The Relevancy of Agile Manufacturing in Small and Medium Enterprises

- Using examples from the computer, electronic and optical manufacturing industry in Sweden –

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Title: The Relevancy of Agile Manufacturing in Small and Medium Enterprises - Using examples from the computer, electronic and optical manufacturing industry in Sweden -

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Background: Today’s business environment is characterized by fast-changing technologies and shorter product life-cycles, well-educated customers and fierce competition. Within this context, agile manufacturing is praised in the literature as one of the solutions for achieving and maintaining a competitive advantage in turbulent times.

Aim: The purpose of this master thesis is to fill in the identified theoretical and empirical gaps by exploring and scrutinizing the relevancy of the agile manufacturing concept in small and medium enterprises (SMEs) in the computer, electronic and optical manufacturing industry in Sweden. Furthermore, a model illustrating the agile manufacturing enablers applied in the selected industry will be developed.

Definition: Agile manufacturing can be defined as a new production concept integrating employees, suppliers and customers, as well as units of production by using the support of software and communication systems.

Methodology: Eight interviews with managers have been conducted in order to capture the big picture of how the SMEs in the chosen industry enable responsiveness to changes. A survey answered by 50 SMEs within the same industry was carried out in order to test the interview findings on a larger scale and to provide the basis for a further comparison with the existing agile manufacturing body of knowledge.

Results: Agile manufacturing is indeed relevant in the studied industry as it is driven by agility drivers and thus characterized by fast-changing technologies and well-educated customers. However, the agile manufacturing enablers partly differ from the ones praised in the literature and are more adjusted to the size and characteristics of SMEs. Nevertheless, a conscious awareness of the agile manufacturing concept itself was not found and the enablers identified were rather described as logical business thinking.

Keywords: Agility, Agile Manufacturing (Enablers), Small and Medium Enterprises (SMEs), Turbulence, Computer, Electronic and Optical Manufacturing Industry, Sweden
Acknowledgement

This thesis is truly the result of a teamwork which goes much further than the two authors themselves.

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Finally, we also would like to thank our families who financially and morally supported us throughout these two years at Linköping University.

Linköping, 30th of May 2011.

Verena Dischler and Antoine Hug.
# List of Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AD</td>
<td>Agility Driver</td>
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<td>AM</td>
<td>Agile Manufacturing</td>
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<td>AME</td>
<td>Agile Manufacturing Enabler</td>
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<td>AMT</td>
<td>Agile Manufacturing Technology</td>
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<td>CEOM</td>
<td>Computer, Electronic and Optical Manufacturer</td>
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<tr>
<td>CRM</td>
<td>Customer Relationship Management</td>
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<tr>
<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<td>FMS</td>
<td>Flexible Manufacturing System</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>JIT</td>
<td>Just-in-Time</td>
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<td>LM</td>
<td>Lean Manufacturing</td>
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<tr>
<td>R&amp;D</td>
<td>Research &amp; Development</td>
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<td>SME</td>
<td>Small and Medium Enterprise</td>
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<td>TMS</td>
<td>Transactive Memory System</td>
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<td>TQM</td>
<td>Total Quality Management</td>
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Part I – Research Framework

1. Background

It is no secret that companies nowadays are challenged by a fast-changing and continuously developing business environment and well-educated customers with ever increasing expectations, like shorter lead times and high level of response and service (Cooke, 2010, Gunasekaran, 2001). Within this context, a survey conducted by the American Management Association (2006) highlights that out of 1472 managers of American companies; only 31% of the respondents did not face a disruptive change within the last 12 months. For 17%, the change was so radical that a complete business shift had to be carried out. These findings are supported by Cooke (2010), who emphasizes that even the most traditional companies have realized that their business processes need to be adjusted and reconsidered in order to achieve and maintain a competitive advantage, while satisfying more and more sophisticated customer expectations. Gunasekaran (2001) even goes a step further by stressing that this shift made pure cost leadership and mass production obsolete and will be replaced by a competition for superiority in delivery-response and product quality, as well as customer service and satisfaction. Aiming to fulfill these new requirements, a focus has been placed on manufacturing strategies as an enabler for enhancing competitiveness through their direct influence on flexibility, responsiveness and quality (Skinner, 1969). One of the most popular examples hereby can be given by the Japanese company Toyota and its capabilities, which outperformed the Western manufacturing companies (Gunasekaran, 2001).

With respect to this, various authors refer to the concept of agility and agile manufacturing (AM) as a new concept of running business and thus as a solution to survive, while sustaining a competitive advantage in turbulent times such as the current one (Mc Cann, et al., 2009; Sherehiy, et al., 2007; Vázquez-Bustelo and Avella, 2006). McCann, et al. (2009) in particular investigates the relationship between agility, resilience and turbulence. Their study shows that out of 471 North American companies, the ones investing in agility and
resilience have significantly better performances and profitability during the time of intense
turbulence. These findings are coherent with Stalks’ (1998) statement of response-time as
the main criterion for achieving competitive advantage.

Agility can be defined as a strategic ability for an organization to react and pro-act to
change with a limited effect on the company structure, while implying a new mindset with
regard to commercial relationships (suppliers and customer) and business processes
(Christopher, 2000; Bottani, 2010; McCann, et al., 2009; Sanchez and Nagi, 2001).
However, being agile is not a static concept, but strongly relies on the dynamic approach of
continuous readiness to learn and to perceive necessary and upcoming changes in order to
react to business requirements and constantly changing contexts of customer opportunities
(Goldman, et al., 1995). According to McCurry and McIvor (2002), the supporting
principles of agility hereby contain the delivery of customer value, valuing human
knowledge and skills as well as forming virtual partnerships. Furthermore, an agile
company must contain the ability to solve the tension between a changing environment
and high quality standards, as well as the needs for economies of scope and scale
(Montogomery and Levine, 1995).

In coherence with this approach and definition, AM has been articulated as a production
concept which integrates “organizations, highly skilled and knowledgeable people and
advanced technologies, to achieve cooperation and innovation in response to the need to
supply our customers with high quality customized products” (Kidd 1994, p.10). This
implies that AM is a decision to be taken at a strategic level, since it involves not only the
operational level but rather every single part of the organization, and thus the alignment of
the strategic direction and manufacturing strategies (Gunasekaran, 2001), namely strategic
fit (Grant, 2010). The literature with regard to AM definitions is rich and will be more
elaborated throughout this thesis. However, most of the definitions circle around the same
features, namely agile workforce, technology, management and integration (Yusuf and
Adeleye, 2002; Vázquez-Bustelo, et al., 2007; Sharifi and Zhang, 2001; Gunasekaran,
2001). This structure is also highlighted by Kidd (1994).
A more current and extended illustration of this definition can be found in the conceptual model of AM used by Vázquez-Bustelo, et al. (2007). Within this context the authors group agile manufacturing into three categories:

1. *Agility drivers* (AD) which refer to the environment and market characteristics a company is operating in;
2. *Agility enablers* (agile manufacturing enablers) which refer to the promotion of a total integration of the basic elements of the firm;
3. *Outcomes* which refer to the competitiveness or business performance achieved through AM.

While none of these categories should be neglected, this paper particularly focuses on the second category, namely *agility enablers* (agile manufacturing enablers) which are reflected in the field of human resources, value chain integration, concurrent engineering, advanced technology and knowledge management (Vázquez, et al., 2007). However, due to the strong linkages between agility drivers (ADs) and agile manufacturing enablers (AMEs), the first category will be looked at to a certain extent. However, no particular
attention will be paid to the influence of AM on the companies’ performance. Instead, this category is recommended to be subject for further research.

While the literature is rich with regard to AMEs for large companies, it is noteworthy that the applicability of these AM practices for small and medium enterprises (SME) has been largely neglected. According to the European Commission (2005), SMEs can be defined as companies with less than 250 employees and an annual turnover below 50 million Euros or an annual balance sheet total not exceeding 43 million Euros. This EU definition is consistent with the national definition for Små och Medelstora Företag (SMF) since 2005 (Tillväxtverket, 2011). Due to the fact that the data collection will be conducted among Swedish SMEs in the computer, electrical and optical manufacturing (CEOM) industry, this EU definition of SMEs will be used throughout this paper.

The shortage of agile theory for SMEs is surprising, as 99% of the companies in Europe are SMEs and account for 23 million companies with approximately 75 million employees. Due to this, SMEs are often named as the “engine of the European economy” (European Commission, 2005, p 3). Sweden as the chosen country is no exception to this richness of SMEs. Therefore, Sundin (2008, p. 212) describes Sweden as “the homeland of small business”. This description is underpinned with the findings of the European Commission highlighting that the number of SMEs in Sweden has grown approximately 20% in the years 2002-2008 (European Commission, 2009).

In order to fill this theoretical gap, a particular focus throughout this thesis will be placed on the AMEs for SMEs with a special emphasis on the CEOM industry in Sweden aiming to shed light on the applicability and relevancy of the praised AM practices among theory. In coherence with this aim and in order to obtain a thorough picture of the relevancy of AM within SMEs, a practical insight will be provided through the conduction of interviews and surveys.

This master thesis is structured in three main parts. The first part provides a research framework by giving an understanding of the problem statement, including problem discussion and problem formulation as well as the purpose and aim of the paper.
Furthermore, a theoretical framework based on literature findings has been developed in order to provide a general understanding of the AM field. A particular emphasis will hereby be placed on the AMEs within the context of SMEs. In addition, the methodology part is aimed to give insight about how empirical findings have been gathered. The second part of the thesis contains the empirical findings of the conducted interviews and survey, while the third part comprises of the analysis, conclusion and discussion, as well as recommendations and further research opportunities. This thesis disposition is furthermore illustrated in the following figure.

Figure 2: Thesis disposition

(Source: Authors’ own elaboration, 2011)
(Adapted from: Salvador, A. and Yakob, R., 2003, p. 50)
2. Problem Statement

2.1 Problem Formulation and Discussion

In the following section the aforementioned gap with regard to the relevancy of AM will be further elaborated and discussed.

As previously mentioned, AM has been identified as a solution to face the turbulent and fast-changing environment nowadays, and thus to deal with shorter product life-cycles, market instability (Yusuf and Adeleye, 2002) and well-educated customers (Cooke, 2010; Sharifi and Zhang, 2001). According to Kidd (1994), the concept of AM emerged in the year 1991 with the publication of the report “21st Century Manufacturing Enterprise Strategy” by the Iacocca Institute. Since then, the body of theories about this new production concept has been comprehensive, particularly with regard to definitions, characteristics, criteria and supporting tools. However, most of the concepts and theories focus on large manufacturing companies (see for example Sharifi and Zhang, 2001; McCurry and McIvor, 2002, Laanti, et al, 2011, Vázquez-Bustelo and Avella, 2006; Brown and Bessant, 2003; Gunasekaran, et al., 2002), and thus highlight the lack of research in the particular field of AM in SMEs. This scarcity of AM theory for SMEs is unexpected due to the fact that 99% of the companies in Europe are SMEs. With approximately 23 million companies and 75 million employees (European Commission, 2005), SMEs are often named the “engine of the European economy” (European Commission, 2005, p. 3).

However, some studies could be found within the context of AM in SMEs (Ismail, et al. 2007; Corbett and Campbell, 2002; Ribeiro and Fernandes, 2010). Nevertheless, it is noticeable that the authors researching within this field highlight the challenges for SMEs in achieving and implementing AM. The spectrum thereby ranges from the required size of investment and lack of sufficient resources (Brown and Bessant, 2003; Ismail, et al., 2007; Abdul-Nour, et al., 1999) over the lack of bargaining power (Ismail, et al, 2007) to the need of changes with regard to processes and layout, as well as investments within the area of employee training and development (Abdul-Nour, et al., 1999). While the mentioned
challenges for SMEs obviously attract the researchers’ interest, just a few of them concern themselves with how these developed strategies, concepts and theories can be applied in SMEs and which actual relevance they have for them.

A contradiction seems to appear when it comes to applying AM in SMEs. It is possible to assume that small and medium organizations would have strong capacities to become agile due to their flat hierarchy and thus a faster information and decision process. It can be reasonably imagined that compared to large organizations, SMEs have closer ties with their team members, as well as their suppliers and customers. Therefore, they should be able to sense and react in a more efficient and structural manner. However, as mentioned before, the literature highlights AMEs that seems out of reach for SMEs, due to their weak financial power (see for example Ribeiro and Fernandes, 2010).

To fulfill this theoretical gap, the underlining purpose of this master thesis is to challenge the existing body of knowledge with regard to the relevance of AM in SMEs and its appraised tools in the literature. This approach leads to the following first research question:

**Q1: Is agile manufacturing relevant in SMEs operating in the computer, electronic and optical manufacturing industry in Sweden and if yes, in what ways?**

The assumption hereby is that, AM can be applied or is already applied in SMEs, however they use different ways to achieve it. Furthermore, this research paper assumes that the challenges of SMEs with regard to AMEs are overrated, and can actually be bypassed through for example their flat hierarchy. In coherence with these assumptions, the findings of the conducted interviews and surveys aim to provide proof of this assumption by answering the following sub-questions:

- What are the drivers for implementing AM?
- What enablers are used by SMEs in order to react to unpredicted changes in their environment and are these enablers coherent with the ones praised in the literature?
- What are the advantages and disadvantages of SMEs with regard to responsiveness?
In addition, an empirical gap became apparent through an informal conversation with a production engineer manager responsible for the production planning in a German manufacturing company, pointing out that he is not familiar with the AM concept. After a description of the main ideas of AM, he remarked that being reactive and proactive to changes should be logical business thinking and hence happens unconsciously and thus without the awareness of AM theories. Furthermore, he supported his critical attitude by stressing that every company operates differently and that academic theories in general lack a practical approach.

While this statement just reflects the opinion of one single person, it can be seen as an indicator for the second research question of this paper:

Q2: Is agile manufacturing already unconsciously a part in SMEs in the computer, electronic and optical industry in Sweden?

The assumption hereby is that the AM concept is already applied in SMEs, even though it is unconscious and more as a result of logical business thinking. Answering this question will furthermore demonstrate the level of awareness of AM in general in SMEs in the CEOM industry and its reputation of being a groundbreaking approach as praised in the literature. Therefore, the following two sub-questions have been developed:

- Are companies aware of the agile manufacturing concept?
- Is agile manufacturing an innovative approach or just a buzzword?
2.2 Research Purpose

As emphasized in the problem discussion, two gaps have been identified within the field of AM. First, the theoretical gap emphasizes the scarce research conducted in the field of AM with regard to SMEs, particularly the AMEs who are more suited for large companies. Furthermore, the empirical gap identified stresses the lack of a practical approach while also questioning the AM concept as an innovative approach.

The purpose of this master thesis is to fill in the identified gaps by providing empirical examples given by SMEs who are operating in the CEOM industry. The findings of the conducted interviews as well as surveys among these small and medium manufacturing companies aim to provide an insight into real-life business practices and processes and thus to contribute to a more practical approach of AM. Furthermore, the conducted research object is to conduce to the body of knowledge of AM within SMEs by challenging the existing theories. The purpose hereby is to identify the enablers used by SMEs to respond to an environment characterized by ADs, like for example fast-changing technology and well-educated and demanding customers. These enablers are assumed to differ from the ones described in the literature so far. Therefore, this research paper aims at being critical towards the AMEs praised by the literature and thus to prove the assumptions mentioned before. However, this research paper’s ambition is not to redefine the field but to shed light on an aspect that is currently scarcely researched.

In coherence with this purpose, the findings of the conducted interviews and surveys aim to contribute to a better understanding of the relevancy and the applicability of AM in SMEs in the CEOM industry and thus to provide an extension to its body of knowledge. Furthermore, the ambition of the research is to create an alternative model of AM focusing on SMEs in the CEOM industry.

Therefore, this research paper implicates the following contributions:

1. This master thesis aims to extend the existing body of knowledge of AM and thus provides an interesting aspect for scholars within this area. Furthermore, the
research paper will reduce the scarcity of research conducted within the field of SMEs and AM, particularly with regard to AMEs.

2. Through the conduction of interviews and surveys, an empirical departure will be taken and thus a contribution to the lack of practical input among the AM theories will be provided. By investigating the SMEs’ approaches to maintain and sustain competitive advantage in a turbulent environment, a better illustration of the AM concept can be given which furthermore can lead to a better appreciation by managers.

3. Based on the conducted literature review, it became apparent that most of the research has been done within industrial management. Analyzing the problem of agility for SMEs through the lenses of strategic management will contribute to the field. As emphasized before, AM is a structure upon which strategic decisions are taken and implemented. Due to this, it is important that the problem is not just tackled from an operational point of view but also with a wider strategic point of view aiming to achieve a strategic fit.

In alignment and with respect to the emphasized importance of the AM strategies, the purpose of the paper is in sum to challenge and extend the existing body of knowledge of AM by providing insight in real-life practices applied by SMEs in the CEOM industry. By comparing the findings from the interviews and surveys with the praised practices in the literature, a model with a specific focus on AM in SMEs for the chosen industry will be provided.
3. Methodology

In alignment with the purpose of this master thesis, a methodology has been developed with the aim of achieving a data collection which will provide an answer to the emphasized research questions in this thesis and thus close the identified gaps a little bit more.

The object of this section is to provide the reader with an overview of the used research approach and strategy as well as the empirical tools used.

