by any organizational member. Identities of participants have to be protected if the researcher finds it necessary or the organization ask for it. For individuals, this includes age, name, gender, position and the department, and for organizations the name, location, or other specific data. The access to this data must be protected to ensure the confidentiality. In our case, by exposing the size of the firm (according to the EU definition) and industry, all participants are still protected. The identities of the participants of our research are protected in the whole study. By doing that, no respondent is getting harmed before, during or after the research is conducted. In order to do so, we selected a unique code for each respondent to ensure privacy and still be able to analyze the data correctly.

All participants of the research must be informed about their role in the study, the potential risks and benefits as well as the nature of the research. Before the researchers begin with the data collection, the participants have to be informed. They either confirm or refuse the consent based on the information provided before. To make sure the interviewees were fully informed, we signed an ‘informed consent’ in which we declared the ethical considerations. This document can be found in the appendix of this thesis. After the participants were informed and all uncertainties are eliminated we started with the interviews. This ensured that we operated in an ethical correct way before, during and after the data collection.

In order to fulfil all the ethical considerations above, Bryman and Bell (2011) developed ten key principles in research ethics:

- Ensuring no harm comes to participants.
- Respecting the dignity of research participants.
- Ensuring a fully informed consent of research participants.
- Protecting the privacy of research participants.
- Ensuring the confidentiality of research data.
- Protecting the anonymity of individuals or organizations.
- Avoiding deception about the nature or aims of the research.
- Declaration of affiliations, funding sources, and conflicts of interest.
- Honesty and transparent in communicating about the research.
- Avoidance of any misleading or false reposting of research findings.

These key principles are considered in all stages of the research as stated above to ensure an ethically correct research.

### **3.6 Trustworthiness**

To make this thesis and its outcome trustworthy the four criteria of Guba were applied in the process of crafting the thesis. According to him, in qualitative research credibility, dependability, transferability and confirmability help to ensure the authors' trustworthiness (Guba, 1981, pp. 79-80). In order to ensure trustworthiness in our research we considered the criteria in the subchapters below to create a valuable report.

#### *3.6.1 Credibility*

According to Patton (2002, pp. 552-553), there are three related elements that assure the credibility of qualitative research. First, fieldwork was done by using rigorous methods to gather data of high quality and analyze it systematically by always considering credibility. To implement these methods, we analyzed various research approaches and selected the most suitable one to answer our research questions. Secondly, the credibility of the researchers, which in this case is assured through the educational mandatory research classes the authors had prior to the drafting of the thesis and the constant monitoring by a credible supervisor. Thirdly, the authors' belief in the values of qualitative research, which are fundamental appreciation of naturalistic inquiry, qualitative methods, purposeful sampling and holistic thinking. Guba describes the credibility criteria as prove that the results are believable and credible for the participants and the readers of the qualitative research.

### *3.6.2 Dependability*

Dependability in research is given when the work could be repeated in the same context, with the same methods and the same participants so that the results would be similar (Shenton, 2004, p. 71). More concrete, the study is reported in detail to enable future researchers to reproduce it. Shenton adds that the research design should be seen as a 'prototype model'. This reproducibility is, according to Guba, the traditional qualitative criterion of reliability. This means that if the phenomenon of the research is observed a second time, the outcome of the results should still be the same. We implemented the dependability in our thesis by describing the theoretical content extensively, asking three research questions based on the literature and formulated three propositions based on the research questions. In addition to what has been said before, Guba states that it is not possible to measure the same thing twice. To ensure that the qualitative study is as reliable as possible the researchers have to construct theoretical notions to make the results replicable. In order to fully ensure the aspects of dependability in our thesis we stated every theoretical source clearly, described our way of analyzing data as extensively as possible and connected the data to the theory in an understandable and clear way.

### *3.6.3 Transferability*

Transferability describes in which degree the content of the results can be transferred or generalized into another setting or context. In qualitative research, it is primarily the generalization aspect which is responsible for the transferability. In our case, we want to link the results and the analysis to a national context (Guba, 1981, p. 89). To generalize the outcome of our thesis for the whole dental laboratory industry transferability is needed. To ensure this aspect in qualitative research the researcher has to describe the research context and the assumptions in an extensive way. To integrate this in the thesis we described the research questions and the propositions thoroughly and stated clearly the central link to our research.

### *3.6.4 Confirmability*

Confirmability in qualitative research describes the perspective of the researchers and how this point of view is shared and confirmed by others. Every researcher brings a unique perspective to the subject of a thesis. Therefore, it is important to which degree this opinion is corroborated by others (Guba, 1981, pp. 87–88). Several strategies to guarantee the confirmability have been developed. Documenting the procedure throughout the study, auditing the data collection and the analysis, making judgements about the potential distortion and actively describing the negative instances that contradict prior observations are possibilities to ensure the confirmability of the research. We established confirmability with an objective point of view and since there are two researchers the perspective has to be shared by at least two persons. In order to ensure confirmability in all stages of the research we judged and evaluated the individually written parts before adding it in the thesis. Since all steps are documented with a valid reasoning we guaranteed that our research has a high degree of confirmability.

## 4 Findings

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*Following, the findings of the collected data are presented. The interview content is stated from a realist's perspective and divided into the three parts: dental technicians, dental industry experts, and dentists. The individual parts are structured according to the interview guide.*

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### 4.1 Interviews with dental technicians

The findings in this section will be presented in the same order according to the interview guide that was used for the semi structured interview with all the dental technicians.

#### 4.1.1 Company C1

Company C1 is a small Swedish enterprise which has been in the market for 11 years already. It was represented by the owner of the firm, who is a working dental technician himself. They produce the whole range of products that are needed for prosthodontics, but they are specialized in the manufacturing of crowns and bridges. They started the production the traditional way: the technician gets the impression tray from the dentist, makes a cement cast and thereupon produces a model. The model of the set of teeth is then used to design the missing tooth by hand. A few years ago, they invested in a desktop scanner for the model to scan it and then design the crown using a special software. At the same time, they bought a CAD/CAM milling machine to cut the crown out of a raw material disc. Not long ago, they started to import additive manufactured framework structures from Germany to make production of cobalt chromium crowns possible.

After the dentists decide that the patient needs treatment they will take an impression. The impression tray, together with the printed work authorization is then either sent by mail service or picked up by the technician. The model is produced, depending on the chosen material, scanned. Here is the first time when errors can occur due to missing or incorrect information. In case of misunderstandings, the technician calls the dentist for clarification. Often, it is very hard to take measurements of some patients so that the patient either needs to go to the laboratory or the technician meets them at the dental practice. C1 replied: *"Without the close collaboration to our clients we couldn't produce that high quality. In 75 percent of our orders we have to call the dentist and ask them about details like the color shade or the exact position of the implant."*

The communication to their subcontractors works in a similar way – they order online by sending a STL file for the AM. According to C1, they often need clarification due to the still not perfect technology. They order those parts from Germany because Swedish subcontractors are way more expensive and although Chinese production has lower cost, the quality is worse. Due to missing mandatory certificates, quality cannot be assured beforehand. The risk of waiting one or two weeks and then getting bad quality is too high for them.

In the last few years C1 experienced a lot of changes in the market. They reported that C1 knows that the numbers of patients are almost staying the same, but the national market revenue is shrinking. The technician blames foreign competition for this. Not only dentists can order whole prosthodontics abroad, but also company C1 itself orders semi-finished parts from internationals. They are aware of the low-cost country production but think that they will not become more threatening as they are already. They did order some example print from China already but were not completely satisfied with the quality. Because of the distance and the language barrier, C1 does not think that they can ‘steal’ more of their customers.

Still the company realizes that they need to do something about both foreign and domestic competition because in the last years word of mouth marketing changed to regular marketing. *“Beforehand, a dentist would stick to its supplier if the quality is good. No matter if the price is a little more expensive than the competition.”* Currently, the dentists realize that they have more opportunities and can choose their supplier with more ease, C1 states. Because of that, company C1 is stepping up their online presence. Additionally, they will start a complete new service that they cannot talk about yet – C1 only mentioned that at some point all small sized companies should consider to change their business model slightly in order to create or access other, new opportunities they cannot address with their current way of working.