3.1 Research Approach

According to Ghauri and Grønhaug (2005, p. 56), “the choice of research design can be conceived as the overall strategy to get the information wanted. This choice influences the subsequent research activities for example what data to collect and how they should be collected.” Hereby, three main classes of research design can be distinguished, namely (1) exploratory, (2) descriptive, (3) causal (Ghauri and Grønhaug, 2005). Within this master thesis, an exploratory research approach has been chosen due to the fact that the emphasized research problem has been neglected by the academic literature (Marschan-Piekkari and Welch, 2004). Within this context, the exploratory research approach aims to answer the question “what” within a special research field (Marschan-Piekkari and Welch, 2004) and is thus coherent with this master thesis purpose and its research questions, which are:

Q1: Is agile manufacturing relevant in SMEs operating in the computer, electronic and optical manufacturing industry in Sweden and if yes, in what ways?

Q2: Is agile manufacturing already unconsciously a part in SMEs in the computer, electronic and optical manufacturing industry in Sweden?
In order to answer these research questions, the thesis started with a deductive approach due to the theoretical gap highlighted before. According to Bryman and Bell (2007), this approach uses the established theory with the aim to deduce an assumption that will then be confirmed or rejected through the collection and findings of empirical material and thus will lead to a revision or a contribution to the established theory. Therefore, the deductive approach can provide guidance for the collection and analysis of data (Bryman and Bell, 2007) and is thus coherent with the research purpose of comparing the enablers of AM praised in the literature with the ones gathered from the empirical data collection. With regard to the theory, a particular focus will be placed on the model developed by Vázquez-Bustelo, et al., (2007) and its enablers of AM. The aim hereby is to scrutinize the existing literature about AM with empirical findings.

However, while the comparison of the theory and empirical findings within the field of AM in SMEs constitutes one aim of this master thesis, another object is to establish a new model of AMEs in SMEs. In other words, based on the collection and the analysis of the data collected, the findings’ ambition is to provide a fresh insight and to extend the existing theory within the research field. Therefore, this research approach is two-fold. While the starting point is a deductive approach due to the use of theories and concepts, the inductive approach will be applied by drawing conclusions from empirical findings and thus will lead to theory building, as the findings will be incorporated back into the existing theory by creating a new model for SMEs in the CEOM industry in Sweden. (Bryman and Bell, 2007; Ghauri and Grønhaug, 2005).

![Figure 3: The interplay between the deductive and inductive approaches](Source: Authors’ own elaboration, 2011)
3.2 Limitations

The objective of this master thesis is to explore and analyze what enablers of AM are used by SMEs. Due to the fact that the SME structure is very heterogeneous (Sundin, 2008), it was decided to focus on one country and one industry.

These limitations are necessary in order to obtain comparable results for the analysis. Therefore, the research constraints are aiming to ensure that the empirical findings comprise the same characteristics concerning the business environment, size and industry.

Consequently, the authors of this master thesis considered the Swedish SMEs from the CEOM industry to be the most appropriate choice, due to the easy access to information. Furthermore, this sector is assumed to provide consistency and coherence in the characteristics and thus results. Therefore, the conclusions drawn by the authors will be limited to this specific industry and its home country.

Sweden is known as the “Homeland for Small Business” (Sundin, 2008, p. 212) with a share of 99.8% of all companies and an employment of 63.7% within the country (European Commission, 2009). Furthermore, the statistics highlight that the number of SMEs in Sweden has increased approximately 20% in the years 2002-2008 (European Commission, 2009). This highlights the richness of SMEs and thus also the need to research within the field of SMEs in Sweden. In addition, the statistics show that Sweden is close to the European average numbers and is thus perceived as a representative for SMEs in Europe (see appendix 1) (European Commission, 2009). Besides these convincing numbers, Sweden also constitutes the country where the authors are studying and thus facilitates the data collection within the constraints set (time and money) for this master thesis.

The engineering industry is one of Sweden’s largest manufacturing sectors and can be divided in four main sub-sectors, namely mechanical engineering, metal fabrication, the manufacturing of transportation equipment and electrical engineering (The Swedish Engineering Industry, 1996; Gan and Jermyn, 2003). The CEOM (computer, electronic
The **engineering and optical manufacturing** industry within Sweden is largely composed of SMEs and forms a vital part for the development of high technology (The Swedish Engineering Industry, 1996). The most important product groups hereby encompass for example telecommunication systems, transmission equipment and electrical appliances, including automation products, computer hardware and software, military and space electronics as well as electrical consumer goods (like TV and stereo sets) and electric and electronics components (The Swedish Engineering Industry, 1996; Gan and Jermyn, 2003). The companies within this industry are assumed to be characterized by a fast-changing, high developed technology and well-educated customers. Therefore, the environment in which these companies operate in can be understood as unpredictable, fast-changing, highly populated and thus face fierce competition with a high diversity of products. These characteristics are described as *agility drivers (ADs)* (Vázquez-Bustelo, et al., 2007) and therefore constitute the criteria for the need of AM and AMEs. Due to these reasons, the chosen industry seems to be appropriate and suitable as a research field.

The EU fact sheet (European Commission, 2009) indicates that SMEs in Sweden contain similar characteristics with the SMEs in Europe in general. However, this being noted, it is not possible to state that the results of this study can be generalized to all European SMEs, or even to Swedish SMEs, for that matter, without further research. This is due to the fact that the Swedish CEOM industry has specific characteristics, as indicated above, and thus differs from other industries. Furthermore, while the sample size provides a good picture of the current state in that industry, it cannot be assumed that the findings are coherent with other sectors.

However, this research paper provides a new insight into possibilities SMEs have with regard to the implementation of AM, due to their size and thus, flat hierarchy. Therefore, a pattern can be found which provides a good starting point for further research in other industries.
3.3 Data Collection

The data collection strategy can be described as the interplay between qualitative and quantitative data. In order to obtain a thorough picture of the research topic and to answer the proposed research questions emphasized throughout this thesis, data has been collected from multiple sources, namely interviews, surveys (primary data) as well as existing scientific literature (secondary data). While the secondary data provided the necessary background knowledge within the field of AMEs, a theoretical gap has been identified regarding AMEs in SMEs. To gather insight in the assigned research area, the need of primary data became evident and thus the conduction of interviews and surveys. Within this context, the interviews provided new knowledge about how SMEs in the CEOM industry are achieving AM, while the survey’s objective was to confirm/reject the findings of the interviews. Therefore, the use of a triangulation method seemed to be reasonable here. According to Marschan-Piekkari and Welch (2004, p. 129), a “triangulation aims at the integration of multiple data sources in a multi-method design” and thus refers to the “use of multiple methods in the study of the same object” (p. 165). In other words, the aim of applying the triangulation method is to gather different data for answering the same research problem. A successful triangulation hereby relies on three key decisions, namely the order, the role and the purpose of the research (Marschan-Piekkari and Welch, 2004).

Within this study the order can be described as sequential, as the first phase of the data collection was the conduction of interviews. Based on the interview findings, a survey has been created to confirm or reject the findings of the interviews. In other words, the different stages were dependent on each other and thus no possibility for a parallel data collection was given (Marschan-Piekkari and Welch, 2004).

This order is aligned with the role of the interview and survey. Due to the aim of using the interviews as a basis for the surveys, the major role was assigned to the qualitative method and thus the interview constitutes the main source of information. However, this does not denote that the importance of the survey findings was neglected as they provided valuable
additional information for confirming or rejecting the findings of the interviews (Marschan-Piekkari and Welch, 2004).

The purpose of this study can be described as knowledge-based, as the aim of this research is to build and to extend on an existing knowledge base (Marschan-Piekkari and Welch, 2004), while getting more insights from empirical findings.

This method and strategy has been chosen to compensate the flaws of the different tools when applied separately (Marschan-Piekkari and Welch, 2004). While the conduction of interviews was crucial for this research due to the theoretical gap identified, this data collection tool also has limitations. Examples of constraints can be found in their reliability (lack of standardization), the interviewers’ bias (comments, tone and non-verbal) and the response bias (perception of the interviewer and the interview atmosphere). Other issues might be given in the interviews’ validity and generalizability (Saunders, et al., 2009; Marschan-Piekkari and Welch, 2004). Due to this, the surveys aimed not just to confirm the findings in the interviews but also to gather answers free from biases. Therefore, triangulation seems to be a good approach to verify the data gathered, to complement the tools used and to facilitate the interpretations of the results (Marschan-Piekkari and Welch, 2004).

![Figure 4: The triangulation method and its benefits](Source: Authors’ own elaboration, 2011)
3.4 Research Process

**Step 1: Literature review**

The research process itself started with a *literature review* within the field of AM, particularly its enablers. The sources of this secondary data used have been articles from scientific journals as well as books about the research topic. While this literature review provided a preliminary research purpose of filling the theoretical gap of AM in SMEs, it became evident that this gap can just be filled with empirical findings and thus in this case, the use of interviews and surveys.

**Step 2: Interview**

Based on the definitions of SMEs used for this research paper and the limitation to Sweden and its CEOM industry, a database has been created with suitable companies. The data hereby was retrieved from the official database “AffärsData”, a website where company and industry information is provided. In addition, the trade and industry office of Motala was consulted. After having created the database, a cross-check with the database “allabolag.se”, a website giving information about the companies, their turnover and employees, as well as the companies’ own websites has been carried out. The aim hereby was to ensure that the data and addresses of the interviewees were coherent and correct. Out of this list, 23 companies were chosen to be contacted by email for an interview. The focus was on companies within the Linköping and Stockholm area in order to keep the travel time and expenses low. All of the emails were addressed to CEOs/managing directors, production managers or development managers of the companies. To create legitimacy of the study, the emails themselves contained a formal request with the university logo and provided background information about the research topic, the researchers themselves as well as a description of the intended interview process. As the response rate to these emails was rather meager, follow-up calls and emails were made one week after the emails were sent out. As a result, eight interviews were scheduled between 18th March and 1st April 2011. The company profiles of these eight companies can be found in appendix 2.
As mentioned before, the purpose of this master thesis is to challenge and extend the body of knowledge with regard to AMEs in SMEs and to identify the awareness about AM. In order to compare the enablers praised by the literature with the ones used in real-life practices, interviews were chosen to provide insight about practices used by the SMEs. The interview questions have been designed and based on already established theories and models, with particular focus on the model used by Vázquez-Bustelo, et al., 2007. The coherency facilitates the comparison of the theory and the empirical findings, and thus also assists with the analysis at the end. The interview questions within this context were semi-structured and open-ended (Saunders, et al., 2009), containing a list of themes and questions to be covered. However, the questions have been adjusted to the response given by the interviewee, which also led to a varied order of the questions, as the flow of conversation was different in each interview. Furthermore, an interview guide (Marschan-Piekkari and Welch, 2004) was used as a checklist and thus gave the possibility of using follow-up questions ensuring that all topics had been covered during the interview. In addition, the interview guide aimed to facilitate the comparison of the answers given as it was used in all the interviews. The interview questions can be found in appendix 3. The findings of these interviews created the foundation for the survey questionnaire, which constituted the next phase of data collection.

**Step 3: Survey**

The aim of the survey conducted was to confirm or challenge the findings from the interviews with a much larger scale of answers. The database which has been created for the interviews was thereby the source of information and was complemented with contact information of the entire sample. The contact information, particularly the right email address and the name of the contact person was retrieved through the company’s website as well as personal and direct phone calls to the companies.

The survey questions (see appendix 4) were designed based on the answers and findings obtained from the previous interviews. In coherence with the interview, the questionnaire was addressed again to CEOs/managing directors, production managers and development
managers of SMEs within the CEOM industry in Sweden and sent out during the first and second week of April 2011.

Christensen, et al. (2001) describe two ways of conducting surveys. The first is defined as a self-completion questionnaire, where the respondent answers the questions on his own, and thus without any guidance from the researcher. As opposed to this method, a questionnaire can also be filled in with the guidance of the researcher (Christensen, et al., 2001). For this master thesis, an online survey has been chosen and therefore the option of a self-completion questionnaire. This choice was based on the following reasons; first, online surveys are expected to consume less response time while granting maximum freedom to the respondent. Second, since the questionnaire was tailored on the findings of the interview, the questions were straight to the point with no need for further clarification. Third, the use of a self-completion online survey also seemed to be an appropriate choice, due to its cost and time efficiency on the researchers’ side. This form of surveys allows a large sample with automatic data processing (Christensen, et al., 2001). The tool used for the online survey was “Google documents” and in particular the use of “Google forms”.

In coherence with the first research question and its sub-questions, and thus to find out what AMEs are contained in SMEs in the CEOM industry and within this context, what advantages/disadvantages they experience, the online survey particularly used multiple choice questions as well as grid questions. However, to answer the second research questions, and thus the degree of awareness of the AM concept, open-ended questions have also been applied. In addition, as has been highlighted before, the linkage between the ADs also strongly influences the need for AMEs. Therefore, one question focused on this area, using a five-point Likert scale (Ghauri and Grønhaug, 2005, Bryman and Bell, 2007).

In total, 198 companies were contacted by email and were given the link for the online survey, as well as a short description of the purpose of the study and a confidentiality statement. Due to a low response rate, further follow-up emails and phone calls were made, which led to an increase in the number of questionnaires. A total of 50 valid questionnaires were returned, representing a valid response rate of 25.25 %.
### Population under study
Manufactures within the computer, electronics and optical industry

### Population census
8 interviews; 198 surveys

### Geographical area
Sweden

### Data Collection method
- Semi-structured and open-ended interviews
- Structured survey

### Sample size
- 8 interviews completed
- 50 answered questionnaires

### Valid response rate of surveys
25.25%

### Time frame
Mid of March – Mid of April

### Respondent profiles
CEOs/managing directors, production managers, development managers

<table>
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<th>Table 1: Research data overview</th>
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<td>(Source: Authors’ own elaboration, 2011)</td>
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<td>(Adapted from Vázquez-Bustelo, et al., 2007)</td>
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### 3.5 Credibility

#### Accuracy and Reliability

The design of this master thesis, as well as the research approach and data collection method, guarantee the **accuracy** and **reliability** of the thesis. According to Marczyk, et al., (2005), accuracy concerns the exactitude of the results, while the reliability refers to the consistency of the measurement and the ability of finding similar results with similar conditions. Within this research paper, the results gathered from the interview are tested by the results of the survey and thus should lead to consistent results.

#### Validity

Referring to Ruane (2005), a knowledge created by empirical observation is best proven valid by the use of scientific methods.
Accordingly, this paper and its conclusions have been looked at with “a healthy dose of skepticism” (Ruane, 2005, p. 32-45). First of all, the measurement validity has been questioned. The criteria chosen for the empirical data collection have been carefully weighted to ensure the appropriateness by an extensive data collection. Secondly, the internal validity was highlighted by a rigorous stress put on understanding the causality of AM for SMEs in the CEOM industry. The agility was set to be the dependent variable and a thorough analysis was designed to understand the different independent variables through the triangulation process explained earlier. Finally, the external validity was at the heart of our sampling selection and has been carefully explained earlier in this paper (Ruane, 2005). Although, this master thesis does not provide the proof of sample generalization or cross population generalizability, the thorough methodology and the extensive data collection provide a good foundation for replication researches (Ruane, 2005).

### 3.6 Research Ethics

This master thesis is also written with the awareness of the researchers’ moral responsibility, and thus aim to provide honest, objective and accurate answers. Therefore, it is important that all the data collected are reliable and trustworthy. In coherence with this aim, the secondary data was collected from official websites and scientific journals and can be easily accessed. The links for the websites can be found in the reference list. In addition, the transcripts of the interviews as well as the survey’s findings can be handed out upon request for the next five years.

Regarding the conducted interviews and surveys, it was of importance to inform the respondents about the real purpose of the research and thus to provide a high level of transparency about the way the data will be used. In addition, the interview questions have been sent out to the interviewees in order to provide enough freedom and preparation time. All the interviews were recorded with the awareness and permission of the interviewees. The anonymity will be preserved throughout this research and thus will not provide any inconveniences for the interviewee.
3.7 Critical Review

In this part of the paper, special attention will be given to a critical review of several points of the thesis process. The authors think that it is necessary for understanding the paper to reflect on a few elements that affected the results collected.

First of all, it is assumed that a better knowledge of the Swedish language would have enhanced the quality and potentially the quantity of the answers given. Even though English did not appear to be a problem for any of the interviewees, using their native tongue in the conduction of the interviews and the writing of the survey would have made the so-called “language barrier” disappear completely. For instance, the word “turbulence” appeared not to be fully comprehended by every interviewee and thus required further clarifications. However, this problem was overcome by verbally explaining the related terms in simpler language during the interviews. By noticing in particular that the words “turbulent environment” caused such confusion during the interviews, the survey question was adjusted accordingly.

With regard to the interviews’ and surveys’ low response rate, the authors of this paper had to “step out of the comfort zone” and approached the companies again with follow-up calls and emails. This strategy resulted in an appropriate amount of interview appointments and survey respondents. Furthermore, stepping out “of the comfort zone” contributed to personal development.

It is also important to reflect on what was learned during this thesis. To that matter, the teamwork between the two researchers was perceived as a completely positive experience. As explained in the acknowledgement, this thesis is truly a teamwork that goes beyond the work of the two researchers. However, the essence of this thesis was based on the solidarity and the hard work of its researchers, together with accurate time planning and a division of work based on the researchers’ own abilities.
4. Frame of Reference

This part of the thesis will be dedicated to a theoretical review of AM and its enablers. The starting point is the concept of AM with regard to its origins, its definitions and characteristics, as well as its opposition to the concept of lean manufacturing (LM) and flexible manufacturing systems (FMS). Furthermore, the benefits and constraints of AM will be exposed shortly. In addition, an overview of the main models and frameworks of AM will be given, followed by a thorough description of the AMEs illustrated in the model. With regard to the focus on AMEs in SMEs in this research paper, a literature review of AM in SMEs will be provided, emphasizing the gap mentioned previously in the research purpose.