The concluding remarks were that they are aware of the Chinese competition but they think that the ‘stolen’ market share is currently at a top level and that the most important function within the collaboration of dentist and dental technician is still the close connection which is needed to clarify missing details and make perfect color matching possible.

#### 4.1.2 Company C2

The owner of company C2 has been a trained dental technician for 40 years and has run company C2 as a micro firm for 20 years. The focus of the work lies in the fast service of high quality dentures<sup>5</sup> and bridges. The production is only done in traditional ways by hand without any modern technology like CAD/CAM. In the current workflow, the dentist takes an impression of the patient’s mouth and the bite alignment. C2 then picks up the impression tray to make a model out of it. Approximately one week later, the technician meets the patient at the dental office to either make corrections of the model or finish it. In the own laboratory, they start to design the teeth by adding layer after layer by hand to a pre-manufactured framing structure. To finish the design, C2 continuously fits it into the model and checks if the bite alignment is still correct and if the shape fits into the overall picture. Impression trays are very sensitive and may not survive high temperature changes or rough handling. For C2 the sending via mail is too risky, so C2 picks them up from the dentist in person.

In C2’s opinion: *“Dental treatment lives from a close collaboration between the dentist and the technician. If this axis won’t work the patients will get a bad product.”* During those regular visits, the technician can also clarify missing details if needed. If the clarification is urgent, C2 calls the next day

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<sup>5</sup> Dentures are also known as ‘false teeth’.

and asks for details or a new impression. *“The partnership is like a marriage. You need to talk.”* C2 argues that there is still a language barrier which makes communication with Chinese companies hard. Often the large production facilities have personnel to communicate with the customers, but those are not the technicians who work on the product. C2 compares it to the game ‘Chinese whispers’, the one receiving the feedback might change it slightly when telling it to the technician. The result is that only minor changes can result in a completely different outcome.

*“The treats from China still seem to be far away,”* C2 states *“a bigger threat are our neighbor countries like Poland because patients can go there and get a better price than in Sweden.”* If patients need one crown they will go to a Swedish dentist and will moan about the price but they will do it. If they need 10 to 15 new teeth it is worth crossing the borders. In Poland, there are even service centers where one can go to, have the impressions made, stay in a spa for one day and on the next day they will get the prosthodontic. In the background, technicians work all day and night in shifts to complete the product within 24 hours. One drawback is that two to four people are working on one single piece which increases the sources of failures. In China, this is even worse - in large plants, the work is done in assembly lines where one person only does one step in the value chain. When a lot of people are working on a single piece no one knows exactly what the previous one was thinking when doing their step and why they might have designed it like that. But still, C2 thinks that crowns from China can be good quality sometimes – the best actors of this branch come from Japan – but patients do not want to wait more than a week for the product. And if the quality is bad, it must be redone which needs at least another week. Other changes in the market are the recent introduction of intraoral scanning which which is not a matured technique yet. C2 does not know anyone who uses it because of the risk, the high investment and the not guaranteed quality. C2 compared the scanners to electric cars: *“99 percent drive a regular car, 1 percent drive electric ones. You won’t buy a Tesla for 1 million SEK when you aren’t sure that it can drive at least 100 kilometers with it.”* At the beginning, only a few were brave enough to buy one, but now everyone who can afford it wants one. For intraoral scanning, it will be the same, it still has to mature and prove its quality.

*“I’m in my mid 50s now, my generation will not have any problems with Chinese competition.”* C2 believes that they do not need to change anything, they had their satisfied customers and will stick to them until the owner retires. But still C2 is aware that there are some major changes in the industry. At university, modern technology is taught and the new generation with full digital equipment will have to find new ways of working to retain the same market level. Their own arrangement to stay on the ball is that C2 reads a lot of dental journals to keep track of the technological evolvement. If the company will spot something they are really interested in, C2 might change their way of working.

Concluding, C2 said that there is no need for being afraid of anyone because the owner will retire soon, but C2 thinks that the next generation must change or otherwise they will fall behind. As C2 is interested in the fourth industrial revolution they will also try out new things if they get cheaper and are not as risky as they are now.

#### 4.1.3 Company C3

Company C3 is a small Swedish firm which has been a market player for eight years. The owner, our interview partner, is the co-founder of the firm. They produce all types of prosthodontics, they work as a full-service laboratory. Since years, they are using the most advanced technologies on the market. Digital printing and CAD/CAM systems are used to manufacture all the products. Investing in new technology is a key capability of the company since they always want to gain a competitive advantage through advanced technology.

When the dentist takes an impression of the patient they either contact the dental laboratory per e-mail or via phone to arrange the job. Locally, all jobs are picked up by the laboratory themselves and if the dentist is far away they use a post service to pick up and deliver the products. After the registration at the arrival the prosthodontics get produced. When there are any open questions regarding a job, company C3 contacts the dentist to remove uncertainty. This is very common, to either answer the questions the company have but also to give the dentist recommendations according to the current job. Since the company often works three to four times a week with the same dentist a close collaboration and an intense communication is needed. C3 stated: *“You as a dental technician have to be 100 percent sure what the patient wants.”*

Since 2009 the Chinese competition is shrinking, C3 argues. They trace this to the good Swedish aesthetic quality, the product quality as well as the service quality. *“You can’t compare local dental laboratories with the foreign competition when it comes to these parameters.”* On the other hand, Chinese firms are producing their products more cheaply than C3’s company could ever do. When the company started, they had about 60 percent of their suppliers located in China. Today, after eight years, this percentage decreased to 4 percent. They shifted from importing the products to manufacturing them locally. From a strategic point of view the company wants to show the customer that the local production of a Swedish dental laboratory is outstanding. When a new machine comes on the market the company is one of the first ones to buy it due to the strategic goals and the competitive advantage that comes with this advancement.

For company C3, the market did not change a lot in the last years. *“The market is transforming but with advanced technology this is manageable for us.”* The company collaborates with other dental laboratories to generate an advantage. For the company, there are always threats as the upcoming technologies, the local and foreign competition, and the increasing investments in the future. The only chance for staying in the market while it is transforming is to deliver high quality products and maintain a good communication with the customers. Nevertheless, C3 argues that without investing in new technology or building a network with other market players a small Swedish dental laboratory will not be able to stay in the market.

Since their strategy worked well for the past years, they continue investing and satisfying their customers with high quality products to stay ahead in the market. Overall, C3 says that all market players have a high dependence on their inner competences. Moreover, the technician considers the local competition and the transforming market a bigger threat than the foreign competition from Asia in the upcoming years.



#### 4.1.4 Company C4

Company C4 is a micro-sized dental laboratory. The interviewee owns the laboratory since 2014 and has been a trained technician for several decades. C4 is specialized in the production of dental splints. Splints protect the already adjusted and corrected teeth from movement after the dental treatment. This acrylic product can still only be produced by hand via shaping the acrylic plastics over the model. Up until today, there are 3D printers that could make splints in good quality, but the material is not allowed to be used in the patient's mouth, *"I'm afraid of the times when I'm replaced by machines. But now 3D printing is still too bad."* Usually, the impression trays are sent from the dentist to the technician if they are located outside the technician's county. Inside, an assistant picks them up by car in person. One singularity about the company is that the customers are even located outside of Sweden because the production is specialized and of very high quality.

*"One of my customers told me that it is easier to change your wife than your dental technician."* C4 emphasized that a close collaboration between the dental technician and the dentist is the most valuable asset one can have. In almost all their orders they need to call the dentist to clarify some details. Sometimes, even the dentist calls before sending the impression tray to discuss how they should treat the patient. Due to the experience C4 gathered throughout the years the quality and reputation is very high. Chinese laboratories will most probably never have a similar reputation because a factory with thousands of employees cannot be as personal as a micro-sized company. Furthermore, the impression tray is made from a material that can only be used for about three days. After that period, the shape is slightly different which makes the making of a model impossible. C4 thinks that sending the impressions to China is possible but very risky due to the fragile nature of the material.

*"My product isn't the expensive part. Dentist like to order splints in Sweden because they want in now and with good quality."* C4 knows that their products can be produced way cheaper in China but also knows that dentists mostly make their decision based upon quality aspects. The respondent mentioned a public bidding process in Sweden where one laboratory was offering Chinese prices with Swedish quality. Of course, all dentists signed the two-year contract with them and then got in trouble. The problem was that they started the laboratory overnight and got so many offers that they needed to hire 'little-skilled' employees to cover the high demand. The result was that the price was Chinese but the quality was one of the worse in Sweden. Since then, C4 knows that dentists check the service in detail before signing a contract. *"Now they know it was stupid. They learned from it,"* C4 added, and said that they are antipathetic towards Chinese production. Another reason why China is not a big threat for the specialized dental laboratory is the time aspect. When the splint is not perfect, it has to be redone which takes a lot of time if it is sent from China. Additionally, it means that the patients need to go to the dentist once more. The patients do not know about the technician which means that the dentist accounts for the quality. Therefore, the dentist needs to choose their supplier wisely.

C4 thinks that the company is not being threatened by anyone at the time. They are specialized in a small sector that not many competitors are situated in. The only danger is when machines evolve that far that they can produce splints with material that is human-

compatible. But due to the current technological progress, this threat will only be a problem in five to ten years the earliest. *“No one will pay me more than the Chinese. Only the machine will do the job.”* Therefore, small laboratories will have troubles to compete because of the high investments for the machines.

All in all, the dental technician C4 does not think that China is a real threat to the laboratory: *“They don’t have a close cooperation, I’m faster, my quality is better, my work is appreciated by my customers.”* The only threat for them is when machines will get that good that they can replace humans and the still skill-requiring handicraft.

## **4.2 Interviews with dental industry experts**

The interviews with the industry experts are held as open interviews to get new insights and not restrain ourselves to the interview guide. The chronological order of the findings presented in the following is similar to the original order within the interviews.

### *4.2.1 Expert E1*

Twelve years of work experience, several inventions in the dental industry as well as hundreds of dental laboratory visits gave Expert E1 the qualification to deeply focus on the dental industry and the threats this specific industry is facing right now. Following, Expert E1 describes the changes and especially the challenges of our target industry. In the expert’s opinion, most dental laboratories create the crisis themselves. Their mind-set did not change over the past years. Gathering new customers or doing marketing for their business is neglected by most of the market players. Expert E1 leads this back to their education and missing knowledge in marketing as well as their fear of close customer contact.

The expert sees the foreign competition from south-east Asia as a stagnating threat in the past years. Since this competition also has the need of new manufacturing technologies the price advantage is not that big anymore. When talking about SMEs in the dental industry, Expert E1 sees the threat especially for the micro and small firms. These firms do not have the financial capabilities to make bigger investments for the upcoming technologies such as AM or intraoral dental scanners. *“The biggest drawback here is, even if they afford such a technology they do not have the capabilities to outlast these machines.”* When Expert E1 focuses on the collaboration between the technician and the dentist itself, a few changes in the future can be seen. The communication is still an important factor but it will be decreasing in the future. The expert argues that in the future dental technicians will work as a refining party in the process chain. Within the next years, the number of market players will decrease due to all these changes mentioned before. Since the dentists and dental assistants will make the basic framework in a chairside-style solution, many companies will not be able to handle this market transformation.

Expert E1 thinks that quality is an important factor of the framework. *“Only when dentists are able to keep the quality high with this basic task the patients will stay.”* The technicians will mostly focus on the refining process of the prosthodontics which minimizes the need for foreign manufacturing. They only have employees to finish the dentures which they purchase from low cost countries and sell them for European prices. Small dental laboratories can only be

successful when they build up a network with bigger companies to use their manufacturing centers. Education for dental technician is an important factor for the upcoming trends in this industry as well. The slow pace in this industry makes it very difficult for small established companies (20 years work experience and more) to go with the additive technology. Also, the missing marketing for these small market players makes it very difficult to keep track of the customers and new technologies. Social media and a website are key factors, according to Expert E1, to be successful. But only a few market players have established such a media presence. Ultimately, in the expert's opinion, the strategic goals for dental laboratories should be marketing and a collaboration with other market players to keep the competitiveness in this industry.

#### 4.2.2 Expert E2

At the beginning of the 2000s, the percentage of foreign-bought dentures was much higher than now. Expert E2 considers the foreign competition from south-east Asia not as frightening as it was back then. Since then the numbers are slightly decreasing but in the expert's view, they will not leave the market. The expert sees the Asian dental laboratories more as manufacturing centers in which European dental laboratories order dentures and just do the finishing in Europe. This is possible due to the improved logistics in the last year. Expert E2 says, *"The most important date for a small dental laboratory is when the logistic company take or bring goods."* Another big reason why the foreign competition is not that dangerous is that big European dental laboratories start to build manufacturing centers in Europe. Since there is very little manpower needed, the products are not more expensive than from a low-cost country.

The new technology of the intraoral scanner is too expensive for small dental laboratories. In the next years when the technology becomes affordable, this will transform the market again. The Expert states *"This is the missing link in the digital workflow."* When facing the problems for the industry, Expert E2 says that the small laboratories will have a hard time staying in the market. This is not only because of the missing resources to invest but also if a small laboratory can afford a 3D printer they do not have the capabilities to run the printer at a reasonable capacity. One of the little things that helps these little market players to stay in the market is the close collaboration with and trust from the dentist. Many small dentists do not have the capability to keep up the pace. For instance, the Expert says, some dentists are not able to use advanced CAD/CAM technologies. This also binds the local dental technician to the dentist. In the future, the market will transform and force the dentists to integrate modern technology. At the same time, new dental technicians who had a different education are entering the market which also means that if the small dental laboratories do not start integrating new technologies they will not succeed in the future.

These small dental laboratories, according to the expert, have to build up a network in order to avoid huge investment and maintenance costs of a new technology. Networking between dental laboratories reduces the manufacturing costs and increases the quality of the goods. In addition to these improvements, the strategic goals for small dental laboratories can be handled more easily. Instead of ordering products internationally from foreign countries, Expert E2 sees a collaboration with a local manufacturing center as more efficient and

successful for the future. When working together closely in a local environment the competences of small dental laboratories stay inside the local networking boundaries. Overall, the expert thinks that without changing, investing or collaborating with others, small sized dental laboratories will have to leave the market.

### 4.3 Interviews with dentists

Similar to the dental industry experts, the dentists' interviews are held as open interviews to support and prove the findings from the dental technician interviews. They are presented chronologically the same way they were held.

#### 4.3.1 Dentist D1

In addition to being a private dentist, D1 works for a large Swedish dentist network. In the networks, participant D1 acts as a consultant for most of the new dentist. Participant D1 knows the sector well and is in close contact with a lot of companies.

As a private dentist, D1 is aware of the technological changes: already 15 years ago, the dentist bought a CAD/CAM machine to produce crowns in-house as a chair side<sup>6</sup> solution. Dentist D1 was very satisfied with the product but when it broke down, dentist D1 knew that an investment in a new one would not be a good idea. The first reason was that the machines are very expensive, a breakeven of the investment was never possible. Second, the dentist has so many patients that participant D1 wants to spend more time on the patient in person and not on the production of additional products. Hiring someone else is out of question as well. Dentist D1 said: *"I tried it myself and I didn't like it. My only possibility now is to outsource making of prosthodontics."* Intraoral scanners would be a good solution for a lot of reasons: *"Taking impressions is very inconvenient for patients and some cannot do them at all."* With digitalizing this step, it would be much better in regards to comfort and even the time needed would be reduced. But again, the investment in a scanner is too high for one dentist to use it in an economically reasonable way.

As a consultant, dentist D1 thinks that the majority of Swedish dentists does not want to produce prosthodontics in-house due to the risk of the high investment and the low utilization level. A lot of participant D1's clients tried out Chinese dental laboratories, some of them were satisfied and some were not. *"Price doesn't matter because I don't pay it. As long as the patients is willing to pay a fair amount to sustain his health I will go for European products."* Participant D1 argued that dentists value quality over cost. Chinese production is cheap, but it has some negative sides. Quality control is hard, the delivery time is way longer, there are almost no labor rights that protect the technicians. Ethically it is better to order from local sources. Finally, a dentist usually still wants a close relationship to the technician. Dentist D1 currently use dental laboratories close to the dentist's location. One is a very expensive one with superior quality, used for front teeth. For non-visible teeth, a second one is used, which is cheaper and from average quality. *"I don't like the way how shipping is done today, everything is sent*

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<sup>6</sup> Chair side means that dentists can use it on their own, directly next to their dentist's chair.