4.1 Development of Agile Manufacturing

In his article “Manufacturing-missing link in corporate strategy”, Skinner (1969) emphasizes the importance of manufacturing as a necessity in achieving a competitive advantage. In coherence with this statement, he furthermore highlights the necessity of an alignment between the manufacturing strategy and the corporate strategy (Skinner, 1969). In other words, the objectives of an organization should determine the characteristics of the manufacturing strategy in order to achieve competitive advantage (Esturilho and Estorilio, 2010). The interrelation between competitiveness and manufacturing strategy attracted more and more interest over the past few years, as the competition became fiercer due to globalization and thus international competition, and the development of new manufacturing technologies, as well as a better understanding of the strategic role of manufacturing (Gunasekaran, 2001). A major role was hereby played by the superior performance of the Japanese company Toyota, which outperformed the Western companies due to its focus on manufacturing as a key factor in achieving low costs and high quality.
(Gunasekaran, 2001). Within this context, manufacturing strategies are driven by the requirements posed by the market as well as the competition resulting in the evolution of different manufacturing strategies notions (Jin-Hai, et al., 2003). During the immediate postwar period, the market was characterized by a high demand and the lack of supply capacity. This inability to supply led to manufacturing strategies characterized by price and speed and the aim for mass production. In the 80s however, the market became more saturated and the customer preferences were focusing on high quality products and thus the implementation of total quality management (TQM) (Jin-Hai, et al., 2003). With the success of the Japanese firms, the lean manufacturing (LM) notion evolved to be one of the most popular manufacturing strategies (Jin-Hai, et al., 2003) with its focus on waste avoidance, high productivity and quality (Gunasekaran, et al., 2002). Within this context, LM is applicable in repetitive production situations, and thus standardized products rather than customized products (Yusuf and Adeleye, 2002). In other words, LM is aiming for efficiency rather than responsiveness (Gunasekaran, et al., 2002). At the same time, flexible manufacturing system (FMS) (Esturilho and Estorilio, 2010) and world-class manufacturing (Hayes, 1994) were seen as the right manufacturing concept in order to respond to the customer requirements and the competition (Jin-Hai, et al., 2003). Within this context, Gunasekaran (2001) describes the environment of the manufacturing industry in the past as rather slow-moving and gradual and thus not demanding fundamental changes with regard to technology and management techniques.

However, with the beginning of the 21st century, various authors refer to new challenges companies have to face (see for example Cooke, 2010; DeVor, et al., 1997; Goldman et al., 1995; Hayes 1994; Ifandoudas and Chapman, 2010; Kidd, 1994; Jin-Hai, et al., 2003; McCurry and McIvor, 2002; Sharifi and Zhang, 2001). The environment is characterized by fast-changing technology, a continuous developing business environment as well as well-educated customers with ever increasing expectations, like shorter lead-times and a high level of response (see for example Cooke, 2010, Gunasekaran, 2001). These characteristics can also be identified as agility drivers (ADs). With regard to this, DeVor, et al., (1997) stress the importance of the companies’ ability of high reactiveness to the market and technology, as well as the satisfaction of individual customer preferences. This means that
manufacturing strategies have to step away from the notion of being reactive and rather need to become proactive in order to understand and perceive the market (Gunasekaran, 2001). Furthermore, Kidd (1994) emphasizes that this evolution is shifting the focus from a price concern to an approach which addresses price, quality and customer choice on a balanced level and without any tradeoff. In coherence with this, Gunasekaran (2001) even goes a step further by stressing that this shift made pure cost leadership and mass production obsolete and will be replaced by a competition for superiority in delivery-response and product quality, as well as customer service and satisfaction.

In response to these new changes and requirements, the Iaccocca Institute (1991) introduced the AM concept, which is described as the solution to survive and remain competitive in turbulent times. (see for example McCann, et al., 2009; Sherehiy, et al., 2007; Vázquez-Bustelo and Avella., 2006; Sanchez and Nagi, 2001).

### 4.2 Definition of Agility

According to the Oxford dictionary, being agile means the ability to move quickly and easily (The New Oxford American Dictionary, 2005). With respect to a company, DeVor, et al., (1997) define agility as the capability of managing a turbulent environment and uncertain changes. This definition is coherent with the interpretation of various authors who describe an agile company as being a business which remains competitive and stable, while both the competition and the consumer demand is changing unexpectedly (Goldman, et al., 1995; Sanchez and Nagi, 2001; Bottani, 2010). Within this context, an organization must contain the strategic ability of being not only active in case of occurring changes, but also pro-active towards future market opportunities (Ismail and Sharifi, 2006; McCann, et al., 2009; Christopher, 2000). Hereby, it is crucial for the company to perceive and sense changes of the environment and to imply a new mindset with regard to commercial relationships (suppliers and customer) and business processes (Christopher, 2000; Bottani, 2010; McCann, et al., 2009; Sanchez and Nagi, 2001). With respect to this definition, it is
pointed out by various authors that being agile is not a static concept, but one that strongly relies on the dynamic approach of a continuous readiness to learn and to perceive necessary changes in order to react to business requirements and constantly changing contexts of customer opportunities (Goldman, et al., 1995). Agility herewith contains the delivery of customer value, valuing human knowledge and skills as well as forming virtual partnerships (McCurry and McIvor, 2002). Within this context, an agile company must contain the ability to solve the tension between a changing environment and high quality standards, as well as the needs for economies of scope and scale (Montogomery and Levine, 1995). Therefore, it can be concluded that agility is a dynamic-driven and context-specific approach with the aim of using the opportunities provided by change. Hereby, it has to be pointed out, that agility is not about pure cost reduction and efficiency but rather about providing solutions to the customers (Gunasekaran, 2001).

The changes and pressures from an increasing turbulent business environment can be described as ADs (Sharifi and Zhang, 2001, Sharifi, et al., 2001). Vázquez–Bustelo, et al., (2007) stress the confusion of the concept of turbulence. According to these authors, turbulence can be associated with dynamism and competition, which is influenced by the company’s own perception about the market, the competition and technology change. These two concepts, hostility and dynamism, are furthermore seen as the main two ADs (Vázquez–Bustelo, et al., 2007). In other words, ADs are the reason for the relevancy and implementation of AM, and can be found in the unpredictable changes in the environment (high dynamism), market, customer requirements and complex/fast changing technology (high complexity), and fierce competition (high hostility), as well as the need for high diversity with regard to products, lines, customers and businesses (Vázquez-Bustelo, et al., 2007). These conditions demand a higher level of manufacturing agility (Vázquez-Bustelo, et al., 2007).
4.3 Definitions of Agile Manufacturing

In coherence with these definitions and approaches of agility, AM is regarded as a new concept in order to respond to the nowadays dynamic and fast-changing environment (Ifandoudas and Chapman, 2010) and described as a crucial characteristic for manufacturing companies to maintain their competitiveness (Sharifi and Zhang, 2001). Within this context, Kidd (1994, p.10) articulates AM as a production concept which integrates “organizations, highly skilled and knowledgeable people and advanced technologies, to achieve cooperation and innovation in response to the need to supply our customers with high quality customized products”. This implies that AM is a decision to be taken at a strategic level since it involves not only the operational level but also every single part of the organization, and thus needs the alignment of strategic direction and manufacturing strategies (Gunasekaran, 2001), namely strategic fit (Grant, 2010). Based on their own literature review, Gunasekaran and Yusuf (2002, p. 1362) define agile manufacturing as

“The capability of an organization, by proactively establishing virtual manufacturing with an efficient product development system, to (i) meet the changing market requirements, (ii) maximize customer service level and (iii) minimize the cost of goods, with an objective of being competitive in a global market and for an increased chance of long-term survival and profit potential. This must be supported by flexible people, processes and technologies.”

In coherence with this definition, other authors also emphasize customer value delivery, responsiveness, and the importance of human knowledge and skills, as well as the formation of virtual enterprises as features of AM (see for example McCurry and McIvor, 2002; Ramesh and Devadasan, 2007; Goldman, et al., 1995). The focus of AM is to improve flexibility through the integration of employees, suppliers and customers and the units of production using the support of software and communication systems (DeVor, et al., 1997, Sharifi, et al., 2001).
Vázquez-Bustelo, et al., (2007) classify the AM definition in three categories, namely (1) agility drivers (ADs), (2) agility enablers (AMEs) and (3) outcomes and highlight the linkage between the three of them. While ADs refer to the environment and market characteristics, they are also the driving force for the creation of AMEs, which in return influences the company’s outcome with regard to competitiveness (Vázquez-Bustelo, et al., 2007).

Based on these definitions, it can be concluded that AM can be defined as a concept which integrates every level of the organization, and thus its employees, as well as the companies’ customers and suppliers. The aim hereby is to create a better understanding of the market and customer requirements, and thus has the capability of sensing change (see for example Gunasekaran, 2001; Gunasekaran and Yusuf, 2002; Kidd, 1994; Goldman, et al., 1995).

However, at this point, it is important to emphasize again that AM is rooted in the LM and the FMS concept (Booth, 1996; Jin-Hai, et al., 2003; Yusuf and Adeleye, 2002) Nevertheless, AM should not be used as a synonym for LM or FMS (Gunasekaran, 2001). Therefore, this master thesis will shortly highlight the main differences of these concepts with the aim to avoid any misconception of the AM concept.

4.3.1 Agile Manufacturing vs. Lean Manufacturing

As mentioned before, AM does not aim for pure cost reduction with a focus on solely achieving efficiency, but is rather a concept that incorporates the importance of price, quality, flexibility and high customer satisfaction (Corbett and Campbell-Hunt, 2002).

Due to this, the AM concept is different to the principles of LM, which focuses solely on the avoidance of waste in order to improve productivity, shorten lead times and cost reduction (Yusuf and Adeleye, 2002). Furthermore, the LM concept is applicable in an environment characterized by repetitive patterns and mass production aiming for economies of scale through standardized products. These characteristics of the LM concept have their limitations with regard to a fast-changing environment and the production of customized
products (Yusuf and Adeleye, 2002). Another major difference can be found in the strategic view of the two concepts. While LM focuses more on the factory floor, the strategic view of the AM concept applies to the whole organization (Yusuf and Adeleye, 2002). A more detailed distinction between AM and LM can be found in appendix 5.

### 4.3.2 Agile Manufacturing vs. Flexible Manufacturing Systems

Another manufacturing concept that is comprised in AM is the flexible manufacturing system (FMS). Goranson (1998 cited in Elkins, et al., 2004, p. 202) defines a “flexible system as a productive system capable of dealing with a specific (or predictable) scope of product variation”. Within this definition, a distinction to AM can be found with regard to the capability of dealing with an unplanned manufacturing request. FMS concentrates on the production of several products within one product range, but does not have the capability to produce outside this specified product range (Elkins, et al., 2004). Another distinction is made by Gunasekaran (2001), who defines flexibility as reactive rather than proactive, highlighting that while AM achieves responsiveness by understanding the market, FMS only has the capability of reacting. This means that AM has the ability to deal with unpredictable changes, while FMS is a more operational concept dealing with actual changes (Blackhouse, et al, 1999). Furthermore, Baker (1996) identified a difference between FMS and AM with regard to the strategic view, emphasizing that while AM is regarded as a strategic tool, FMS operates simply on the operational level.

### 4.4 Benefits and Constraints of Agile Manufacturing

Based on the definitions of AM, the potential rewards of this theory as well as the conditions of its application will be reflected. As mentioned earlier, AM is implemented to successfully meet the fast-changing environment requirements (see for example Brown and Bessant, 2003; Sharifi and Zhang, 2001), by not just providing products, but solutions for
the customer (Gunasekaran, 2002). The benefits of AM are described as achieving a more efficient product development process, a reduction of the production costs and thus an enhanced competitiveness (Bottani, 2010). Furthermore, the integration concept opens the possibility for a learning environment and continuous improvement. In addition, companies who integrate their customers and suppliers will achieve a better understanding of the market and the customer needs (Gunasekaran, 2002). In short, AM helps finding the right product at the right time with an entirely customized high quality product (Gunasekaran, 1999).

However, reaching AM is in itself not an easy task and has a few constraints. One of the limitations of AM can be found in its roots in the contingency theory (Sherehiy, et al., 2007). The contingency theory defines organizations as constituting an open system where each situation is different and requires adaptation. This adaptation can be for instance according to the size or the age of the organization (Sherehiy, et al., 2007). Therefore, no situation is similar and it is impossible to create a best practice of AM theory applicable to every company.

Finding the right alchemy of enablers is not the only concern managers may face when implementing AM. They must also be cautious about its application on a company-wide level. In order to be successful, the AM concept requires a change in the mindset of every single employee in the organization (Christopher, 2000; Goldman, et al., 1995). This is congruent with other recent literature, emphasizing that open-book accounting and full transparency are necessary to complete the agile process and strongly rely on the used information and communication technology (Amin, et al. 2008; Coronado, 2003; Jiang and Chen, 2007). Therefore, AM should affect every part of the organization and thus needs the full support of the management, technology and workforce resources.

In addition, AM relies on work resilience (Sherehiy et al., 2007). For a company, in order to be resilient, its employees need to be open to changes, ready to cope with the unexpected and resistant to a high level of stress (Sherehiy et al., 2007).
4.5 Conceptual Models and Frameworks of Agile Manufacturing

By comparing different conceptual models and framework presented in the literature, it appears that the models were similar with regard to the generic features. Within this context, the conceptual framework of Kidd (1994, pp 24 – 25) comprises of for example:

- Human networking organization and empowerment of the whole workforce;
- Focus on core enterprise competencies and virtual corporations;
- An environment enhancing experimentation, learning and innovation;
- Skill and knowledge enhancing technologies;
- Change and risk management;

Another model can be found in the research of McCurry and McIvor (2002, p. 82) who identify the (1) knowledge-driven enterprise, (2) virtual enterprise, (3) core competence management and (4) the capability for reconfiguration as the core concepts of AM and thus demonstrate the coherence with Kidd’s framework (McCurry and McIvor, 2002).

A more extended model was found in Gunasekaran and Yusuf’s (2002) research. While the core concepts were again very similar to the other models, these two authors of this research are furthermore defining some enablers for achieving each of these strategies. The aforementioned techniques can also be found in several research publications within the field of AM (Amin, et al. 2008; Coronado, 2003; Jiang and Chen, 2007; Ifandoudas and Chapman, 2010; McCurry and McIvor, 2002; Sanchez and Nagi, 2001).
Figure 5: Agile manufacturing strategies and techniques

(Source: Gunasekaran and Yusuf, 2002, p. 1363)

As aforementioned, one major focus of this paper will be placed on the AMEs praised in the literature with the aim of comparing them with the ones applied in SMEs operating in the CEOM industry. Therefore, the model provided by Vázquez-Bustelo, et al., (2007) has been chosen as a directive for this master thesis. In coherence with this, the structure of the findings as well as the analysis is done through the lenses of this model. In this model, AM has been classified in three categories, namely

1. *Agility drivers* (ADs) which refer to the environment and market characteristics a company is operating in;
2. *Agility enablers* (AMEs) which refer to the promotion of total integration of the basic elements of the firm;
3. *Outcomes* which refer to the competitiveness or business performance achieved through agile manufacturing.
However, it should be mentioned again that a particular focus of this master thesis is placed on the AMEs which are reflected in the field of human resources, value chain integration, concurrent engineering, advanced technology and knowledge management. To a certain extent, the turbulence from the environment and the manufacturing strengths will also be looked at. However, no particular attention will be paid to the influence of AM on the companies’ performance due to time constraints. Instead, it is recommended to be subject of further research.
4.6 Enablers of Agile Manufacturing

Based on the conceptual models and frameworks, this section will expose the different enablers of AM. Hereby, the literature provides quite a few ways to structure AMEs. For example, Gunesakaran and Yusuf (2002, p. 1357) identify seven key AMEs to respond quickly to changes of the environment which include (1) virtual enterprise formation tools; (2) physically distributed manufacturing architecture and teams; (3) rapid partnerships formation tools/metrics; (4) concurrent engineering; (5) integrated product/production/business information systems; (6) rapid prototyping; and (7) electronic commerce. However, this is not the only way of representing the enablers for AM. Vázquez-Bustelo, et al., (2007) created a discussion of the different enablers, which will be used as a foundation for the data collection and as a guideline for the analysis conducted for this research paper. Furthermore, they also identify three resources to implement AM, namely: technology, management and workforce. This is coherent with Kidd (1994), pointing out that all the manufacturing strategies need to be based on three resources, namely (1) innovative management structure and organization, (2) a skill base of knowledgeable and empowered people and flexible and (3) intelligent technologies. These different enablers need to be implemented with a mindset open for perpetual change and adaptation. In addition, it is important to understand that AM has to be carried out at a companywide level (Christopher, 2000).

4.6.1 Integration

The resources and enablers for agility cannot be understood alone. It is stated in the literature (see for example Jin-Hai, et al., 2003; Kidd, 1994) that integration is the key to a successful implementation of AMEs. Creating a coherent set of tools tailored to the specific goals and characteristics of an organization and its’ surrounding, is required to capture the big picture of the company. The integration has to be done at the internal as well as on the external level (Jin-Hai, et al., 2003). At the internal level, this requires that companies build
their set of actions designed to build on each other in a coordinated manner. At the external level, companies are expected to act in a coherent fashion with their partners. The reason behind this external integration is that companies are said not to be competing as a single entity anymore but rather as a network of companies (Christopher, 2000).

Scholars have been researching the different enablers of AM since the 90s. As a consequence, there is a very extensive list of AMEs that one can draw from all of these researches. Within this context, table 2 is an attempt to create a coherent framework of AMEs from a variety of different taxonomies used by different scholars. They are structured around the three resources for AM identified by Vázquez-Bustelo, et al., (2007) which have been described earlier. The AMEs are separated de facto in the technology, management or workforce category even though these three are deeply connected, making it sometimes difficult to distinguish.