*around the world for more than one time. I want my products from local suppliers with a low carbon footprint. We are in the health business, this includes a clear planet and clean air.”*

The last comments from dentist D1 were that in the future dental technicians will still be needed because dentist will spend their time on the patient and not on products. The dentist knows that the industry is changing and automation starts to settle in the dental industry – but thinks that in the future dentists will still want to buy from local sources.

#### *4.3.2 Dentist D2*

For 5 years, dentist D2 acts as a private and public dentist in the industry. The participant knows the dental laboratory industry well due to a cooperation with two different dental laboratories.

The dentist is in full knowledge of the market changes because they always try to go with time and the technology’s pace. The product portfolio reaches from aesthetic dentistry to pine surgeries, dental prophylaxis as well as braces. No production is done in-house. This means that if the dentist needs any kind of dentures, dentist D2 contacts one of the two dental laboratories. The dental technicians there are in very close contact with the dentist and the patient. Dentist D2 says: *“If a patient isn’t satisfied with the service I contact the technician. They are kinda nice thoe, they even come here if it’s too hard to discuss on the telephone.”* This is possible due to the close location to the doctor’s office. This proximity as well as the close and frequent collaboration are the main reasons for participant D2 to select the dental laboratories. In the opinion of the dentist, this cannot be achieved with an online supplier or a foreign manufacturer. In terms of future collaboration with the dental laboratories, participant D2 stated: *“Even if the processes change, the collaboration between dentist and technician will always be important.”*

In the participant’s opinion, daily business quality, service and expertise always value higher than the price. This is also reflected in the customers’ attitude, *“If the quality and the service fits they are willing to pay the little higher price.”* The dentist has no experience with Chinese products, solutions or services because of many reasons. The close collaboration within a friendly and personal work environment which is not existing if someone is ordering dentures in China is always wanted. Dentist D2 also thinks that ordering from China is unethical due to the wages, the exploitation of labor and the effects long-distance traveling has on the environment. However, in the future intraoral scanners will result in a major change to the industry. It saves valuable time for the dentist and the dental technician. Nevertheless, dentist D2 thinks that this digitalization will not be a threat to the European dental laboratory industry.

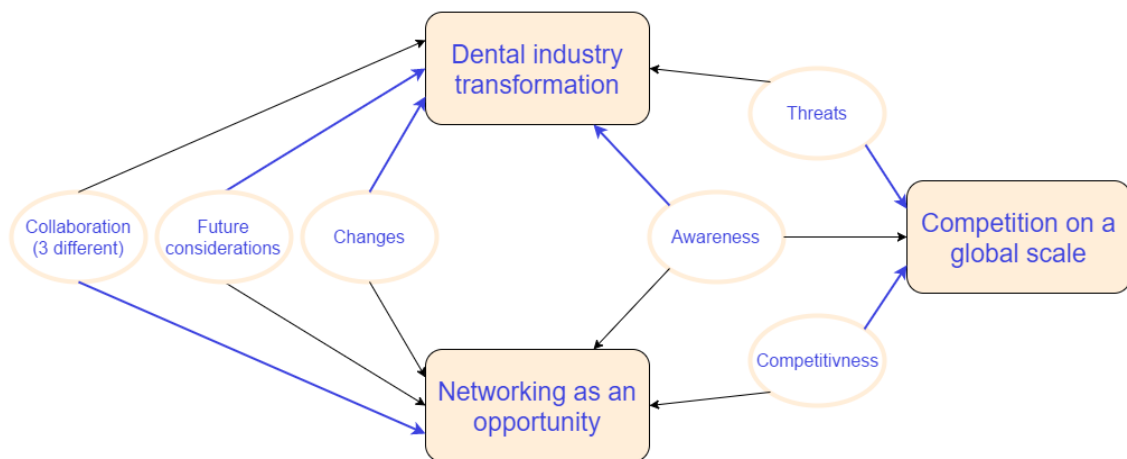
## 5 Analysis of data

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*The aim of this chapter is to analyse the empirical data in comparison to previous research. First, the three themes including the categories are discussed. Secondly, the research questions will be answered with additional support from the research propositions. Finally, an overall conclusion of the Swedish dental laboratory industry is drawn.*

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To illustrate the process of the thematic analysis and how the data is constructed to a final theory we designed Figure 5.1. Each circle represents a category of similar codes. Some of the categories have similarities and are centralized in one of the themes, which is represented by the large pink boxes in the figure. Each category directly relates to one of the themes. This correlation is illustrated by the blue arrow reaching from the category to the theme. Due to the complexity of the system, some categories partly belong to one or two other themes as well – those dependencies are illustrated by the thin, black arrows. As an example, to explain this better we highlight the category ‘changes’. Changes are directly linked to ‘dental industry transformation’ due to the nature of transformations. Furthermore, ‘networking as an opportunity’ is also indirectly affected by changes in that building a network is a change for the dental technician. This chosen way of analysis connects the theory driven approach with our empirical data in a comprehensible way and it eliminates the possibility of dismissing important data. In order to draw a valid conclusion, the themes are matched with our previous research model.



*Figure 5.1: Map of the themes and categories*

To combine our empirical data with the previous research we looked for similarities in the different sections. In order to compare our research model with the findings we searched the empirical data for codes to fit our context. By comparing them to the research model we evaluated them to come up with categories which match the structure of the analysis. Then the developed categories were validated and adjusted and afterwards connected into themes. Subsequently, those themes including their categories are analyzed and discussed within the

next three sub-headings. The fourth, and last sub-heading in this chapter will be the overall conclusions that can be drawn from the data analysis. These conclusions aim to answer the research questions which emerged from the previous research.

## **5.1 Competition on a global scale**

### *5.1.1 Threats*

According to all interviewed dental technicians, the overarching threat for the Swedish dental laboratory industry is the changing environment caused by the fourth industrial revolution. Because of the advent of AM-methods, automatization of industry and the rise of connectivity some threats, that the market did not have to face before, occur.

Moreover, all dental technicians apart from respondent C2 stated that since the possibility to produce prosthodontics with CAD/CAM technology, the way of working for dental technicians changed. They went from complete production by hand to milling the teeth either in total or just semi-finish it and finalize it by hand. Additionally, with the rise of digital scanning it was, from that time on, possible to relocate production to any location. The scanning of either the model or the patient directly lift the data to a digital level. This three-dimensional data can be sent anywhere. There are a few factors limiting this threat, like possible bad quality of data, too long transportation time or ethical reasons.

The fourth industrial revolution brought a lot of game changing technological evolutions. To stay competitive, purchasing up-to-date equipment is recommended by dental industry experts. This highly complex equipment often comes with high price. For micro or small sized companies, it can be a threat if they do not have the capability to take the risk and invest in non-established products. Geissenbauer et al. (2017, p. 4) underline this by emphasizing that companies which do not invest will lose their competitive advantage.

Increasing health might reduce the number of patients that need to see the dentist and get treatment which requires a dental technician. But due to the growing population and other reasons, the market is expected to grow (Dental Laboratory Market Analysis, Growth, Industry Outlook To 2022, 2015).

In a nutshell, the threats are caused by the fourth industrial revolution. Blau (2014, p. 2) describes cloud computing, internet of things, and AM as the main changes. According to the interviewees, this is not a big threat. The real one is the low-cost production from China. According to Jin (2015, p. 1), China will continue to put pressure on the global market. On the other side, our empirical data shows that this pressure is still manageable today but might change in the near future.

### *5.1.2 Competitiveness*

When comparing Swedish with Chinese dental laboratories, a few characteristics emerged from the empirical data. The most important factor is the close collaboration between the dental laboratories within the industry or with the dentist. Our interviewed dentists and the

dental technicians agree on this importance. Due to that, the collaborations are highlighted in the separate theme 'Networking as an opportunity'.

Currently, the main competitive advantage of dental technicians in Sweden is the product quality. Interviewee C4 stresses that good quality is appreciated and therefore a high value asset. If the quality of the prosthodontics is superior a lot of other factors can be left behind. The manufacturing of dentures, crowns or bridges requires artistic skills. The closer the technician is to an artist, the better the product quality will be and therefore the competitive advantage will increase. A skillful employee can be the most valuable asset of a laboratory and which should be kept at any rate. Since quality plays a central role, the education and the level of profession of the technicians is very important (Pigliacelli, 2015, p. 19). When comparing that with the responses, it is clearly visible that companies should maintain or even improve their level of expertise. Therefore, quality assurance in combination with skilled dental technician is the most valuable core competence.

Additionally, respondents C4 and D1 stated that time is also an important aspect when it comes to product quality. Since the imprints need to be in best conditions to make a high-quality product, it is an important parameter to consider. When looking at foreign dental laboratories the travel time is very high, which makes it difficult to ensure the product quality. Also, both dentists stated that local dental laboratories with long-time collaborations deliver products on time and with good quality. This underlines how important a well-working communication flow is when looking at the collaboration between the dentist and the technician.

The price, of course, is a factor that needs to be taken into consideration as well when talking about competitive advantage. Swedish products will never be as cheap as Chinese low cost production. But still, Swedes do not need to be afraid that their only way is to get cheaper. Almost all interviewees stated that quality is of greater importance than the price itself: *"Price doesn't matter because I don't pay it. As long as the patients is willing to pay a fair amount to sustain his health I will go for European products (D1)."* National products still are of higher quality compared to the international low cost supply, therefore, customers are fine to pay more as long as the product quality is worth the additional cost. This impacts, according to Van der Zande et al. (2013, p. 4), not only the dentists but also the technicians and industry partners. They state that all the included parties think that quality is one of the most valuable advantages.

Data from the dentist respondents shows a clear trend to sustainability, not only concerning environment but also humanity. In China, labor is treated more like goods than as human. In large production facilities with more than thousand employees, workers with little training – not even trained technicians – work in assembly-line-like production in long shifts all day long. This mass production makes it possible to manufacture the large amount of cheap prosthodontics the Western world orders. Regarding the ethical considerations, humanitarian sustainability prohibits any business with companies that make their employees work under horrible conditions. In Sweden labor is protected by different kinds of laws that only allow employers to treat their staff under regular – in Sweden typically good – conditions. This creates a competitive advantage for the whole Swedish industry.



The interviewed dentists highlight that in general it is quite accepted to order goods from all over the world and ship them from one side to the other side of the planet more than once. Transportation and shipping contribute a heavy part to the overall CO2 emissions. To be as economically friendly and sustainable as possible, routes of transport shall be limited to a minimum. Since most of the raw material needs to be imported, dentists tend to think that this is enough and the final manufacturing of the end product should be done as closely as possible. This goes that far that some dentists do not want to order outside of their county.

According to the dental industry experts, at some point, small companies will face the situation that they cannot afford to invest in state of the art equipment and therefore find no possibility to keep up with both foreign and domestic competition. The last resort could be to change the business model. Switching from a producer to a service company or building networks might save a company's life. According to Lutter-Günther et al. (2015, p. 549), a combination of business models would be another possibility. This could merge the advantages and the core competences with other dental laboratories.

To maintain the leading position a couple technicians see it as a necessity to keep track of the market changes. From a marketing perspective, this could mean to adapt to the connected society and create an online presence. From the technological perspective, reading journals or blogs and going to industry fairs to jump on the train if there are some major changes the company thinks they are useful and affordable. Or from an overall perspective, to keep track of the whole industry. Giovannone (2015, p. 48) states that adapting to these technological changes is necessary to stay in the market.

Considering the different stated competitive advantages, it can be seen that quality, ethical considerations, and sustainability have a significant value for the Swedish customers. All those facts are still in favor for the local dental technicians. The dental industry is growing at the moment and the number of dental laboratories is going down which means there is a possibility to stay competitive (Statistics Sweden, 2017). Concluding the empirical data, the advantages are currently still on the Swedish side, but could change in the close future to foreign production. Only by adapting to this environment they can still maintain their position and stay the prime mover.

## **5.2 Dental industry transformation**

From existing literature and the interviews taken it can be seen that the dental laboratory industry is currently undergoing a process of transformation. In this chapter, the awareness of change for the dental laboratories as well as the market changes that have happened until now and how the market will transform in the future is discussed.

### *5.2.1 Awareness of the changing environment*

From the interview data, we found that the respondents know that the market is transforming. All interviewed dental technicians have noticed the technological changes in the past years. On the one hand, the new technologies are a great opportunity for dental laboratories to create a competitive advantage over the foreign competition. On the other hand, the small Swedish dental laboratories fear this expensive technology. Since it is not

affordable because of the limited budget they have, the single product might cost more than the ones which are manufactured the traditional way. Also, the process before the actual manufacturing is becoming digitalized which means the close collaboration will become less important in the future.

Moreover, all interview partners know that the foreign competition is present in the market. The opinions on this competition itself differ from each other. While the experts and one dental laboratory say that the competition is slightly decreasing the others say that it has been a growing threat for their business for years. Our market analysis clearly shows that the foreign market share is slightly increasing (Allabolag, 2017). The conclusion here is that only the ones which have already established new manufacturing technologies or have experience with them, do not see low cost countries as a threat. To integrate such a manufacturing technology, small firms need guidelines and a strategic mindset (Lutter-Günther et al., 2015, p. 550).

Also for the dentists, foreign competition in the dental laboratory industry is present. Their opinion is that quality is the most important aspect when it comes to buying prosthodontics from another country. This opinion is also shared by the dental laboratories. Quality in the health sector will also stay the biggest and most important parameter in the future. All interviewees are aware that for the patient, quality is the most important feature. Only if dental laboratories can ensure quality in this transforming industry they can bind the customers to their businesses.

Based on that, all dental laboratories confirm that quality is their main advantage in terms of competition and customer relationship. Only if a dental laboratory is able to maintain the quality specifications and satisfy the customer they are able to stay in the market. Van der Zande et al. (2013, 3) underline the importance of quality in the changing industry. They further state that only if a company is able to maintain quality during the digitalization process the customers will stay. Summing up, the industry is aware of the transformation it is going through. Technology, competition and the workflow of dentists, laboratories and suppliers are changing. This new solution keeps threatening the local market and especially the micro dental laboratory firms.

### *5.2.2 Changes in the transforming market*

In the past years, the industry has been transforming towards a digitalized economy (Geissenbauer et al., 2017, p. 6). All interviewed companies and experts agree that the dental industry is currently undergoing a change. All companies stated that the number of patients stayed the same for the past years. Other than that, there are different opinions on the number of Swedish market share. Since it decreases for respondents C1 and C2, the market share of the foreign competition decreases slightly.

Company C3 always wants to obtain their competitive advantage through advanced technologies. The upcoming technologies are the key to success for all companies. Only if a company tracks the upcoming trends in manufacturing technologies, a dental laboratory can

be successful. The industry shifts from the traditional way of manufacturing prosthodontics to a more digitalized production.

In this transforming industry, the key technologies are AM, digital printing as well as the intraoral scanning. The new manufacturing technologies are already commonly used in the market which means that the market players using them already have a competitive advantage. AM reduces the effort for the value creation. Therefore a competitive advantage is generated through a reduction of manufacturing time and cost (Lutter-Günther et al., 2015, p. 549). This modern way of manufacturing is expensive in acquisition. As a result, it is difficult for small and micro firms to make the investment for this expensive manufacturing technology. According to the interview data, AM is the future for the dental laboratory industry. If a company is not able to establish this manufacturing technology in the close future, they will have to face great challenges competing.

Another way for small and micro firms which has to be considered in the future is a collaborative usage of this new technology. In the dental experts' opinion, this collaboration has positive effects for both sides since the manufacturing center owning the machines can outlast them and the dental laboratories are able to use this advanced manufacturing systems. On the opposite side of the manufacturing technologies there is a digitalized way of making the imprint of the jaw. This new way of collecting information from the patient, the intraoral scanning, is also changing the market situation. When this technology is established between the dentist and the dental technician, productivity can be increased dramatically. At the moment, the advantage of this technology is not really tangible for the industry but will become a game changer in the future, according to the experts.