4.6.2 Technology

Technology is often expressed as being essential for the implementation of AM (Coronado, 2003). However, there is little consensus on which technology best supports AM and as described in table 2, a variety of technological options have been identified as AMEs. For example, some authors argue that AM should contain automation (Corbett and Cambell, 2002; Goldman, et al., 1995) while some opt for manufacturing cells (Power and Sohal, 2001, Vázquez-Bustelo, et al. 2007). However, most of the authors agree on the fact that IT systems are crucial for AM (Ribeiro and Fernandes, 2010; Ramesh and Devadasan, 2007; Power and Sohal, 2001; Corbett and Cambell, 2002; Coronado, 2003; Ismail and Sharifi, 2006; Gunasekaran and Yusuf, 2002; Christopher, 2000; Jiang and Chen, 2007; Ribeiro and Fernandes, 2010; Vázquez-Bustelo, et al., 2007). But once again, the type of IT systems can vary between the most elaborated Enterprise Resource Planning (ERP) systems to a simple email box. Within this context, research on information systems showed that advanced IT solutions will benefit organizations that are trying to implement AM (Jiang and Chen, 2007). These extensive IT devices provide top management with the latest information.
about customer demand, production level and resource analysis (Jiang and Chen, 2007). Furthermore, it allows top managers to capture the big picture and therefore be able to align resources, planning and production (Jiang and Chen, 2007; Christopher, 2000).

4.6.3 Management

The management resources also play a very important role in achieving AM. Power and Sohal, (2001) illustrate for example that participative management is one key element of the most agile companies together with computer-based technology, supplier relations, resource management and technology utilization. Within this context, Coronado (2003) emphasizes that without a sound business strategy, the IT system will lose its agility benefits.

Due to this, management resources are seen as the enablers for a successful implementation of AM. For instance, an important criterion in reaching AM is a collaborative relationship with the customers and the suppliers in order to better sense the changes in the environment and also to create a better match in the supply chain (Lee, 2004, Christopher, 2000). This network cooperation is essential in the creation of the “extended organization” and can take place together with concurrent engineering (Ribeiro and Fernandes, 2010; Sharifi and Zhang, 2001; Vázquez-Bustelo, et al., 2007; Kumar and Motwani, 1995; Yusuf, et al., 1999). Within this context, concurrent engineering is the execution of the different steps towards new product development carried out simultaneously between partners.

As discussed earlier, companies no longer compete on a single entity basis but together with their network partners (Christopher, 2000). New challenges thus appear in the quest for AM and hence have led to a profound reshaping and re-strategizing of the value chain towards a strong focus on competency building (Jin-Hai, et al., 2003). This is coherent with Burgelman and Doz., (2001), who stress the importance of a complex strategic integration. For Prahalad and Hamel (1990), creating core competencies requires a corporate architecture where collective learning is created to coordinate technology, skills and resources and thus to enhance the value creation process. A core competence should allow
access to a variety of markets, enhance customer perceived value, and should be difficult to imitate (Prahalad and Hamel, 1990; Grant, 2010). In this context, the managers’ role is to define the strategy architecture to create the appropriate core competencies (Prahalad and Hamel, 1990). Taking its roots in the core competency concept, dynamic capabilities (Teece, et al., 1997) can be defined as an integrative process of how to capture the new source of competitive advantage in a changing environment by enhancing corporate agility. Therefore, the idea of AM underpins the necessity of achieving continuous learning to maintain a competitive advantage (Jin-Hai, et al., 2003).

4.6.4 Workforce

The workforce appears in the literature to be a crucial resource for AM. First, in order to fully exploit the technology resources in the organization, AM needs an educated workforce (see for example Vázquez-Bustelo, et al., 2007; Yusuf, et al., 1999). Furthermore, the employees’ ability of multifunctional working can increase the company’s agility (Vázquez-Bustelo, et al., 2007; Gunasekaran, 2001; Yusuf, et al., 1999; Sharifi and Zhang, 1999), which as a consequence can reduce the dependence on key employees. This can be facilitated by an access to continuous learning and training (Goldman, et al., 1995, Gunasekaran, 2001), and the creation of a learning organization by the management (Yusuf, et al., 1999). The empowerment of employees given by a higher autonomy and high decentralization is identified as another important input for AM (Goldman, et al., 1995, Sharifi and Zhang, 1999, Breu, et al., 2002, Kathuria and Partovi, 1999). The objective therefore, is to train the workforce to become a flexible resource by itself. In turn this enables the employees to not only acquire cross functional knowledge but also to be more enthusiastic about their work, which as a result can lead to a reduced absenteeism (Sharifi and Zhang, 1999).
4.7 Agile Manufacturing in SMEs

While the literature is rich with regard to AMEs for large companies, it is noteworthy that the applicability of these AM practices for SMEs has been largely neglected. This shortage is surprising as SMEs are an important factor for the Swedish economy (see for example European Commission, 2005; Sundin, 2008). The purpose of this research paper is to fill this gap by investigating SMEs in the CEOM industry in Sweden. In coherence with this aim, a short literature review will provide an overview of what has been done within the field of AM in SMEs.
By highlighting that AM can be defined as relying more on people and their creativity than on the process itself, Ribeiro and Fernandes (2010) illustrate the agile methods used by SMEs in the construction area. The authors emphasize that the interviewed managers recognize the main AMEs in their people, the collaboration of business partners, organizational culture and technology (Ribeiro and Fernandes, 2010) and the benefits of implementing AM. However, Ribeiro and Fernandes (2010) also highlight that the application of AMEs requires a strategic shift which can lead to hurdles with regard to the implementation. Within this context, Corbett and Campbell-Hunt (2002) emphasize that in the quest for competitiveness, a crucial factor is the capability of SMEs to respond to the turbulent market by implementing appropriate manufacturing procedures and by finding a niche for their business. This strategy therefore is intended to provide the environment for quality products with a shorter lead time and a high customer service (Corbett and Campbell-Hunt, 2002) and thus as a solution to “stick out of the crowd”.

Another research has been conducted with regard to the effectiveness of IT within SMEs, giving guidelines on how SMEs can manage agility. The results emphasize the need to develop people’s skills and expertise in IT to reach agility (Coronado, 2003).

A further research carried out by McCurry and McIvor (2002) highlights a gap between the application of the LM and AM concepts with regard to SMEs and large companies. While in large companies, LM is a step towards becoming agile, SMEs are capable of avoiding many elements of LM (McCurry and McIvor, 2002). Bohan (2010) goes even further, stating that SMEs should neglect the lean concept and concentrate solely on achieving and maintaining AM by using enabling tools, like workplace organization and quick set-ups (Bohan, 2010). This view, however, is a contradiction to the statement of other authors who describe LM and AM as not mutually exclusive (see for example Kidd, 1994; Christopher, 2000; Power and Sohal, 2001).

As highlighted in the problem statement and with regard to this literature review, it became evident that a main focus of the current research has been placed on the study of challenges for SMEs in achieving and implementing AM. The spectrum thereby ranges from the required size of investment and lack of sufficient resources (Brown and Bessant, 2003;
Ismail, et al., 2007; Abdul-Nour, et al., 1999) over the lack of bargaining power (Ismail, et al., 2007) to the need for changes with regard to processes and layout, as well as investments within the area of employee training and development (Abdul-Nour, et al., 1999). This leads to the assumption that SMEs are less likely to invest in elaborated communication devices and to uncover the relevance of agility due to a lack of technical skills, financial constraints and administrative capacity (Ribeiro and Fernandes, 2010).
Part II – Empirical Findings

5. Empirical Findings

Within this part of the master thesis, the findings of the interviews and surveys conducted will be presented. The structure hereby is strongly adapted to the conceptual model of AM by Vázquez-Bustelo et al., (2007). In total, eight interviews were conducted and 50 surveys were filled out. Within this context, the interviews provided the foundation for the survey questions, and thus were a source of insight information. Therefore, the figures shown in this findings part reflect the results of the survey answers. At this point it has to be mentioned again, that the survey is “only” supposed to confirm or reject the findings of the interviews and no further quantitative methods, like correlation analysis will be applied within this master thesis.

Out of the investigated companies, 76% and thus the majority of the companies employed 10 – 50 employees, while 16% had between 50 – 100 employees. A minor part was constituted by companies which employed over 100 employees (6%) or under 10 employees (2%). The respondents’ professions were mainly CEOs/managing directors (52%), production managers (20%) and development/technology managers (10%). However, the survey also constituted answers from sales managers (6%), design and engineering managers (4%), marketing manager (4%) and not specified professions (4%).

As previously mentioned, the purpose of this master thesis is to shed light on the question of how relevant AM in SMEs is, and what enablers are used for achieving it. However, as described earlier in the frame of reference, the need for these enablers in general is strongly driven by the environment, which in turn can be outlined as ADs. Therefore, the conducted interviews and surveys also investigated the environment and thus the ADs for Swedish SMEs in the CEOM industry, which will be discussed first. Afterwards, the findings of the used AMEs will be categorized and displayed. Furthermore, the results of the advantages and disadvantages of SMEs with regard to responsiveness will be demonstrated. With
regard to the second research question, findings will be provided about the level of awareness of the AM concept as well as its reputation as a groundbreaking approach.

5.1 Agility Drivers in the CEOM industry

As described before, the CEOM industry is described as a high technology sector, containing product groups, like telecommunication systems, transmission equipment and electrical appliances, including automation products, computer hardware and software, military and space electronics as well as electrical consumer goods (for example TV and stereo sets) and electric and electronics components (The Swedish Engineering Industry, 1996; Gan and Jermyn, 2003).

In general, most of the companies described their environment as rather fast-changing and demanding. However, it became apparent that the perceived environment varied with regard to the ADs, for instance technology, competition and customers. Therefore, out of the eight conducted interviews, three companies described the level of technology change as rather slow-moving while customer requirements were becoming more sophisticated. In other words, for these three firms, the turbulence arose more from a customer side than from the technology side. The other five companies indicated their ADs mainly within a fast-changing technology and thus shorter lead-times, unexpected customer orders as well as more sophisticated requirements from the customer side. Therefore, the main AD was found in the customer. The competition itself was not regarded as a main AD and hence was not associated with a fast-changing or turbulent environment. All the companies emphasized that the reason for this lay in their product specialization. In sum, the key finding here is that the companies interviewed in general perceived their environment to be fast changing, however not with regard to the same ADs. The findings of the surveys support the result of the interviews by indicating that on a scale from 1 (slow changing) to 5 (fast changing), 58% of the companies described their environment as fast-changing and even 6% perceived their environment as very fast changing, while only 10% reported a
slow moving environment. The rest of the respondents (26%) related the level of turbulence to be between a slow and fast-changing environment.

The next section will provide an overview of the findings with regard to AMEs in SMEs within the CEOM industry in Sweden. Based on the model of Vázquez-Bustelo, et al., (2007, p.1313), the five categories of AMEs will be presented, namely (1) agile human resources, (2) knowledge management, (3) value chain integration, (4) concurrent engineering and (5) agile technologies.

5.2 Agility Enablers in the CEOM industry

5.2.1 Human Resources

According to the literature and as highlighted before, one of the crucial points in achieving AM lies in the human resources of a company itself (see for example Sharifi, et al., 2001). All of the interviewed companies described their employees as the key success factors with regard to responsiveness. Without any exception, the employees were considered not only as being capable of dealing with different working procedures, but also as the heart of the company and a pool of ideas. Hereby, the employees themselves were perceived as being experienced, highly skilled, knowledgeable and flexible. Through the use of a multifunctional workforce, the companies relied rather on cross-functional training than on specific training.

“Our engineers are pretty skilled; they are like a self-playing piano. You don’t need to educate skilled engineers; they automatically absorb possibilities that arise.”

(CEO of Company B)

The reliance on the employees was described as high. While the given responsibility was seen as a source of motivation, two of the companies emphasized that this high reliance can also lead to a shortage of people in case of sick leaves.
Another factor with regard to human resources was highlighted by the low employee turnover and the commitment of the employees to the company. This was described as one main contributor to responsiveness and customer service, as the employees know the company and are known by the suppliers and customers. This furthermore contributed to a trust creation among the different business partners. It was also stressed that due to their small and medium size, the companies’ employees were aware of all of the products, the business processes and the importance of quality and responsiveness.

Within this context, all of the companies emphasized the involvement of the employees in the decision-making process as a tool to integrate their human resources and thus to create an understanding of the business itself. This was assumed by the managers to be having a huge impact on the motivation and commitment of the employees.

“Everyone has an impact on the decision. Sometimes it’s worth listening and sometimes it’s not.”

(CEO of Company D)

This quote shows the emphasis on the top management support with regard to new ideas and responsibility given to the employees.

These findings were coherent with the survey results indicating that 60% of the companies described their employees as flexible and even 32% described their employees as the most flexible part of the organization (figure 7).

![Figure 7: Flexibility of employees in SMEs in the CEO industry](image-url)
Furthermore, the survey results indicate the high importance of a skilled and experienced workforce with a rate of 62% of the answers given. In addition, it was displayed that 24% of the respondents saw the cross-functional cooperation between departments as one of the key assets to achieve responsiveness (figure 8).

![Key assets for reacting to a fast-changing market](image)

Figure 8: Key assets for reacting to a fast-changing market of SMEs
*The choice of multiple answers was possible

### 5.2.2 Knowledge Management

The second category focuses on knowledge management and is closely related with the first category of human resources.

The interviewed companies stressed good information flow within the company as essential to achieve responsiveness. The companies then described the knowledge of their employees
and the use of cross-functional teams as a main practice. With regard to this, all of the interviewed companies emphasized that the knowledge transfer is supported through the size of the companies and that every employee knows where to find important information. However, one of the companies pointed out that the knowledge transfer within the organization still needs a lot of improvement and is not implemented in the company yet. In addition, some of the interviewed companies described the close integration of customers and suppliers as a source of knowledge management and transfer. Furthermore, it was implied that the companies strongly aim for continuous development through internal and external knowledge acquisition.

The awareness of the importance of knowledge management was evident as most of the companies highlighted that their main asset is the knowledge and skills of their employees. In coherence with this, the interviewed companies expressed the value and importance of creating an understanding about what the company is actually about. Knowledge management and thus the integration of the employees in the process, as well as the creation of a business understanding played a major role for ensuring high quality products.

“If they don’t know what the product or component they are manufacturing is for, they don’t care. But if they know this dozer will lubricate a paper machine which costs 250 000 SEK every hour it doesn’t work, then it’s easier for them to do a good job.”

(CEO of Company D).

While the interview answers mainly highlighted the cooperation between departments and the cross-functional work as means of knowledge transfer and acquisition, the survey indicated that companies ensure their knowledge acquisition through the cooperation with partners and training. Academic/professional literature was only used by 22% of the companies (figure 9).
5.2.3 Value Chain Integration

Value chain integration is the ability of a company to connect the different actors of the value chain into a coherent bundle (Christopher, 2000). This integration is done at three levels, namely the company, the customers and the suppliers.

**The Company**

According to the data collected, it appears that companies had a very close relationship to their employees. Actively listening and involving every employee was very important for the interviewees.

The cross-functionality of the human resources had a direct impact on the interviewed companies, since their department heads often had a very strong understanding of the rest of the company and its processes. As a consequence, an improved communication between the departments was emphasized. This is also supported by informal relationships and meetings between the different spheres of the companies interviewed. Also, the decision-making process in SMEs was mainly described as a mix between informal and formal procedures. The interviewed managers emphasized that due to their small size, a formal process is not a necessity. However, some companies pointed out that due to their growth, a more structured process might be needed in the future. All of the companies were aware of
the fact that too much structure would impede the benefits of being small. Last but not least, another reason for the integration of employees was that the companies felt that a certain level of integration would improve their motivation and their work commitment.

Different interviewees even stated that this relationship with their employees had created a strong transactive memory system (TMS) (Akgün, et al., 2006) of “who knows what” in the organization. In addition, the team closeness created a continuous information flow within the companies.

The Customers

Customer integration was identified as a requirement in every company interviewed. In order to be as close as possible to the market requirements, meetings with the customers and/or end customers were arranged regularly. In addition, particular attention was paid to customer comments in order to ensure high service quality.

“If you try to do something without understanding the customers’ requirements, it’s always a bad idea, especially for a small organization.” (Development Manager of Company F)

The different managers claimed the need to have very close and/or personal customer relationships in order to get the most accurate information from their customers and thus to better manage their production processes with regard to changes. Often, these close ties with the customers were described as informal partnerships, rather than just pure buyer-seller relationships. The accent was set on creating open discussions with key customers in order to understand their needs. In most of the cases, sales people were illustrated as dedicated to taking care of this relationship with the customers. Fairs, meetings and communication on a regular basis were the different means used by the companies to stay up-to-date with their customers.

A thorough understanding of the customers’ needs was said to improve trust building and enhance customer satisfaction, which in turn will lead to improved sales numbers.

“We don’t get paid if the customer is not happy.” (Production Manager of Company E)
The Suppliers

In order to achieve efficiency, most of the companies relied on parts from suppliers and sub-contractors who manufactured their needed components. It was said that suppliers are “cherry picked” to provide SMEs with the highest level of quality for their product and sales opportunities. Most of them had very long-term relationships with their suppliers, which guaranteed them the expected quality and service results. One company interviewed declared that they worked with some of its suppliers for over 25 years.

Many of the companies interviewed stated that they outsourced most of their activities in order to focus on their core competencies. In consequence, the suppliers’ integration was a core issue. The managers of this master thesis’ sample stressed that their flexibility was related to an efficient communication with their suppliers. Some companies, for example, pointed out that they only deal with big suppliers because of their perception of smaller organizations being less reliable.

In the survey, 82% of the respondents qualified the close relationship with customers as being one of their key assets to reacting to market changes (figure 8). Out of all of the different possible answers, this is the highest number. It is far ahead of the cross functional co-operation between departments (24%) or the cooperation with suppliers (26%). Also it was said that the most influential actors of the decision-making process were the customers (63%), owners (48%), employees (47%) and the department heads (41%).

5.2.4 Concurrent Engineering

As mentioned above, every company from the interview sample seemed to be aware of the necessity to cooperate with its partners and to integrate its employees. However, the level of integration was shown to be very different among the companies interviewed.

Multifunctional Teams

In many cases, teams were said to be very much cross-functional. For instance, in one company the different project teams and the steering committee had a high multifunctional
level by collecting all of the good ideas from the organization’s employees for groundbreaking development.

“It is difficult for large companies to get the knowledge from the development department down to the sales man.” (CEO of Company D)

In most of the companies from the interview sample, product development was seen as team work constituting of both the technicians and the sales people.

**Close Collaboration with Partners**

The interviewed managers stated that they were improving the process together with the partners at every point of the process. The cost figures were often shared with the partners to reach transparency in the collaboration.

“It key customers [...] are very early involved in the decision process, defining the requirement and so on very early.” (Development Manager of Company F)

However, differences in the way companies perceived the role of their partners also became apparent. For some companies, their role was described as purely taking and placing orders, while a few others were sitting down together with their suppliers and/or customers in order to develop the most appropriate solution.

“If we have a new product we take in the supplier early in the project so they are working together with us to get it right.” (CEO of Company D)

### 5.2.5 Advanced technologies

It became apparent that among the companies interviewed, the level of integration between technologies and production varied from being very traditional to fairly advanced. According to the size of their organization, the managers were conscious that their investment power was limited.
“Small companies like ours, we don’t gamble at all, we can’t afford to gamble. Huge companies they can gamble, it’s easier for them to try to do something and fail.”

(CEO of Company D)

**Advanced Manufacturing Technologies**

With regard to manufacturing technologies and processes, all SMEs interviewed highlighted that their production is not automized, but rather relies strongly on handcraft. Therefore, no high investment requirements were implied as being necessary for the machinery and assembly line. There was a consistency in answers, emphasizing that through their business model and strategy of using a lot of handcraft, the need to invest in machinery is meager. This is consistent with the mentioned company strategies and their focus on mainly fabricating customized rather than standardized products. SMEs described their required product batches as small, and thus did not perceive the necessity of investing in big machinery. However, one company stressed the solution of buying secondhand machines in case of a future need for increased production capacity.

**Advanced Planning Technologies**

The production planning technologies of the interviewed companies contained either traditional planning or not fully integrated planning tools. However, it is important to notice that quite a few companies had been investing in mid-size ERPs or other customized IT systems. These were said to be not as expensive as complete solutions and as having an easier setup due to their number of parameters already preselected. The same information was given for the stock-keeping systems. In one company, an electronic stock-keeping system was nearly inexistent while in some other companies a more thorough system was implemented.

**Integrated Customer/Supplier Communication Systems**

Almost every company had a very traditional way of communicating with suppliers and customers, by mainly using emails and phone calls rather than more elaborated tools.

“I think we should have invested in a system that helps track the products day by day.”

(Production Manager of Company E)
Even though there were various states of IT integration in the different companies interviewed, many of them recognized the future need for further development in that field to increase their flexibility and improve their efficiency.

According to the survey, the most dominant IT solutions used in the organizations from the sample were emails (94%), CAD (50%) and databases (48%). With regard to this context, ERP came fairly low in the answer with only 22% (figure 10).

![Used IT solutions in SMEs](image)

**Figure 10: Used IT solutions in SMEs in the CEOM industry**

*The choice of multiple answers was possible*

### 5.3 Manufacturing Strengths

Manufacturing strength is a direct consequence of different AMEs implemented by managers, or simply already present in the organization. With regard to manufacturing strengths, a clear distinction between two groups was identified. The first group stated that they do not have a clear manufacturing strategy defined.
“I don’t really think I have any manufacturing strategy, not anything that I have written or that we have something specific.” (Production Manager of Company G)

For the second group, the key manufacturing strategy was to be responsive and thus to be able to respond to the customer’s demand, which is stressed as the real key to success. The concept of ‘just-in-time’ was also mentioned multiple times during the interviews. The interviewed companies were aware that they cannot compete on price and therefore pursue a strategy which is based on flexibility, quality and reliability. However, even though having the lower cost is not an option, all of the companies were aware of the importance of cost efficiency and waste avoidance.

“Our main idea now is to be flexible because this industry was suffering very hard from the fact that some components that we use have a very long lead time.”

(Development Manager of Company F)

All of the companies argued that flexibility is ensured through mainly handcrafted manufacturing and the avoidance of automation. Within this context, most of the managers stressed again the importance of the employees, their experience and knowledge.

The survey results have a strong correlation to the interview answers. As illustrated in figure 11, quality (74%), flexibility (68%), service (60%) and long-term relationship (50%) were at the core of the respondent strategy, while price (16%) and personal relationship (20%) were not really put forward.
With regard to the manufacturing strategy, the survey indicated that the core concepts were found within the FMS (66%), focus/specialization on core products (34%) and TQM (30%). The JIT approach (22%) and the integration of the workforce (16%) were less used by companies of the sample (figure 12).
5.4 Advantages and Disadvantages of SMEs with regard to responsiveness

Based on the conducted literature review the following question arose: to which degree do SMEs have disadvantages or advantages compared to large companies, with a focus on responsiveness (see for example Brown and Bessant, 2003; Ismail, et al., 2007; Abdul-Nour, et al., 1999)?

According to the conducted interviews, it became obvious that the interviewed SMEs were considering themselves not to have huge disadvantages compared to large companies. Rather the contrary appeared to be true. SMEs saw their advantages and their capability of being flexible in their small organization form, characterized by flat hierarchies and thus
faster-decision making process. In addition, a flat hierarchy was also indicated as beneficial with regard to customer relationship and the establishment of trust, due to the fact that the customers can associate a “face” to their contact person.

Furthermore, the closeness to the employees was indicated as one of the main advantages of SMEs with regard to quality, flexibility and knowledge transfer. SMEs perceived their size as a facilitator for inter-departmental cooperation.

This integration of employees and the possibility of conducting different operation steps were seen by the managers as a reason for high employee satisfaction and commitment and thus low employee turnover, which in return creates stability and ensures long-term relationships with the suppliers and customers.

**Advantages of SMEs with regard to responsiveness**

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*Figure 13: Advantages of SMEs in the CEOM industry with regard to responsiveness*

*The choice of multiple answers was possible*
These statements of the interviews were confirmed by the survey findings, indicating that 90% of the answers given perceived flexibility as their main advantage, followed by a committed workforce (52%) and personal relationships to customers (50%). Also, the flat hierarchy was perceived to be an advantage with a response rate of 40% of all the answers given (figure 13).

Nevertheless, **disadvantages** were also pointed out, particularly with regard to a lack of financial resources and the capability of long-term planning. However, at this point, it has to be stressed that the lack of financial resources was not associated with flexibility or the implementation of IT systems, but rather with the possibilities of developing new ideas and the ability of having enough strength to gamble with them.

Another aspect emphasized was the high reliance on their employees. As mentioned before, SMEs indicated their employees as the heart of the company, and as the main enabler of flexibility. This approach displayed a high dependency on the workforce, which in cases of sick leaves can lead to a shortage of human resources.

These statements are also reflected in the survey answers reporting that out of the replies given, 55% of the survey respondents saw the dependency on their key employees as a disadvantage, while 31% saw their long-term planning resources as a constraint. Furthermore, the lack of financial resources (29%) and the R&D resources (27%) were associated with a disadvantage (figure 14). However, some respondents of the survey stressed that there is no correlation between the level of responsiveness and investment strengths. This finding was further elaborated by the interview statements emphasizing that due to their size, high investments in IT solutions, like SAP and their ERP systems can be avoided. It was indicated that the use of customized software programs obtains the same features as the popular ones, and thus do not affect the responsiveness of the company. The following two quotes reflect this non-relationship of financial resources and responsiveness and highlight that on the contrary, the lack of financial resources can lead to flexibility and creativity.

> “With a lack of finance, flexible solutions must be made in order to match the current financial situation.” (Answer from an open question of the survey)
“Flexibility is the “smart” use of available resources, not the ability and willingness to invest in new resources.” (Answer from an open question of the survey)

5.5 Awareness of the agile manufacturing concept

Out of eight companies, just two were a little familiar with the concept of AM and their enablers, while only one had a more extensive knowledge of it. After a short explanation of the concept itself, most of the interviewed companies perceived AM as a good approach and actually as the core of their business. In alignment with this finding, the AM approach was however not seen by the managers as an innovative approach but rather as something the companies are unconsciously applying every day in their daily business. All of them emphasized that achieving agility is enabled through their small size and thus flat hierarchy.
These findings were supported by the survey, as most respondents denied an awareness of the AM concept. Furthermore, 92% of the survey answers did not see an innovative approach in the AM concept.

An interesting finding was that some of the companies highlighted the importance of understanding this process to better evaluate their performance and thus to create a higher flexibility and efficiency.

“It is important to look and actually understand the process instead of just doing it and not understanding what is actually happening”. (Development Manager of Company F)

Therefore, the concept was perceived as useful and interesting. However, some managers pointed out that they did not consider theoretical concepts, due to two main reasons, which were indicated as the lack of practical orientation and the complex vocabulary used in scientific literature.
Part III – Analysis, Discussion, Conclusion

6. Analysis

In this part, the findings will be looked through the theoretical lenses defined in the frame of reference. The aim of the chapter is to compare the results collected with the theories given in the literature and the assumptions made at the beginning of this master thesis. Furthermore, a new model will be created based on the empirical findings from this research, which in addition will extend the existing body of knowledge. Therefore, this analysis will provide the foundation for the discussion and the conclusion, as well as the basis for the recommendations and further research suggestions.

6.1 Agility Drivers in the CEOM industry

As described in the frame of reference, the turn towards an AM strategy depends on the environment in which the company is operating in (see for example Vázquez-Bustelo, et al., 2007). The ADs can be high hostility, high dynamism, high complexity and high diversity (see for example Vázquez-Bustelo, et al., 2007). As highlighted in the methodology part, the CEOM industry was assumed to be unpredictable, fast-changing, highly populated and facing fierce competition with high product diversity. These characteristics are reflected in the ADs highlighted in the literature.

Compared to the ADs emphasized in the frame of reference, three of them have been strongly reflected in the findings. These three are technology, customer and competitors. In the literature, technology is associated with dynamism, the customers are connected with high complexity, while the competitors are seen as hostile.

With regard to the technology, the companies’ perception of the environment varied a lot. A reason for this can be found in the companies’ comprehension of their industry and their
product. While all the companies contacted were listed in the CEOM industry, some of the companies did not see themselves operating in this industry but rather associated themselves with their key customers’ industry, like the wood sector. This finding can be affiliated with the statement of various authors that one of the aims of AM is to understand the customer requirements and thus the market itself (see for example Goldman, et al., 1995; DeVor, et al., 1997). The companies interviewed and surveyed stressed this aim as one of the most important factors of their business strategy. Furthermore, this finding is coherent with Vázquez-Bustelo, et al. (2007) highlighting that the development of AM is dependent on the managers’ perception and their capability to sense change. It appears that the close identification with the key customers’ industry influences the company’s perception with regard to the degree of a turbulent environment. In other words, the ADs defined in the literature can differ from the perceived and sensed ADs of real-life businesses, in this case the CEOM industry. Therefore, based on this finding it can be concluded that ADs indeed varied even within the same industry. In correlation with the first research question posed in this master thesis (“Is agile manufacturing relevant in SMEs in the computer, electronic and optical manufacturing industry in Sweden?”), the analysis is providing two-fold results. ADs have been found in the empirical findings, and thus the incentive for the implementation of AM is given. Nevertheless, it also became apparent that the managers’ different perceptions influence their attitude toward the ADs in their industry due to their close relationship with their key customers/suppliers. As a consequence, the importance of AM cannot be completely denied or confirmed, but rather strongly relies on the company’s perception and the connected capability to sense changes.

However, it also has to be mentioned, that another reason for this variation in the results can be given by the different data collection methods. During the interview questions, the meaning of “turbulent environment” was not clear to the respondents and needed further explanations. This confusion about the expression “turbulent environment” is also highlighted in Vázquez-Bustelo, et al. (2007) and is strongly connected to the above mentioned analysis point about the environment perception. In order to avoid this misconception in the survey, the question with regard to ADs was adjusted to a more
explanatory description of the environment and therefore the survey answers have been more coherent with each other than the answers given by the interview respondents.

Concerning the **customers’ demand**, it seems that there was a consensus over the fact that this AD is much more fluctuating over time, and that clients were perceived as well-educated with regard to technical product aspects. Within this context, the findings of the interview showed that the unpredicted environment changes are rooted in the customer requirements. This result is completely consistent with the argumentation for the need of AM described in the literature (see for example Gunasekaran, 2001; Kidd, 1994, Sherehiy, et al., 2007, Sanchez and Nagi, 2001). Referring back to the first part of research question 1, this result highlights the relevancy of AM, due to the fact that the condition for the AD is given.

The last AD was identified as the **competition**. While the literature emphasizes high hostility as a condition for the implementation of AM, the findings of the empirical research showed that this driver was not apparent in the answers of the respondents. The competitors were rather seen as a negligible threat for their business, as the companies considered themselves to be operating in market niches or/and focusing and specializing on specific products. It is noticeable that this view might be rooted in the fabrication of handcrafted products, which leads to customized products with high quality standards. The managers therefore experienced their products and business as not facing fierce competition.

The following chart summarizes the ADs in the literature compared with the empirical findings. As mentioned before, just three of the ADs introduced by the literature are reflected in the empirical findings. However, according to Vázquez-Bustelo, et al. (2007), high diversity can also be seen as an AD. High diversity hereby is defined as varied products, lines, customers or businesses (Vázquez-Bustelo, et al., 2007). It can be assumed that this aspect was not mentioned since the companies saw themselves as specialists for certain products. However, referring to their strategy of producing customized products, a contradiction was found. It can be imagined that the strategy of manufacturing customized products was reflected in a varied product range, in some cases through the application of
high modularity, which in other words means a high diversity in products. On the other hand, the companies interviewed and surveyed emphasized the long-term relationship with their customers and suppliers. This therefore reflects a low diversity due to the fact that the business partners and customers mainly stay the same.

<table>
<thead>
<tr>
<th></th>
<th>Agility Drivers identified in the literature</th>
<th>Agility Drivers identified in the empirical findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology</strong></td>
<td>Dynamic</td>
<td>From slow to fast-changing</td>
</tr>
<tr>
<td><strong>Customer</strong></td>
<td>Fast changing requirements and well-educated customers</td>
<td>Fast changing requirements and well educated customers</td>
</tr>
<tr>
<td><strong>Competitors</strong></td>
<td>Hostile</td>
<td>No perception of competition influence because of the perception of operating in a niche market</td>
</tr>
<tr>
<td><strong>High diversity</strong></td>
<td>Varied products, lines, customers and businesses</td>
<td>Varied products but long-relationships with customers and focus on one core business</td>
</tr>
</tbody>
</table>

Table 3: Comparison of agility driver identified in the theory with empirical findings
(Source: Authors’ own elaboration, 2011)

In sum, the ADs described by the literature were partly found in the empirical findings. Due to this, the conditions for the implementation of AM and thus its relevancy are given in the chosen industry, namely the CEOM industry. However, it also became apparent that the description of this industry used in the methodology was not confirmed by the companies interviewed and surveyed. As exposed above, particularly the characteristic of facing fierce competition was not approved.
6.2 Agile Manufacturing Enablers in the CEOM industry

As highlighted before, AMEs are one of the pillars of this thesis. Therefore, an extensive analysis will be carried out and will be used to build a model explaining the enablers used within the CEOM industry in order to react to unpredicted changes in their environment. The different AMEs hereby will be scrutinized according to the three types of resources: technology, management and workforce, which are furthermore strongly related.

Referring back to this paper’s problem statement, the first assumption stated was that AM can be applied, or is already partly applied in SMEs but in a different way. It was hereby assumed that SMEs cope with a different set of enablers than the ones praised in the literature.

6.2.1 Integration

Vázquez-Bustelo, et al., (2007) emphasize the importance of the integration at both the internal and the external level. The level of integration is fostered by the managers of the company, the right use of integrated customer/supplier information systems and a close cooperation with suppliers and customers, as well as an inter-departmental cooperation (Vázquez-Bustelo, et al., 2007). These AMEs were mainly reflected in the practices of the SMEs in the CEOM industry, particularly the close collaboration with the suppliers and customers, as well as the internal cross-functional work settings. Furthermore, this close collaboration was indicated as a replacement for the sophisticated IT tools and as a source of knowledge creation. Therefore, it can be reasoned that the AMEs and the practices used in the studied companies are coherent, however with a different emphasis. In other words, this means that the integration in the interviewed and surveyed SMEs is achieved predominately through close and long-term relationships with customers, suppliers and encouragement for cross-functional department work.
A strong connection can be found within concurrent engineering and thus another AME emphasized in the literature. Within this context, concurrent engineering contains the product development and process design in cooperation with the different business partners, through an early involvement and multifunctional teams (Vázquez-Bustelo, et al., 2007). While it has already been stressed before, a high level of multifunctional teams and early collaboration was found. However, the focus of the studied SMEs hereby is mainly on the process side, rather than on the product side. It appears that the companies were more reacting to the customers’ needs than pro-actively searching for future market opportunities. Therefore, the findings are two-fold. While the enablers for concurrent engineering were apparent in the studied SMEs in the CEOM industry, the focus on pro-active behavior was missing, as the product and process development seemed to be more linear than concurrent.