Dentists are also aware of these changes and work towards a digitalized workflow to simplify their way of communicating with the dental laboratory. With this digitalization, the collaboration and the close contact with the dental laboratory becomes less important. In some cases, dentists already manufacture the framework of their products inside their facilities. As a chairside solution, the dental technician works as a refiner for the prosthodontic. According to experts, the changes can also be spotted in the education of the dental technicians. Weber (2015, p. 723) states that the fourth industrial transformation has also a big impact on the education system, especially in universities. In university, marketing and the new manufacturing technologies play a central role. Dental laboratories have to establish some kind of virtual marketing for their companies. Without online presence, the acquisition of new customers becomes almost impossible.

All these changes in manufacturing technologies, competition, workflow, marketing and collaboration makes it difficult for Swedish SMEs in the dental industry to stay competitive. Especially for micro firms which have been in the market for several years, this turns out to be even more frightening. In order to stay in the market a change of the business model need to be considered. Outsourcing the competences and processes which are not fruitful in the company is one way to maintain the market position. This outsourcing process can reduce the overall costs of dental laboratories (Outsourcing dental laboratory work, 2007, p. 29). Focusing on competence sharing as well as building up networks are key strategies for these companies, according to the experts and the opinions of the dental laboratories. Overall,

several changes are happening in this industry. Each company has to implement strategic goals based on their key competences to ensure a working business model (Lutter-Günther et al., 2015, p. 549).

### *5.2.3 Future considerations*

In order to see the bigger picture of the dental laboratory industry, the outcome of the transformation, the fourth industrial revolution brought, needs to be considered. As stated above, the technological changes play a central role in the process of digitalization. Even when a company is able to integrate AM systems, this is not a guarantee for future success. Without outlasting and considering the total cost of ownership this investment can turn out quite bad in the future (Geissenbauer et al., 2017, p. 9). When deciding to implement a new manufacturing technology, a step that becomes necessary for most market players, alternatives to purchasing the technology should be considered. According to the interviewed dental industry experts, networking with other dental laboratories is a key strategy for micro firms. By sharing the investment and increasing the productivity of the manufacturing system the investment can be profitable. This is only possible when small firms collaborate with other market players. In the future, this business strategy seems most beneficiary when it comes to the technological changes for small dental laboratories. According to Jiang et al. (2017, p. 7), the focus of AM technologies will be on bio-medical products, and this prediction symbolizes the large impact that this technological transformation will have in the future.

Since competition also changes as the industry transforms, companies have to be able to track market changes to gain a strategic market view. In the changing environment, the quality of the products continues to be of the greatest importance. The foreign competition is hard to predict, but if they are not able to deliver the same quality as the local dental laboratories, the market share will not increase dramatically. Even if the collaboration between the dentist and the technician becomes digitalized the need of a reliable technician will always be necessary. Davenport et al. (2000, p. 471) state that people's satisfaction is the most important aspect in the dental industry and this can only be ensured when the collaboration between the dentist and the technician is successful.

## **5.3 Networking as an opportunity**

### *5.3.1 Collaboration between the dental technician and the dentist*

The interviewees reported that before the fourth industrial revolution the close collaboration between the dental laboratory and the dentist was the quintessence of a successful and sustainable partnership. The dental technician acted as a supplier and needed to rely on the quality of the dentist's order. If the written instructions or the impression tray were missing some details, unclear or impossible to read, the technician had to get in contact with the buyer and ask for clarification. Often a simple telephone call can bring clarity but sometimes the impression has to be redone or the technician has to see the patient in person. Otherwise, the final product might not fit the patients and they need to wait even longer until the prosthodontic is finished.

Today, in a digitalized world, the fourth industrial revolution has resulted in most communication being done online. Nowadays orders are placed online via mail, web interfaces or even with the help of digital 3D data. But both, the interviewees and an already existing study (Dentist–dental technician communication, 2010, p. 240), agree that still the added instructions lack information, the same issues occur and the close collaboration is as important as it was before.

From another angle, namely, the interviewed dentists' point of view, provision collaboration has the same importance. The interviewees also emphasized that the focus is on quality and not on quantity. This implies that the price of the product is not that important for many dentists if it stays within reasonable limits and if the quality is superior. The quality of dental prosthodontics depends on the effort that is put into the production. According to Derbabian et al. (2001, p. 161), the color matching of the teeth is a highly challenging task. Our data compares the production to an art piece which needs to be crafted by hand with the highest degree of care. In Chinese production facilities with thousands of employees, one piece is handled by many different people in an assembly line. The interviewed dentists want to know who made their product and want it to be done by a single person who knows the piece from the impression through to the final product. The communication between a Swedish dentist and a Chinese laboratory works well online but for clarification telephone calls are still needed. There arise new problems due to the existing language barrier. The technicians who work on the product do not speak English and the ones who communicate with the international counterpart are not technicians. This results in major communication problems and, therefore, is a disadvantage for the Chinese competition.

Another reason against importing goods from China that we found during our empirical data collection are the prevalent labor policies that penalize employees to an extent no European country would do. Additionally, quality control from Asian products needs to be assessed in Europe because they do not have the same, high standards and certificates there. It seems that some suppliers have good quality and some do not. Even though there are some dentists who are willing to order from the cheapest source regardless of the consequences, sometimes the appreciation for detail reaches as far as that dentists are willing to pay more if the whole service is first-class. For instance, when the packaging of the crowns is made to look like expensive jewelry.

Expert E1 outlines that up until today, about 80 percent of all dental technicians have no strive to fish outside their pond. They rely on their existing customer base and word-of-mouth recommendation to get more customers. Dental industry experts emphasize the importance of marketing. However, according to expert E1, only a fifth of the market uses online marketing like webpages, social media or blogs to communicate with the public. If this minority of technology and internet experienced technicians continue to do so, they will share the market with foreign online working competition – but 'offline companies will start to become extinct.

Summing up, one of the most important things for the dental technician is to sustain a close collaboration with their customers. Here, the theoretical framework from Davenport et al. (2000, p. 471), Afsharzand et al. (2006, pp. 203, 206), and the additional study

(Dentist–dental technician communication, 2010, p. 240) are supported by the empirical data. The aforementioned literature has shown that communication is crucial for a successful collaboration, the participants stating this to be the major reason how dentists choose their dental technician. Alshiddi (2014, p. 558) recommends to use modern technology to increase the quality of collaboration. From the interviews, it can be seen that networks can even make it possible to still charge higher prices for products that sometimes have the same level of quality but the production time is shorter and the trust is way higher.

### 5.3.2 *Collaboration among dental technicians*

Mainly, due to their marginal investment potential and small production batch sizes, small dental laboratories have little chance to survive in the future. Even if one decides to take the risk and buy an expensive machine to keep up with the times, batch size will most probably be way too small to produce economically efficiently or even reasonably.

One dental expert stated that additionally to new ways of marketing, dental laboratories have another chance to gain new competitive advantages. By collaborating with each other, the dental technicians can make use of arising synergies. Usually, Swedish competitors have quite a good relationship with their counterparts. It seems that everyone is happy with their customers and if no one ‘steals’ from the others they do not have troubles with each other, albeit they will not help one another if they think that they could lose customer themselves. With respect to competition, technicians who do not share a business area or location can collaborate and build up a network. In those partnerships, either investment capital can be shared equally to buy a machine together and use it equally when needed, or the stronger player gets just a little financial help from the weaker ones. Then the powerful one can make the investment and guarantees the others service that is either cheap or free of additional charge. By signing a special agreement for partnership occasions like that, trust can be generated and the relationship will benefit.

A more aggressive strategy is through merging and acquisition: the participating company C3 was recently bought by an investor who intends to acquire up to one third of all Swedish dental laboratories in the next few years. With this strategy, the investor can build a strong network with comprehensive service in all national areas. This kind of network solves the issue of competition among the participants and they can work together more successfully without the fear of helping a competitor.

To recap this category, if micro or small dental laboratories want to survive the current market changes and still be successful in the future, they need to focus more strongly on building networks with other laboratories. This could be done either through contractual collaborations among competitors or through mergers and acquisitions to build a network that is free of internal competition. By doing so, they can lift the heavy weight of large investments for the modern technology they would need in order to not lack behind the Chinese competition. Those findings are backed up by the literature from Erickson (2012, p. 57) and Giovannone (2015, p. 48), arguing that technicians need to make careful calculations before taking high-risk investments if they want to withstand the upcoming price

pressure. Therefore, the weak players can combine their low power to create something bigger than the individual in order to withstand the mentioned pressure.