6.2.2 Technology

Even though the literature advises enterprises to introduce advanced IT solutions in order to achieve a successful implementation of AM (see for example, Jiang and Chen, 2007), in many cases, the flat hierarchy and close ties between team members were indicated to substitute the use of technologies. The employees from the studied SMEs were described as knowing where to find the information and as being able to take decisions relying on their knowledge rather than on the support of technologies. Therefore, the interviewed and surveyed companies relied more on traditional ways of communicating with customers and suppliers, like personal phone calls, emails or face-to-face meetings. In addition to the statement of the managers that sophisticated IT solutions are not necessary due to the size, it was also indicated that the direct contact and thus the use of traditional communication tools supported the personal relationships and enhanced the closeness to customers and suppliers. These concepts of closeness and good relationships were found to be some of the main features of the competitive strategy of the interviewed and questioned SMEs.
The manufacturing methods used in the studied SMEs furthermore reduce the need for AMTs. As a matter of fact, the need for automation and investment in flexible manufacturing capacities recommended by AM scholars (see for example Corbett and Cambell, 2002; Goldman, et al., 1995; Power and Sohal, 2001; Vázquez-Bustelo, et al. 2007) is diminished through a production which is mainly based on handcraft and small order batches. Some companies had also a modular reconfigurable system or bought secondhand machines. However, the employees’ ability to capture the big picture in SMEs is weakened, due to the fact that the integration between IT solutions and production was fairly low. Within this context, companies which had customized ERP software or similar solutions seemed more open to the changes of their environment than the companies that had no ERP system at all. The desire to acquire technological resources was clearly a concern for the interviewed managers, but it appears that they were anxious about its implementation. Another reason might be the lack of appreciation of IT solutions and IT workers described in the literature. Furthermore, the managers seem to be skeptical about its usefulness in a small company, as the flat hierarchy was thought of as being sufficient.

The use of technology clearly constitutes the major area of improvement in SMEs’ quest to AM. Their lack of resources together with their size advantage should indeed guide SMEs in their choice of the appropriate IT solutions. Going back to the literature, the big picture was partially captured by the studied companies, but the resources planning and production alignment (Jiang and Chen, 2007; Christopher, 2000) would deserve a more in depth integration for most of the studied organizations. Therefore, it can be concluded that the AMEs stressed in the theory are not or just partly reflected in the studied SMEs of the CEO industry. This leads to the result that the assumption made within this paper cannot be confirmed completely with regard to agile technologies.

### 6.2.3 Management

The situation of the management resources seems to be more contrasted. In theory, management is made a determinant to the success of AM, because it optimizes the use of
technology and of the flexible workforce (see for example, Power and Sohal, 2001; Coronado, 2003). The studied SMEs appeared to lack the vision for agility, and thus no clear direction in terms of manufacturing strategy was found. None of the companies were clearly empowered to implement AM, Just-in-time (JIT), Total Quality Management (TQM) or LM to that matter. These tools were replaced by a close relationship with customers, employees and suppliers. Nevertheless, a well-developed “extended organization” (Christopher, 2000) was apparent in SMEs, due to their long-term collaborative relationships with their direct suppliers and customers. These partnerships are often created with a focus on core competencies (Prahalad and Hamel, 1990; Grant, 2010), as most of the researched organizations outsourced the activities which they either had no expertise about, or which were not classified as the core competences of the company. In addition, a quite extensive amount of information-sharing with the partners was found. This is in coherence with the need of information mentioned in the theory. However, it became apparent that this information sharing was not the result of a virtual organization setting. Once again, it appeared that the importance of the workforce in SMEs and the absence of IT solutions strongly influenced the organization. The educated and flexible employees, together with a close listening to business partners, create the appropriate conditions for dynamic capabilities within SMEs’ network organizations and the learning organization. However, the limited use of AMTs impedes the ability for these organizations to develop an elaborate manufacturing strategy. Within this context the manufacturing strategy of the studied SMEs was not clearly defined, while their business strategy was mainly based on flexibility and quality. In conclusion, this means that the management resources and its enablers are not fully exploited in the studied SMEs.

6.2.4 Workforce

As illustrated in table 4, the AMEs in the SMEs of the data collection can be described as quite advanced, with regard to their workforce resources. It was striking from the records collected that the SMEs answering from the Swedish CEOM industry have a strong AM
asset in their employees. This is highly coherent with the theory that demonstrates a company’s workforce as a crucial element of AM (see for example: Vázquez-Bustelo, et al., 2007; Gunasekaran, 2001; Yusuf, et al., 1999; Shariﬁ and Zhang, 1999). In every company from both the survey and the interviews, employees were described as empowered and acted with a strong entrepreneurial spirit. In addition, they were indicated to be highly trained, and thus able to accomplish multiple tasks. The training and the continuous learning appeared to be done through socialization and cooperation between departments, but without formal training programs. This high level of cooperation was seen as one of the main factors for enhanced responsiveness and a high level of customer service. In addition, SMEs seemed to be characterized by a similar level of decentralization as the one advised in the theory (see for example Goldman, et al., 1995; Shariﬁ and Zhang, 1999; Breu, et al., 2002; Kathuria and Partovi, 1999). However, most of the companies studied declared that this decentralization also created a strong dependence on some key employees and their knowledge. Due to their small or medium size, the workforce was characterized as multifunctional. While this definitely enhances flexibility, the dependence on key employees could also be a drawback in case of sick leaves, as no labor buffer exists. This high level of dependency on the employees in the studied SMEs is contradictory to the theory which stresses the cross functionality of team members as a means to reduce the dependency on key employees because of their substitutability (see for example, Vázquez-Bustelo, et al., 2007; Gunasekaran, 2001; Yusuf, et al., 1999; Shariﬁ and Zhang, 1999). However, this seemed not to impede the companies’ perception of their workforce, since it was still considered to be one of their strongest assets in being flexible. This perception might be a direct consequence of the fact that according to the survey, the managers considered their employees to be highly committed and their employee turnover to be fairly low. However, the prevalence of human resources indeed influences the role of the rest of AMEs. In conclusion, it can be said that SMEs’ employees can be associated with the agile human resources stressed in the theory, due to their high degree of teamwork, motivation and commitment as well as cross-functional training and knowledge transfer.

According to Vázquez-Bustelo, et al., (2007), good knowledge management encompasses documentation supports, accessible databases, team-based knowledge exchange and the
creation of best-practices norms. Based on the findings of this research, the quality of human resources appeared to be fostered by an overall good knowledge management, although no real formalized structure for this was found. Instead of formal documentation of the best practices and later their broadcast throughout the entire structure, it seems that teamwork and socialization are the keys for knowledge management in SMEs in the CEOM industry. This enables a transactive memory system by providing information about who does what in the company. However, the identified knowledge management practices might also have negative consequences, as it increases the dependency on key employees. Furthermore, it has to be pointed out that the applied knowledge management was happening unconsciously and thus was completely unintended. Based on these findings, it can be concluded that some of the knowledge management enablers as described in the literature, particularly in Vázquez-Bustelo, et al., (2007) were already part of the studied SMEs. Within this context, the main practices of knowledge management were relying on the cross-functional team, a flat hierarchy as well as a close relationship with the customers and suppliers. However, the comparison also showed that the picture is incomplete, as no formalized process, like the absence of accessible data bases, has been found.

As illustrated in the literature, it is crucial to reflect upon the ability of SMEs to integrate their different resources and therefore to create a coherent bundle of enablers. It appears that although the extended organization and the human resources of SMEs are highly integrated, these organizations lack a companywide initiative to develop a vision for AM. Therefore, the set of AMEs explained above is inherent to the organizations, rather than actively created for an overall agility purpose. Companies are lacking a consistent AM plan of action, which results in an incomplete consistency with the AM model praised in the literature.

An overview of the existing AMEs in the organizations interviewed and surveyed is provided using the table presented in the frame of reference.
Overall, it can be concluded that the AMEs identified in the literature are partly reflected in the practices of the studied SMEs, and thus confirms the assumption of this research paper that AM and its enablers are partially applied in SMEs. While some of these enablers showed a high coherency with the ones in the literature, particularly the ones with regard to AMT, displayed a high deficiency. This however can be a consequence of the company’s size, its product or resources. In other words, it became apparent that SMEs in the CEOM industry created their own and suitable set of AMEs in order to respond to a turbulent environment.

**6.3 New Agile Manufacturing Model for SMEs in the CEOM industry**

The findings and the results of the conducted analysis are illustrated in the following model, emphasizing the AMEs found in the SMEs in the CEOM industry. With regard to this, the model highlights the practices applied in the studied industry, in order to respond to a turbulent environment. In summary, it can be argued that the main AMEs are rooted in the workforce and a strong network cooperation, fostered by the company’s size (flat...
hierarchy), its products (handcraft and customized production) and the long-term relationship with suppliers and customers. Furthermore, the size of the studied companies, as well as close and long-term relationships contributed to a high level of integration along the value chain and a distinctive knowledge management. In addition, it seems that these factors are to a certain extent replacing the need for AM technologies, for example advanced manufacturing technologies, integrated customer/supplier information systems and planning systems.

Figure 15: Identified agile manufacturing enablers in SMEs from the CEOM industry

(Source: Authors’ own elaboration, 2011)
Referring to the research question of this paper, it can be reasoned that the assumption of the partially existence of AMEs in SMEs in the CEOM industry is confirmed. While this analysis highlights the coherency of the theory and empirical findings with regard to AMEs, it becomes apparent that nevertheless the right set of AMEs is affected by the company’s size, products and industry it is operating in, as well as the available resources. Therefore, the developed model should be seen as illustrating a picture of the AMEs used in the SMEs in the CEOM industry in Sweden, aiming to suggest possible strategies and tools for SMEs to achieve AM with fewer resources.

6.4 Advantages and disadvantages SMEs with regard to responsiveness

Referring to the first research question of this master thesis, and thus the relevancy of AM in SMEs operating in the CEOM industry in Sweden, it was assumed that the identified challenges for SMEs highlighted in the theory can be bypassed through, for example, their flat hierarchy. In coherence with this conjecture, the disadvantages and advantages of SMEs in the CEOM industry with regard to responsiveness will be analyzed.

Based on the AMEs indicated in the existing body of knowledge, various authors argued that due to a lack of financial resources, SMEs have a disadvantage with regard to the implementation of AM (see for example Brown and Bessant, 2003; Ismail, et al., 2007; Abdul-Nour, et al., 1999). Within this context, some authors refer to the need for a paradigm shift to implement AM (Ribeiro and Fernandes, 2010), and to enforce a sophisticated IT infrastructure accompanied with advanced design and manufacturing technologies (see for example Coronado, 2003). Overall, it became transparent in the literature that these authors describe the implementation of AM as more complicated for SMEs, due to their lack of capacities compared to larger organizations.

In reality however, the studied companies declared themselves as having an advantageous position with regard to responsiveness. Hereby, the interviewed and surveyed managers in
the CEOM industry emphasized the quick-decision making process and the improved relationship to their business partners and employees as a key aspect in achieving efficient and quick changes in their organization. In addition, the need for expensive investment in IT was seen as redundant, as the close relationship and face-to-face contact fostered through the flat hierarchy enhanced the integration mechanisms, and thus replaced the quest for sophisticated IT solutions. Furthermore, the studied companies emphasized that the employees’ solidarity with their company intensifies the knowledge transfer, commitment and flexibility of the employees, which as a consequence, reduces the need for advanced technologies.

However, it cannot be completely denied that the empirical findings partly confirm the disadvantages stressed in the literature, particularly with the lack of financial resources and the capability of long-term planning. Nevertheless, these two factors were not seen as having an impact on the responsiveness level of the studied companies but were rather identified as a nice addition. In addition, it was emphasized that the lack of financial resources and capacities can enhance creativity and flexibility. This thinking approach is strongly reflected in the principles of AM by sensing opportunities and the eagerness of continuous learning.

In conclusion, these findings are coherent with the previously made assumption and the undervalued possibilities of SMEs in achieving AM, and thus responsiveness. Therefore, it can be reasoned that the challenges for SMEs as described in the literature, constitute a contradiction to the reality of the SMEs in the CEOM industry.

6.5 The awareness of agile manufacturing in SMEs within the CEOM industry

The objective of the following section is to provide an answer to the second research question (“Is agile manufacturing already unconsciously a part in SMEs?”). This research question is strongly related to the analysis of the first research question, particularly the
practices of SMEs used in order to respond to a turbulent environment. While the analysis so far shows that AMEs can partly be found in SMEs within the CEOM industry, the second question deals with the level of awareness managers have about the AM concept. Hereby, the assumption of this master thesis was that AM is already unconsciously part in SMEs, and is seen as logical business thinking. Within this context, the answers to the two sub-questions posed in this master thesis will be analyzed, namely (1) “Are companies aware of the agile manufacturing concept?” and (2) “Is agile manufacturing an innovative approach or just a buzzword?”

Besides the consistency of some AMEs praised in the literature, and the ones highlighted in the empirical findings, some other features of AM reflect the occurrence of AM in SMEs in the CEOM industry.

According to the definitions emphasized in the frame of reference, an agile company has the ability to successfully deal with a turbulent environment and changing market requirements (see for example Ifandoudas and Chapman, 2010, Sharif and Zhang, 2001). In order to achieve this strategic ability of being not just active but rather pro-active, companies must be open-minded and continuously ready to learn and to perceive necessary changes (see for example Goldman, et al., 1995). Within this context, the implementation of AM is described as a strategy that emphasizes the importance of the alignment of people, management and technology resources, in order to respond to these new changes and requirements (see for example Kidd, 1994; Gunasekaran, 2001). This pro-active behavior was shown in most of the interviewed and surveyed companies through the early involvement of their suppliers and customers in the process. This approach is in accordance with AM principles, aiming for a thorough understanding of the customer needs, and thus the characteristics of the desired product. Some of the companies even declared that their strength is in forecasting new technological trends and market requirements, through the close collaboration with their key suppliers and customers. However, it cannot be neglected that some companies react passively to the market. Nevertheless, it can be assumed that this passivity is rather connected to poor planning skills than the underestimation of the importance of a dynamic approach. This finding was also highlighted in the survey result,
stressing that one disadvantage of being a SME is the capability of long-term planning. In
despite of it all, the attempt towards AM is evident due to the fact that the sample companies
are trying to react proactively to a turbulent environment by applying the principles of AM.
This in other words means that the AM approach appears in SMEs operating in the CEOM
industry, although it is not associated with the AM concept emphasized in the literature.

Furthermore, it has been described in the theory that AM comprises of the LM concept
which aims for cost reduction through the avoidance of waste and better production
efficiency (see for example Yusuf and Adeleye, 2002). This theoretical approach was partly
found in the SMEs within the CEOM industry in Sweden. While overall, every company
was concerned with keeping their cost as low as possible, the findings also reflected that
this attempt at cost reduction was not the main competitive strategy of the interviewed and
surveyed SMEs. On the contrary, it appeared that customer satisfaction, customized product
and quality were core elements of the company’s strategies. This leads to the conclusion
that with regard to the competitive strategy, the definition of AM can be reflected in the
SMEs operating in the CEOM industry. Based on the literature, AM is described as not just
focusing on pure cost reduction, but rather as finding the best solution for the customer by
incorporating the importance of price, quality, flexibility and high customer satisfaction
(see for example Corbett and Campbell-Hunt, 2002). However, while a consistency of the
business process of the sampled SMEs with the definition of AM can be found, no evidence
of a conscious knowledge about the AM concept was identified.

Another key element of the AM approach is the internal, as well as external flow of
information within the organization, which not only allows an early and accurate
forecasting capability but also enables a fast-decision making process and easier
cooperation among the different departments. The findings of the interviews and the survey
showed that this information flow is also a current business practice for the SMEs in the
CEOM industry in Sweden. This statement can be underpinned by the fact that a very good
integration of employees, suppliers and customers was indicated by the interviewed and
surveyed managers as the key for success. However, this integration was built upon the size
of the company and their flat hierarchy and thus, their informal decision making-process.
Within this context, the virtual enterprise, as praised in the literature, has been found in the empirical findings. The use of IT was by all means given (for example, customized ERP systems and emails), however none of the companies were 100% integrated through the use of IT, but rather through personal, close and long-term relationships with other parties. At this point, it can be assumed that due to their size, a virtual company to a certain extent is not absolutely necessary. Therefore, it can be reasoned that even though there is a lot of room for improvement with regard to the means of communication and IT tools, having an overall efficient flow of information is indeed already at the core of the interviewed and surveyed SMEs’ way of doing business. Nevertheless, the understanding of the importance of a transparent and good information flow was not associated by the interviewed managers with the AM concept, but rather seen again as logical business thinking.

Another feature of AM was reflected in the appreciation and integration of the company’s workforce. Hereby, the literature emphasizes that AM relies on a workforce that is flexible, knowledgeable, resilient and open-minded to change (see for example Vázquez-Bustelo, et al., 2007; Kidd, 1994, McCann, et al., 2009). In the studied SMEs, the managers indicated that their employees contain these characteristics by understanding the business processes and products, and thus the company itself. The already mentioned integration of the employees in the decision-making process was expressed as a reason for low turnover and a committed workforce, which in turn strengthened the ability to react to high levels of stress and change. Although this finding constitutes an attribute of AM, and thus highlights that the concept can be found in SMEs operating in the CEOM industry, no connection with the theoretical concept became evident. The integration and appreciation of the employees was again rather seen as common knowledge and logical behavior. Therefore, no awareness of the AM concept is given.

In conclusion, it appears that the interviewed and surveyed managers are largely unaware of the AM concept and its implications, and only a very small sample within the studied industry was familiar with the AM concept.