### 5.3.3 *Collaboration between the dental technician and their suppliers*

Due to the small sizes and little buying power of Swedish small and medium sized dental laboratories there is no real collaboration with their machine or raw material suppliers. They act as small customers that just buy the products on the regular market.

The collaboration with suppliers they have is the one with those who deliver semi-finished products. Usually, the laboratories have the equipment to either produce their whole product catalogue in-house in a traditional way, by hand, or with desktop scanners and CAD/CAM machinery. Only a small minority of the participants use AM machines in their laboratories already. The vast majority orders 3D-printed models to fit the crown or they buy similar manufactured framework structures made from metal and later add the top layer themselves. Generally, those orders can be bought from Chinese countries. Ordering an additive manufactured part rarely needs clarification because the file can be checked in advance if it is possible or not to print the file. Therefore, there is no language barrier which could impede the collaboration. Nevertheless, in accordance with both Pigliacelli's (2015, p. 19) who argued that products might include dangerous substances, as well as the collected data, product quality assurance is difficult, which, in turn, hinders the drive to order from Chinese manufacturers. If the product is of bad quality the technician cannot use it and it needs to redo it. As a consequence, the dentists and hence the patients need to wait for their treatment some more days or even weeks. The result is that Swedish technicians changed their purchasing behaviour and prefer to buy from European countries, such as Germany or Poland, instead of from China. Prices are not as low as in China but still lower than at national supplier or than an investment in a new machine and produce it personally.

The overall situation shows that the collaboration between dental laboratories and their suppliers is of little importance. It does not require the close connection and constant communication that the dentist and the technician need to have.

## 5.4 **Conclusions**

Subsequently, the conclusions that can be drawn from the analysis will be presented. First, the three research questions are answered by a combination of the research propositions and the analyzed empirical data. Afterwards, an industry conclusion will answer the general question of this study.

Research question 1 *'How is the low-cost competition from China a threat to existing dental laboratories in Sweden?'* connects to the first proposition *'The threat from Chinese dental laboratories can be overpowered by laying focus on building strong personal relationships to the dentists.'*

The interviews showed that the main reason for choosing a dental technician is good quality of the product. In order to get good quality, most dentists trust laboratories which are located close to themselves, enabling a close collaboration between the two partners. Both are aware that they often need to clarify details of the order. This only works when they have a good

relationship, talk on a regular basis, and sometimes even visit each other to get a personal view of the patient.

The second research question *'Which actions are Swedish dental laboratories undertaking to prevent losing market share to foreign competition?'* can be answered with the help of the second proposition *'Swedish dental laboratories need to invest in know-how and new technology to stay on the same technological level as the Chinese competition and stay competitive in den Swedish market.'*

Since machine cost is similar in all areas of the world, the competitive factor in China is the low labor cost. A main part of modern 'Industry 4.0' technology is that it replaces labor. Therefore, the Chinese advantage is reduced. This is a chance for Swedish laboratories to get on the same technological level and eliminate the foreign supremacy. In order to get on this advanced level, they need to invest in both know-how and machinery like 3D scanners or printers.

Research question 3 *'Will small dental laboratories still be able to compete against both large enterprises or networks and low-cost country production in the future?'* connects to the third proposition *'One major opportunity for small dental laboratories to stay competitive in the future is to build up networks and benefit from synergies and combined financial power.'*

In the previous paragraph the necessity to adapt to modern technology has been emphasized. 'Industry 4.0' and 3D printing is still rapidly changing. The lifetime of the machines is very short because new ones are introduced to the market almost every month. SMEs usually do not have the resources to regularly buy state-of-the-art equipment all the time. By collaborating in networks among like-minded companies they can join their forces, invest together and use the machines together.

The first part of the title *'How is Chinese competition affecting the Swedish dental industry?'* is a general question of this study. According to the data, Swedish dental laboratories have been affected by the Chinese competition to some extent already. The low-cost production peaked a few years ago, but is stagnating due to many reasons. The most widely discussed reasons are the close collaboration, ensured quality, and ethical considerations. The second part is *'Are Swedish dental laboratories aware of the current market changes and what are they doing to maintain their competitive advantage against foreign competitors from China?'* Empirical data points out that all interviewed Swedish dental laboratories are aware of the changing environment in the market. They know that in order to stay competitive in the future – to both domestic and foreign threats – they need to change their ways of working. The better prepared they are, the more they fear the competition because they know that the technological advantage is hard to keep without heavy investment. The trend shows that Chinese competitions was a big threat but is decreasing. The bigger threat is the low investment potential of SMEs and the small chance to adapt to the high-cost changes in the technological environment.

Summing up these conclusions, there are four major statements: first, China was a big threat but the situation is becoming better due to higher demand from national dental laboratories. The second statement illustrates why national demand is increasing: dentists want a close collaboration with their technician because of good quality and time, and patents claim the best possible for their health, therefore good quality prosthodontics is a must and they want it as fast as possible. The third major statement is that Swedish dental laboratories need to



invest in modern technology to stay competitive with the already highly evolved Chinese market. The fourth statement suggests a possibility on how to overcome the issue of small investment capabilities: by partnering up with national competitors or buying of others a small company, they can build a strong network, which, in turn, can buy the needed expensive equipment with their joined forces.

## 6 Discussion

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*In this final chapter, it is discussed how this study contributes to the existing literature. This part includes both additional findings and confirmative data. Additionally, considerations for future research are presented and the limitations of the study are described.*

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Up until today, the dental laboratory industry is a rarely discussed topic within existing literature. Therefore, there is no model that directly shows the current situation which the Swedish small and medium sized laboratories are facing. During our research, we came up with a research model combining three themes. Those themes emerged when combining literature from different fields and industries. Within the analysis of the empirical data we were able to fit the emerged categories into the same three themes. This matching presents the analysis more clearly and adjusts the gathered data to the research model. Moreover, it is a contribution to literature directly concerned with the dental laboratory industry.

Previous research propounded that due to economies of scale and cheap labor cost, China is a big threat for the Swedish dental laboratory industry (Outsourcing dental laboratory work, 2007, p. 29; Dental laboratory industry, 2013, p. 240; Pigliacelli, 2015, p. 19). An industry analysis from Killian (2011) and Statistics Sweden (2017) points out that there is a clear trend. The Chinese competitive advantage will continue and they will keep gaining market share in the Swedish dental technician market. With this study, we dissent from this trend. Both interviewed industry experts emphasized that the out-sourcing capacity peaked a few years ago, and is declining already. Findings from the interviews with the dentists prove this right because they avoid ordering prosthodontics from Chinese dental laboratories. Therefore, we point out that the Chinese competition lost their initial competitive advantage of cheap prices to the needs of Swedish dentists. They are more likely to buy from local sources and attach greater importance to close collaboration and product quality than on cheap prices. In the opinion of dental technician C3 and both dental experts, the local competition will be a bigger threat than the Chinese one in the future.

For competitive advantages there are significant aspects to consider when looking at the empirical data and the literature. Petrick and Simpson (2013, p. 13) state that the competitive advantage will move towards those who can manufacture products with the highest quality at the lowest costs. All respondents confirmed that quality is one of the most important features whereas cost does not play a central role. Patients in Sweden are willing to pay a higher amount of money if the quality and the service suit their needs. The product quality, which is not an explicit part of the research, has a big impact on the competitiveness of dental laboratories. As stated in the analysis, quality is valued over price. Therefore, everything which ensures product quality contributes to an advantage in the industry.

In addition to product quality, time influences the industry performance of a dental laboratory. Dentists, the laboratories' customers, underline this time aspect in their workflow.

During our previous research this aspect was not found to be part of the competitive advantage of dental laboratories. To satisfy the patient who needs the manufactured products, the order cycle time is crucial. In order to guarantee a valuable service, delivery time is crucial when looking at the work flow of a dental laboratory. As a result, time benefits create a competitive advantage in the dental industry. Lutter-Günther et al. (2015, p. 549) state that AM reduces the effort for value creation. From our experts' responses, this trend is not proven because technicians still need to put the same effort in the manufacturing. In addition to that, at least short-term, this does not hold true for the dental industry.