However, at this point it has to be stressed that this “unawareness” does not disqualify SMEs in the CEOM industry from being good candidates for AM. On the contrary, the
findings emphasized first of all that the studied industry faces certain agility drivers, which in return verify the implementation of AM. In addition, the practices used by the researched SMEs are partly consistent and similar with the ones praised in the literature. The lack of a complete conformity of the AMEs praised in the literature and the ones used in real-life practices is not surprising, as the right set of AMEs depends and can vary due to the industry itself and its environment, as well as the company’s size, products and resources. Furthermore, the findings of this research indicated that AM is not seen as an innovative approach, but rather as logical business thinking, and as the only solution to survive in a turbulent environment. These results are coherent with this paper’s assumptions that the AM concept is unconsciously already a part of the chosen SMEs. In addition, it was not seen as an innovative approach, but rather reflected the statement from the German engineer which described the AM concept as logical business thinking.
7. Discussion

Based on the conducted analysis, the following discussion will highlight some major findings and issues in the apprehension of the empirical findings. Particular focus will be placed on the way SMEs are dealing with AM and the problems that might occur. Furthermore, the significance of the developed model will be addressed, and the learning potential of this paper for both, SMEs and large organizations will be emphasized. In addition, reasons for the high level of unawareness of the AM concept itself will be discussed.

The analysis showed that AM is indeed relevant for SMEs operating in the CEOM industry, and that these companies are using AMEs in their own fashion, however unconsciously. The model developed throughout this thesis highlights the enablers of AMs in practice in the studied industry. As the aim of the paper was to contribute to a better understanding of the relevancy and the applicability of AM in SMEs, this model cannot be seen as a best-practice model, but rather provides an illustration of how SMEs in the CEOM industry in Sweden react to a turbulent environment, and thus which enablers they use. Therefore, this model provides the opportunity for other SMEs to reflect upon the different practices of how to react to changes and to find some gaps for improvement within their own business processes. The study showed a pattern in the researched sample with regard to the application of AMEs, particularly the prevalence of the workforce and the scarcity of AMT solutions.

However, this model has a major limitation, as it only reflects the enablers applied in the studied industry in Sweden. While it can be assumed that the pattern found would be fairly similar in SMEs operating in other industries, it has to be pointed out that many variables might affect the choice of AMEs. Taking into account the contingency theory, it appears to the authors of this thesis that no best practice model of AM can be created, as the companies are influenced by various variables, for example the size of the company, its industry and products, its resources available and the environment the company is facing.
In other words, this means that the model developed requires some adaptations regarding each company’s own situation.

The industry plays a major role with regard to the relevancy of AM, and thus its enablers. An industry which is characterized by an environment constituting of fast-changing technology, demanding customers and fierce competition is more likely to see benefits in implementing AM than an industry that is featured by a static and slow-moving environment. Therefore, it depends on the capability of the managers to perceive ADs and to proactively react to them by applying the right set of AMEs.

In addition, one of the most influential variables is the size of the company. As described in the background, the size of a SME can vary between 1 and 250 employees, therefore making no difference between micro, small and medium enterprises. As a matter of fact, this of course largely influences the model. As stated by the interviewed managers and as confirmed by the survey findings, the two main stated advantages of SMEs with regard to AM were reflected in the quick decision-making process and the close collaboration with the customer and suppliers. Therefore, it can be assumed that these advantages would be negatively influenced by a bigger size and the more formal processes coming with it.

Together with the size of the organization, the company’s resources also have a strong effect on the set of AMEs to be implemented. For example, the range of IT solutions which a company can acquire is indeed positively connected with the level of financial resources they possess. The larger SMEs would be able to afford a deeper integration between production and technology with, for instance, the use of customized ERP systems, while smaller enterprises can only afford very basic tools. However, it has been proven that the interviewed and surveyed SMEs managers considered their small size as a feature which reduces the need for IT solutions.

Another variable is the product itself, and thus its manufacturing process, which might vary from one company to another. Most of the companies indicated the use of handcrafted assembly and customized products, which are reducing the need for investments in automation and flexible manufacturing devices. Therefore, companies producing more
standardized products are more likely to need AM technologies than the ones relying on handcrafted assembly lines.

Due to these facts, the model developed cannot be seen as the right set for every company, and thus no generalization can be made. Nevertheless, it provides a thorough illustration and starting point about what might be possible for SMEs in their aim to accomplish AM and thus to respond to the challenges of a turbulent environment. At this point, it is important to stress that AM strongly relies on the managers’ capability to perceive upcoming changes, and furthermore on their proficiency to build the right set of AMEs.

Going more in-depth with the enablers used by the SMEs in the CEOM industry and reflected by the model developed in this master thesis, some flaws in the practices used will be discussed and elaborated.

The use and importance of knowledge management as a pillar of AM and the aim for continuous learning was indeed mirrored in the findings of the interviews and surveys, and thus can be said to be apparent in the studied industry. However, the knowledge management approach still leaves room for improvements, particularly with regard to knowledge storage and re-use, due to the fact that no knowledge documentation approach was found. In other words, this means that the knowledge within the company might disappear over some time, as it is transferred into tacit knowledge rather than explicit knowledge. This constitutes the danger that the knowledge transfer will have some gaps as all of the tasks and processes are done unconsciously or are inherent in some key employees, which in return increases the dependency on them. Therefore, it can be concluded that regardless of their size and the use of cross-functional working teams, a certain knowledge transfer process and documentation should also exist in SMEs.

This knowledge transfer and documentation could be supported by the right use of IT technologies. However, as emphasized in the frame of reference, IT solutions need to be supported by an IT literate workforce. Therefore, the training or the hiring of IT workers seems to be the next logical step for SMEs from the CEOM industry in Sweden in their quest to fully benefit from AM. As indicated in the frame of reference and throughout the
analysis, AM needs not just to be implemented on the operational level, but also on a strategic level. This strategic vision furthermore requires a transformation in the mindset, and thus an open-minded attitude for continuous learning and change. In reality however, the authors of this master thesis got the impression that a long-term vision is lacking. This statement can be underpinned by the scarcity of knowledge management and contingency planning. Nevertheless, it can be assumed that this long-term vision might be easier to implement among SMEs than large companies due to their smaller size, good communication and long lasting relationships with their employees, suppliers and customers. In addition, it can be assumed that the long-term vision is already in the mind of the CEOs, although not communicated or documented. This however, does not mean that the short-term vision is neglected in the studied SMEs in the CEOM industry.

The interviewees confirmed Bohan’s (2010) statement that SMEs can bypass LM. Although SMEs are largely aware of LM, most of them neglect it. However, the authors of this paper disagree with both the statement from Bohan (2010) and the results of the empirical findings. It is strongly believed that SMEs would benefit from having a further implementation of LM. Although it is agreed that a strong focus should be set on quality and customer service, SMEs should not only use the FMS side of AM, but combine both manufacturing concepts, and thus FMS and LM. While there is no question about the necessity of being flexible, it is also important to optimize processes and to avoid waste to a certain extent in order to stay competitive. This statement is also reflected in the definition of AM, emphasizing that a successful implementation of AM comprises of and needs both manufacturing concepts.

The analysis of the findings identified a learning potential from the identified AMEs used by the SMEs from the CEOM industry for the large organizations and vice versa. The main lesson for large organizations would be the adoption of the personal relationships SMEs have with their business partners and employees. Such relationships allow the creation of a TMS, faster decision making, a good flow of information through the transparency of the information, greater employee autonomy with an enhanced entrepreneurial spirit and the
development of a strong company culture, characterized by a high level of commitment and thus, a low workforce turnover.

Nevertheless, SMEs might also benefit from the practices of big organizations, for example a performance improvement, by rationalizing their production processes with the help of suitable and customized IT solutions. In addition, SMEs could yield the benefits of AM through the implementation of a company-wide long-term strategy and indeed a continuous reflection of their current strategy to identify gaps and thus react appropriately to changes.

It can be stated that no matter if a company is an SME or a large organization, integration is the key factor of a successful implementation of AM and therefore of company resiliency.

From this discussion, and in connection with the research questions, it was emphasized that SMEs are implementing AM, but they have their own specific way that differs from one company to another. From that, it can be concluded that the main limitation of AM as it would be described in a best-practice model would not be applicable or feasible in every company/industry. Therefore the model developed within this paper should be considered as a guideline and an illustration of feasible AMEs due to the fact that it is the sample of a single industry.

While it seems that the AM concept can indeed enhance responsiveness and thus competitiveness, the high level of unawareness of this concept impedes a full exploitation of this concept. This identified lack of familiarity with the AM concept might stem from the abstractness of this approach for SMEs’ managers or even managers in general. In other words, the majority of the interviewed and surveyed managers felt that the theoretical concepts are too far away from real-life examples. This is coherent with the empirical gap identified at the beginning of this thesis and the emphasized statement of the German engineer. Therefore, an attempt should be made to “translate” the scientific language and concepts into more feasible and comprehensive articles. Furthermore, it is assumed that less academic language would enhance the possibility for managers to reflect on their current strategies and to find opportunities for improvement.
8. Conclusion

“Change is the way of life. And those who look only to the past or present are certain to miss the future.” (John F. Kennedy, 1963)

This quotation highlights the fact that change will always be there, no matter if it is in one’s personal life, society or the business environment. It is up to the people themselves to deal with this change and to create opportunities out of it.

Companies nowadays are confronted daily with an environment that is characterized by fast-changing technologies and market requirements, as well as well-educated customers. Within this context, the AM concept is praised as being one of the solutions to respond not just to such a turbulent environment, but also to achieve and maintain a competitive advantage through the right set of tools and strategies.

While the literatures’ richness of AM definition, concepts and enablers for large companies was highly visible, barely any attempt has been made to challenge the concepts’ relevancy and applicability in the context of SMEs. Therefore, this master thesis’ purpose was to shed light on the AM concept itself and to scrutinize the concepts enablers suitable for SMEs, and thus companies with less financial resources than the large ones. The aim hereby was to challenge and to extend the existing body of knowledge not just by identifying the practices used by SMEs in the CEOM industry in the quest to achieve high responsiveness, but also by providing a more practical approach gained from real-life examples. In coherence with this purpose, the main contribution of this master thesis was the creation of a model illustrating the AMEs applied in SMEs in the CEOM industry (see figure 15). Furthermore, this model will give other SMEs the possibility to reflect on their practices and to identify feasible areas of improvement.

Within this context, the empirical findings gathered from the eight interviews conducted and the 50 survey questionnaires answered provided not only the answers to the research
questions of this research paper, but also confirmed the assumption made throughout this master thesis.

With regard to the first research question,

“Is agile manufacturing relevant in SMEs operating in the computer, electronic and optical manufacturing industry in Sweden and if yes, in what ways?”

the assumption was made that AM is indeed relevant to SMEs, although the enablers described in the literature differ from the ones used by the SMEs, due to their distinct characteristics of having a flat hierarchy and thus a short decision-making process. This assumption was confirmed with regard to the enablers. As the created model in this master thesis (see figure 15) highlights, SMEs in the CEOM industry in Sweden are in fact applying practices which are coherent with the AMEs identified in the literature. However, it became also apparent that these AMEs were adjusted to the size, the products and the resources of the companies. Within this context, particularly the flat hierarchy and the close and long-term relationships with suppliers and customers were seen as a substitute for the implementation of advanced IT solutions, like integrated customer/suppliers information systems, or planning systems and formal knowledge management approaches. In addition, the IT systems found highlighted the possibility of implementing customized IT systems which are not just less expensive but also easier to apply. The need for highly advanced manufacturing technologies was replaced by the characteristics of the companies’ products, as the major part was manufactured through handcraft production.

In general, it can be concluded that SMEs in the CEOM industry particularly considered their workforce and strong network cooperation to be key assets for achieving flexibility and responsiveness, as well as sensing changes.

The need for these enablers is driven by the characteristics of the environment, the so-called agility drivers. The sampled industry hereby particularly highlighted technology and well-educated customers as their ADs, while the competition was neglected. This highlights the inconsistency with the literature, which associates one of the main ADs with the competition. However, the reason for this neglect can be found in the specialization
strategy of the SMEs in the CEOM industry, and thus their focus on core competencies. While the theory furthermore describes a high variety as an AD, it has not been found in the empirical findings. However, it can be assumed that this AD is still apparent in the CEOM industry, due to their highly customized product range. Due to this, it can be concluded that the relevancy of the AM concept is partly confirmed through the occurrence of ADs within the sampled industry. In other words, this means that AM is also relevant for SMEs and that this kind of company indeed is in the position to apply at least the main enablers with regard to the workforce and management. Nevertheless, it is not sufficient just to perceive the ADs and to apply the AMEs in isolated ways. The AM’s main principle is constituted in the integration of all three factors; the people, the organization and technology. In this connection, it is crucial to have a strategic fit between the business and manufacturing strategy. Without this, the benefits of AM cannot be fully exploited. Within this context, the empirical findings showed that this strategic alignment was not given, and thus leaves room for improvements. The change in mind on all levels, namely the management, suppliers and customers is hereby essential.

This change in the mindset is of course only possible if the company’s management, its employees, and its suppliers and customers are aware of the possibilities provided by the AM concept. Therefore, the second research question,

“Is agile manufacturing already unconsciously a part in SMEs in the computer, electronic and optical manufacturing industry in Sweden?”

was aimed at identifying the level of awareness of the AM concept and its enablers. Within this context, it was assumed that even though the SMEs in the CEOM industry in Sweden are using practices which can be identified as AMEs, they are NOT aware of it.

This assumption was completely confirmed as highlighted in the empirical findings and the analysis, as a major part of the interviewed and surveyed managers were not aware of the concept. Furthermore, after providing an explanation of the AM concept, the managers still indicated that this is not an innovative approach, but rather their daily way of doing business. Therefore, the managers perceived themselves as applying their own set of
enablers to respond to change and a turbulent environment. This finding also strongly underpins the first assumption that SMEs can have AMEs in their own suitable fashion.

In short, it can be concluded that the assumptions of this paper were mainly confirmed, as the SMEs in the CEOM industry in Sweden are facing ADs and thus react with the application of AMEs, although without associating them with the AM concept itself, but rather as the only way to survive in a turbulent environment.

However, the authors are convinced that even though SMEs can replace some of the traditional AMEs of the theory through their distinct characteristics and thus, for example, their size and specialized products, the sampled companies should nevertheless be open for some improvements. With regard to this, some flaws were identified among the practices and enablers used by the SMEs in the CEOM industry which could decrease by considering and implementing other AMEs, like IT technologies and formal knowledge management approaches. The usefulness of these tools will be further explained in the recommendation part of this master thesis. Notwithstanding, the choice of the right enabler mix is strongly dependent on the company’s size, its product range and its resources.

The aim of this master thesis was to critically scrutinize the relevancy of AM and the identified AMEs in the CEOM industry. While there is no doubt about the appearance of ADs, and thus the need for AMEs, some of the enablers identified in the SMEs in the CEOM industry need to be complemented or even established. Furthermore, it is crucial to recognize the AM concept, and also the created model within this thesis, as a guideline rather than a best-practice model applicable for each and every company and industry. The capability of the SMEs managers to create the right set of AMEs relies strongly on their capability and willingness to perceive and act on change. Therefore, it is essential to pursue a continuous learning approach by constantly reflecting its own business processes and by being open-minded. Within this context, it cannot be denied that the awareness of theoretical concepts can at least give assistance in finding new solutions and strategies. However, the authors are convinced that most of the concepts should be adjusted to the SMEs distinct characteristics. This approach of continuous learning and development is
also one of the basic principles within the AM theory. This thinking is also apparent in the following quote.

“Unless you try to do something beyond what you have already mastered, you will never grow.”

(Ronald E. Osborn)

Within this context, this master thesis is contributing by providing a model of identified AMEs in SMEs in the CEOM industry. While the authors are by all means aware of the created models’ limitation, this paper provides one of the few attempts to disclose the secret of the relevancy and suitability of the AM concept for SMEs. Hereby, the model provides an illustration about the possibilities and advantages given by the features of SMEs with regard to the AM concept, its relevancy and applicability for SMEs. The master thesis’ practical approach might enhance the appreciation of the AM concept and its’ potential as it provides real-life examples and actually applied practices.

8.1 Recommendations

In the light of the research findings, the practical outcomes for SMEs’ managers should be emphasized as they are the core beneficiaries of this work. As explained in the conclusion, AM is partly present in SMEs, but there is still room for improvements regarding the set of AMEs used. A list of advice for SMEs’ managers can be drawn, which will help them improve their company’s responsiveness, while facing a challenging environment. These recommendations take into account the specific characteristics of SMEs uncovered in the analysis part of this thesis. This list should be seen as a starting point in the strategic reflection towards an AM implementation in SMEs.

First consideration: The technologies

Concerning the technological aspects, one piece of advice is that SMEs should invest more in IT solutions. The authors of this thesis are aware that the sophisticated IT solutions for
the integration between production and information used by large organizations is out of reach for SMEs, due to their scarce financial resources. However, as highlighted in multiple interviews, nowadays there exists a wide range of solutions dedicated to SMEs. Consequently, managers should consider implementing mid-size IT solutions to improve their flow of information. For instance, devices such as SME-customized ERPs, stock-keeping systems or CRMs are assumed to improve their responsiveness to change and their perspective of future growth.

In case of the implementation of sophisticated IT solutions, the authors recommend the training or the hiring of IT workers in order to achieve a better implementation. The return of IT investment is assumed to be higher if employees receive training about these technologies. A better understanding of IT systems would also improve the understanding of the different offers in the marketplace, which would lead to more cost-efficient investments.

Concerning the manufacturing technologies, the authors of this paper recommend that SMEs “stick to their strategy”, and thus not to invest in automation devices. It seems to be unnecessary, due to their customized and handcraft production approach. It can be assumed that automated production lines would instead slow down the change process in SMEs, since they mainly produce small batches of customer-specific products. SMEs’ managers should rather invest in increasing the modularity of their products. Through this, a higher level of generic components could be stocked and therefore a shorter product lead time would be achieved.

In addition, companies should focus on their core competencies, and thus be open to outsourcing strategies as it was shown in the data collected. Other SMEs in different industries should consider rethinking their business around their expertise skills, as these activities are the ones where the return in investment is the highest. This should also lead to an increased flexibility, as part of the manufacturing process would not be done in-house. Within this context, it is nevertheless of high importance that the SMEs keep a close and long-term relationship with their suppliers to ensure flexibility and high quality standards. In other words, it is important to integrate the outsourced supplier too, due to the fact that
these suppliers can also be a pool of ideas and knowledge. Furthermore, they are crucial for a smooth business process.

**Second consideration: The human resources**

Regarding the human resources, SMEs appear to already have a very flexible workforce. However, this flexibility can be improved by reducing the dependency on key employees with the creation of contingency plans and an intensification of the cross-functional training for employees in case of sick leaves or such events. Considering their limited resources, companies should develop a pool of external personnel to tap from, like freelancers or temporary workers. In other words, the potential consequences of losing key employees or having capacity shortage should entitle a good management team to be proactive rather than passive to these events.

Another big concern that arose in the analysis and the discussion was the lack of formalized knowledge management processes. SMEs lack the documentation side of the knowledge transfer. The externalization of the best-practices knowledge acquired with the experience accumulated in the employees should be documented and available to every employee in the organization. This process, although time-consuming, would allow a reflection of the best-practices in an organization and furthermore, would facilitate their internalization by new team members. This, together with the intense knowledge transfer by socialization of the members, is assumed to have the potential to enhance the substitutability and therefore the resilience of organizations.

**Third consideration: The management resources**

A major recommendation for SMEs would be the improvement of their strategic vision and thus the alignment of their business and manufacturing strategies. It is crucial for SMEs to develop a coherent strategic approach on how AM should be implemented to enhance its efficiency. In order to define these requirements, managers and leaders must critically analyze their business processes with regard to AM. There the model developed in this paper and the checklist from figure 4 provide practical analysis tools to capture the company’s big picture, and thus its current business processes and possibilities for
improvement. However, it is important that the companies develop their own model with the different enablers present in their organization. From that, managers would be empowered to choose the most appropriate AMEs, taking into account their own needs. Once this gap analysis is done, managers should spread their AM vision using the informal channels of communication, in order to create a new company mindset. Within this context, managers should also be open to scientific articles, in order to become familiar with possible new concepts and methods, and thus to maintain a continuous learning approach, not just from inside the “extended company” but also from external sources. Nevertheless, it is also important to note that the abstractness from the real-life practices of most of the scientific literature might impede the understanding of these concepts.

8.2 Further Research

Considering the genuine interest in our research by the SMEs’ managers from the CEOM industry in Sweden, it is believed that SMEs’ AM deserves further investigations.

As a matter of fact, the authors of this paper are well aware of the generalizability issues raised in the methodology part. The choice made to focus on a single industry and a single country restrains the expandability of the conclusions. Therefore it would be interesting to compare the findings at a wider scope with a comparative analysis with different industries and perhaps different countries. Replication researches on a similar basis than this one are therefore encouraged in order to challenge our contributions.

It would also be of scientific relevance to expand the scope of the empirical data collected in the survey and to scrutinize it with quantitative analysis tools such as factor analysis or regression analysis. Such methods would underline patterns and causality which are impossible to find with a hermeneutic approach.

In addition, the performance outcome of AM for SMEs would provide managers with an idea of how much they can really benefit from implementing it. From that, they would be
able to evaluate the appropriate level of investments in order to improve the company performance without harming their financial results.

Finally, it would be of great interest to research the impact of the company size on AM. The understanding of the relation between agility and company size would enable managers to determine the appropriate AMEs for their size, in order to yield the maximum benefits of personal relationships with employees, suppliers and customers. This approach would maximize the integration of production and information.
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Assessed the 2011/03/25


### Appendix 1 – SMEs in Sweden - Basic Figures

<table>
<thead>
<tr>
<th>Enterprises</th>
<th>Sweden</th>
<th>EU-27</th>
<th>Sweden</th>
<th>EU-27</th>
<th>Sweden</th>
<th>EU-27</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Share</td>
<td>Share</td>
<td>Number</td>
<td>Share</td>
<td>Share</td>
</tr>
<tr>
<td>Micro</td>
<td>523,126</td>
<td>94.2%</td>
<td>91.8%</td>
<td>685,631</td>
<td>24.7%</td>
<td>29.7%</td>
</tr>
<tr>
<td>Small</td>
<td>26,486</td>
<td>4.8%</td>
<td>6.9%</td>
<td>578,795</td>
<td>20.9%</td>
<td>20.7%</td>
</tr>
<tr>
<td>Medium-sized</td>
<td>4,661</td>
<td>0.8%</td>
<td>1.1%</td>
<td>501,667</td>
<td>18.1%</td>
<td>17.0%</td>
</tr>
<tr>
<td>SMEs</td>
<td>554,273</td>
<td>99.8%</td>
<td>99.8%</td>
<td>1,766,093</td>
<td>63.7%</td>
<td>67.4%</td>
</tr>
<tr>
<td>Large</td>
<td>968</td>
<td>0.2%</td>
<td>0.2%</td>
<td>1,005,178</td>
<td>36.3%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Total</td>
<td>555,241</td>
<td>100.0%</td>
<td>100.0%</td>
<td>2,771,271</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value added</th>
<th>Sweden</th>
<th>EU-27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billion €</td>
<td>Number</td>
<td>Share</td>
</tr>
<tr>
<td>37</td>
<td>20.2%</td>
<td>21.0%</td>
</tr>
<tr>
<td>32</td>
<td>17.8%</td>
<td>18.9%</td>
</tr>
<tr>
<td>33</td>
<td>18.0%</td>
<td>19.0%</td>
</tr>
<tr>
<td>101</td>
<td>55.8%</td>
<td>57.9%</td>
</tr>
<tr>
<td>60</td>
<td>44.2%</td>
<td>42.1%</td>
</tr>
<tr>
<td>181</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Data refer to the non-financial business economy (NACE C-I, K) and represent estimates for 2008. The estimates have been developed by EIM Business and Policy Research, based on 2006 Eurostat Structural Business Statistics figures.

(Source: European Commission, 2009)
### Appendix 2 – Company Profiles of the interviewed SMEs

<table>
<thead>
<tr>
<th>Name: Company A</th>
<th>Contact person: CEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover (2009): Approximately 4.760.000 Euro</td>
<td></td>
</tr>
<tr>
<td>Employees: 25-50</td>
<td></td>
</tr>
<tr>
<td>Brief description: Contract manufacturer of electronic and electromechanical equipment covering the production of prototypes as well as series production by using handcraft as well as mechanical assembly.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name: Company B</th>
<th>Contact person: CEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover (2009): Approximately 1.456.000 Euro</td>
<td></td>
</tr>
<tr>
<td>Employees: 10-25</td>
<td></td>
</tr>
<tr>
<td>Brief description: Designer and manufacturer of a wide range of standardized integrated circuit components as well as customized applications.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name: Company C</th>
<th>Contact person: CEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover (2009): Approximately 3.625.000 Euro</td>
<td></td>
</tr>
<tr>
<td>Employees: 10-25</td>
<td></td>
</tr>
<tr>
<td>Brief description: Designer and manufacturer of harness systems and standard cable products as well as the production and design of prototypes and complete solutions.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name: Company D</th>
<th>Contact person: CEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover (2009): Approximately 2.632.000 Euro</td>
<td></td>
</tr>
<tr>
<td>Employees: 25-50</td>
<td></td>
</tr>
<tr>
<td>Brief description: Developer and manufacturer of markets equipment for handling of lubricants as well as whole lubricants systems and components.</td>
<td></td>
</tr>
<tr>
<td>Name:</td>
<td>Company E</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Contact person:</td>
<td>Production Manager</td>
</tr>
<tr>
<td>Turnover (2009):</td>
<td>Approximately 4.401.000 Euro</td>
</tr>
<tr>
<td>Employees:</td>
<td>25-50</td>
</tr>
<tr>
<td>Brief description:</td>
<td>Developer and manufacturer of standardized and customized leak detection instruments, machines and systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name:</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact person:</td>
<td>Development Manager</td>
</tr>
<tr>
<td>Turnover (2010):</td>
<td>Approximately 6.602.000 Euro</td>
</tr>
<tr>
<td>Employees:</td>
<td>25-50</td>
</tr>
<tr>
<td>Brief description:</td>
<td>Developer and manufacturer of products and technologies for Digital TV and cable TV for all distribution types (professional and home use).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name:</th>
<th>Company G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact person:</td>
<td>Production Manager</td>
</tr>
<tr>
<td>Turnover (2009):</td>
<td>Approximately 3.117.000 Euro</td>
</tr>
<tr>
<td>Employees:</td>
<td>10-25</td>
</tr>
<tr>
<td>Brief description:</td>
<td>Manufacturer of flow monitors and meters.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name:</th>
<th>Company H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact person:</td>
<td>CEO</td>
</tr>
<tr>
<td>Turnover (2009):</td>
<td>Approximately 5.481.000 Euro</td>
</tr>
<tr>
<td>Employees:</td>
<td>10-25</td>
</tr>
<tr>
<td>Brief description:</td>
<td>Developer and manufacturer of systems for quality and production control.</td>
</tr>
</tbody>
</table>

* All the companies are independent.
* Due to anonymity reasons the company profiles are intended to be short.
Appendix 3 – Interview Questions

Turbulent Environment

In what way is your company dealing with a turbulent environment and well-informed customers?
We want to find out:
• What are these abilities?
• Why did you choose them?
• How are you sensing, perceiving and anticipating changes?
• Would you describe your workforce as flexible and if so, why?

Company Strategy

In what way do you approach your customers compared to your competitors?
We want to find out:
• What are the principles of your competitive strategy?
• Is efficiency and responsiveness of same importance?

In what way do you link your manufacturing strategy & competitive strategy?
We want to find out:
- How is your manufacturing integrated within the organization?

How would you describe your main manufacturing strategies? And how would you perceive your responsiveness and flexibility hereby?
We want to find out:
• What are the main manufacturing strategies and policies (“best practices”)

Advantages/Disadvantages of SME

In what way do you consider SMEs are holding advantages/disadvantages with regard to responsiveness?

What would you say are the key strengths of your company with regard to responsiveness?

Importance of Investments

Many authors claim that being responsive to the environment is strongly related with high cost investments. Do you agree? Why do you think so?
- What was your last investment you did to enhance flexibility/ responsiveness?
Influence and decision-making

Could you please explain the decision-making process in your company?
We want to find out:
- Who is influencing the decision-making process?
- How is the co-operation between parties (internal & external)? Enhancement through IT?

In what way would you perceive the importance in understanding the customer requirements? Why do you think so?

Importance of Cooperation & Networks

Could you please elaborate your thinking/experience with temporary alliances and partnerships?
We want to find out:
- Is it supporting your flexibility and responsiveness of your company and SMEs in general? Or do you see networks as a threat for your independency?

Relevance of the Agile Manufacturing Concept

Now as we explained the approach of agility and agile manufacturing, do you think it is feasible for SMEs and in what ways? To what degree do you think it is an innovative approach?
We want to find out:
- Are they necessary or would you say that due to your size most of the strategies are redundant or can be passed by?
- Would you say that as a SME you need the same strategies than large companies?
Appendix 4 - Survey Questions

SMIO Master Program Survey - Verena Dischler and Antoine Hug (Linköping Universitet)

We are two international master students at the Linköping University with a major in strategic management in international organizations.

For the empirical part of our master thesis, we need to conduct an online survey to learn about your company’s approach with regard to responsiveness and adaptability in a fast-changing environment. The time to fill survey is estimated to no longer than 10 minutes. As we are short of time we would like you to return your answers by the 15th of April. In return for your time and co-operation, we will of course provide you with the result of our analysis.

We also emphasize that this research is:
#Purely and entirely academic
#Really quick to complete
#Completely confidential
#Not having any commercial interest

Your participation, experience and contribution will not just be of great help for our master thesis but will also give us a great opportunity to gather insights from empirical examples.

Thank you in advance for your time and co-operation.

With best regards,

Verena Dischler and Antoine Hug

* Required

How many employees does your company directly employ? *
(excluding subsidiaries)
• <10
• 10-25
• 25-50
• 50-100
• 100-250
• >250

Is your company’s turnover below 50 million Euros or your annual balance sheet total not exceeding 43 million Euros *
(excluding subsidiaries)
• Yes
• No

What is your function as an employee in your organization? *
(For example: managing director, production director…)

What is the name of your company? *
How would you describe the customer demand and the technology development in your industry?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

What are your key assets in reacting to a fast changing market?
Please tick maximum three boxes
- Close relationship to customers
- Skilled and experienced workforce
- Cross functional co-operation between departments
- Quick decision process
- Continuous product development
- IT systems (ERP, CRM, Computer aided production...)
- Co-operation with suppliers
- Market information (e.g Fairs, meetings...)
- Focus/Specialization
- No ability to react to a fast changing environment
- Other:

How flexible is your organization with regard to these elements?

<table>
<thead>
<tr>
<th></th>
<th>Most Flexible</th>
<th>Flexible</th>
<th>A little bit flexible</th>
<th>Unflexible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your network</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Your employees</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Your strategy</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Your products</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Your stock</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

What IT solutions do you use dominantly in your organization? Please tick maximum three boxes
- Email
- Databases
- ERP (Enterprise Resource Planning)
- CRM (Customer Relationship Management)
- MRP (Material Requirement Planning)
- Computer aided design
- Customized IT Solutions for small and medium companies
- No IT solution
- Other:
What is the focus of your strategy compared to your competitors?
Please tick maximum three boxes
• Price
• Quality
• Flexibility
• Service
• Long term relationship and collaboration
• Personal relationship
• No particular approach to customer
• Other:

What are your core manufacturing strategies?
Please tick maximum two boxes
• Lean manufacturing
• Flexible manufacturing
• Focus/specialization on core products
• Just-in-time manufacturing
• Integration of the workforce
• Total quality management
• No particular strategy
• Other:

What do you consider to be the biggest advantages of being of small or medium size?
Please tick maximum three boxes
• Flexibility
• Personal relationship to customers
• Personal relationship to suppliers
• Committed workforce
• Expertise in the area
• Flat hierarchy
• Informal communication
• Trust
• Multi-tasks workforce
• No advantages
• Other:

What do you see as the key disadvantages of being of small or medium size?
Please tick maximum three boxes
• Difficulties to make long term planning
• Bargaining disadvantages with partners
• Difficult to capture the big picture
• Lack of financial resources
• Manufacturing capacity
• R&D resources
• Dependence on key employees
• Lack of capabilities
• No disadvantages
• Other:
Please explain your major arguments to agree with the statement: "lacking financial resources does NOT mean an impossibility to be flexible."

How would you describe the decision making process in your company?
- Formal
- Informal
- Mix of informal and formal communications
- Other:

Who do you think are the most influencing actors in the decision making process of your company?
Please tick maximum three boxes
- Employees
- Owners
- Department heads
- Consultants
- Suppliers
- Customers
- Other:

Is knowledge management crucial in your company?
- Yes
- No

How do you insure knowledge acquisition in your company?
Possibility to tick more than one box
- Co-operation with partners
- Co-operation between departments
- Training
- Academic/professional literature
- Other:

Are you aware of what "Agile Manufacturing" is? If yes, please explain what it means to you.

According to Goldman (1995), agile manufacturing is: "a new manufacturing concept aiming at enriching the customer, cooperating to enhance competitiveness, organising to master changes and leveraging the impact of people and information". Do you think it is really something new?
- Yes
- No

Any comments or questions?
## Appendix 5 – Agile Manufacturing vs. Lean Manufacturing

(Source: Yusuf and Adeleye, 2002, p. 4548)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Agile</th>
<th>Lean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Fast-moving market suitable for sequential production</td>
<td>Traditional market best suited for batch production</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Agile factories retool flexible equipment for different products</td>
<td>Lean factories produce consistent products</td>
</tr>
<tr>
<td>Production</td>
<td>Agile factories focus on continuous improvement for better efficiency</td>
<td>Lean factories emphasize efficiency by reducing waste</td>
</tr>
<tr>
<td>Technology</td>
<td>Agile technology embraces change and innovation</td>
<td>Lean technology maintains stability and efficiency</td>
</tr>
<tr>
<td>Productivity</td>
<td>Agile factories maximize productivity by reducing cycle time</td>
<td>Lean factories optimize productivity with focus on efficiency</td>
</tr>
<tr>
<td>Quality</td>
<td>Agile factories use computer-aided design (CAD) and other technologies</td>
<td>Lean factories use traditional methods</td>
</tr>
<tr>
<td>Costs</td>
<td>Agile factories minimize costs by maximizing productivity</td>
<td>Lean factories control costs with emphasis on efficiency</td>
</tr>
<tr>
<td>Environment</td>
<td>Agile factories focus on sustainability</td>
<td>Lean factories emphasize efficiency by reducing costs</td>
</tr>
<tr>
<td>Safety</td>
<td>Agile factories prioritize safety and environmental protection</td>
<td>Lean factories control safety with focus on efficiency</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Agile factories focus on sustainability</td>
<td>Lean factories control costs with emphasis on efficiency</td>
</tr>
</tbody>
</table>

(For a more detailed comparison, see the original source.)