As can be seen in the industry analysis, marketing and social presence are also proven to be important aspects according to the industry experts. Since the industry is transforming into a digitalized economy, marketing is crucial to stay in the market. This is a challenge for micro firms in particular because these do not have the expertise and financial resources to implement marketing and customer acquisition in their businesses. Therefore, networking within the dental laboratory industry as well as competence sharing is essential for Swedish SMEs.

A vague idea of the importance of networking existed in the literature. Pigliacelli (2015, p. 19) stated that the expenses for keeping up the technological pace by investing in state-of-the-art equipment often cannot be lifted by small dental laboratories. By making use of resource complementarity, sharing financial resources, those stand-alone companies can combine their forces and build networks to invest together (Marchi et al., 2016, p. 180). On the one hand, our analysis proves the importance of shared financial resources. The smaller a dental laboratory is, the harder it is to generate money to invest in expensive technology. Moreover, the dental industry experts both emphasized that especially for micro firms (like Company C2 & C4), it is very important to build networks in order to still be competitive in the future. On the other hand, empirical data extends the existing theories by adding the importance of networks for technological or human resources. Respondent C3 already makes use of this kind of network. AM machines need large production batches which small single laboratories do not have. When using the machine together with other players it can be used economically reasonably.

## **6.1 Managerial implications**

The result of this thesis indicates that there are two major aspects for Swedish small and medium sized dental laboratories. Firstly, the already existing close collaboration between the dental technician and the dentist needs to stay at the same level or even needs improvement. Secondly, our data illustrates that modern technology is necessary to deal with competition in the future. Therefore, small players with minor investment capabilities should build networks to join their forces and to survive the digitalization of the dental industry.

Concluding, our research suggests, if managers implement these changes their dental laboratory will stay competitive in the future. Additionally, *product and service quality* is confirmed to be the driving factor for a laboratories' success in the transforming industry.

## 6.2 Future research

The Swedish dental industry, with all market players and links, is a very complex business. In order to get a full picture of this transforming industry some major fields have to be explored even further. From our empirical findings and the already existing literature we know that small laboratories have to build networks and relationships with other market players in order to stay competitive. This could be a starting point for future research on how to establish such networks in the industry. Working close together with dental laboratories which have already implemented such a network successfully, could help developing a strategy of how small firms are able to stay competitive in the dental industry. In addition to the networking strategy, other approaches for implementing our findings in the dental industry will create new opportunities for future research. In order to be competitive in the future, Swedish SMEs need to consider some changes in their workflow. Since most of the firms do not have the capabilities to develop strategies and implement them, this is a major point for further research to tie into.

Furthermore, the correlation between the different strategies is an unexplored topic. How the implementation of one of those approaches affects different parts of a business or a collaboration is also worth investigating before implementing them. In a complex business environment, the change of parameters in a business model can have an impact on the whole company performance. Therefore, the interaction between the different strategies should be discussed further.

Another starting point to understand the multifaceted industry from a different angle is to enlarge the study in terms of company size. To get a better idea of the dental industry and how the competitive advantages are generated in different firms, the analysis can be either narrowed down to a specific company size or even enlarged to get an overall picture of the industry. This can help to understand why micro firms struggle more when it comes to long time performance in the market. In addition to that, this broader picture of the industry helps to understand how the future of the dental industry will look like.

Moreover, when it comes to the variety of the different market players' future, the number of years a company has been performing in the market should be taken into consideration. Since we know that the education of dental technicians has changed significantly in the last years, this is an important aspect too. In this industry transformation process, the ways how companies work differ a lot. To fully understand why and how these big differences exist and how the diverse companies should handle their competences in order to stay competitive, additional development in this area can also be fruitful for the whole industry. Furthermore, it helps to understand the correlations between a successful dental laboratory and how a competitive advantage in this industry is generated.

However, the whole supply chain should be analyzed in order to fully understand how the different actors work together and where the value of each company is created. This includes suppliers as well as the final customer of the dental products. In addition to that, future research could focus on the national competition between the different laboratories. This helps to understand why literature, statistics and empirical data differ from each other. As a

result of this, dental laboratories in Sweden will be able to understand why their business works well and what they can improve to stay competitive in the future.

### **6.3 Limitations**

The research was done only with specific dental laboratories in the Swedish market. To see how the whole industry in Sweden performs, a larger number of dental laboratories should be included in future analysis. Also, the sample size of the dental laboratories was not extensive enough to generate an accurate representation of the whole industry. The chosen research practice also limits the study. Since the thematic analysis breaks down the data, some content for future research is lost during this process. Furthermore, the realist approach limits the findings of the thesis because no interpretation of *how* the respondents said something is considered. The abductive theory-driven approach also excludes the possibility to produce entirely new themes. This also isolates the themes from a broader social context.

Moreover, previous research in this area restricts our outcome. Since the literature does not specifically describe the industry for small and medium sized dental laboratories in Sweden, it limits our theory-driven approach. However, according to the limitations and future considerations, there is a lot of potential to increase the performance of the dental laboratory industry in Sweden.

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## 8 Appendix

### 8.1 Interview guide

To start the interview, we give a short introduction of our thesis to the participants. We clarify the ethical considerations and hand them the informed consent. Additionally, we give an overview over the structure of the interview.

#### **Background about company**

Please give us a short introduction over your company! (Age of the company, size, type of organization)

#### **Current Workflow**

- Which technology do you use at the moment?
- What type of products is your company currently producing?
- Which manufacturing technologies do you use for those products?

#### **Communication**

- How does the communication with the dentist work? Focus on the collaboration between the two parties. How are they collaborating and what are the important factors?
- How does the communication with suppliers' work? Ask them which products they buy in, why they use third party services and how they choose their suppliers. The focus of this part is to find out why they use services nationally or internationally.

#### **Threats**

##### Changes in the market?

- Did you notice changes in the market in the last years (numbers of customers, patients, orders)?
- Did the materials and technologies of productions change?
- What changes could you notice from the local competition in Sweden?

##### Awareness of low cost country (LLC) production

- During the past years, many industries had to struggle to stay competitive with cheap production in china. From previous research, we know that recently china is adapting additive manufacturing technologies to the dental industry and the market share in Europe is declining and displaced to china. How do you notice the changes?
- Ask the participant about their opinion which is the biggest threat.
- What do they think the future will look like?

## **Arrangements**

- What is the company doing against the threats they are facing? What could the possible benefits and drawbacks of the mentioned changes be?
- If not mentioned, ask about changes in:
  - a. Communication-flow between the involved parties,
  - b. Manufacturing technologies,
  - c. Monetary aspects,
  - d. Collaboration with China,
  - e. Change in business model;
- How is the company keeping track of the market changes?
- What are the strategic goals and changes they plan for the future? Did they already try out some new strategies?

## **Change in workflow**

- How does the new workflow differ compared to the older version?
- How could a future workflow look like?

## **Conclusion**

- Give the participant a short summary of the interview to clarify the overall comprehension.
- Ask for missing information. Does the participant want to add some more facts?
- Where do you see your company in five years from now?

## 8.2 Informed consent

### Consent for participation in a research interview

#### Master thesis – engineering management

#### Conducted by

**KNEISSL Lukas, MODRE Christian**

I agree to participate in a research project from the Jönköping International Business School (JIBS) Jönköping, Sweden. The purpose of this document is to specify the terms of my participation in the project through being interviewed.

1. I have been given sufficient information about this research project. The purpose of my participation as an interviewee in this project has been explained to me and is clear.
2. My participation as an interviewee in this project is voluntary. There is no explicit or implicit coercion whatsoever to participate.
3. Participation involves being interviewed by two researchers from JIBS. I allow the researchers to take written notes during the interview. I also may allow the recording by audio or video tape of the interview. It is clear to me that in case I do not want the interview to be taped I am at any point of time fully entitled to withdraw from participation.
4. I have the right not to answer any of the questions. If I feel uncomfortable in any way during the interview session, I have the right to withdraw from the interview.
5. I have been given the explicit guarantees that the researcher will not identify me by name or function in any reports using information obtained from this interview, and that my confidentiality as a participant in this study will remain secure.
6. I have read and understood the points and statements of this form. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.
7. I have been given a copy of this consent form co-signed by the interviewer.

\_\_\_\_\_  
Participant's Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Researcher's Signature

\_\_\_\_\_  
Date

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