

Industry 4.0: The role of small and medium-sized enterprises in Germany

Indústria 4.0: O papel das pequenas e médias empresas na Alemanha

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Abstract

Purposes: In the present study, the concepts inherent to Industry 4.0 and Mittelstand will be initially defined in a clear way, for a better understanding of the context under analysis. Afterwards, the current situation of Industry 4.0 in the German SME sector will be evaluated, presenting as results the respective inherent challenges and opportunities. In this follow-up, the research will conclude whether the concept of Industry 4.0 can represent a key success factor for the SME sector in Germany.

Methodology: The data analysis in the present research are based on a bibliographic review and an analysis of statistical data, seeking to represent a combination of quantitative and qualitative approaches.

Results: The challenges analyzed and discussed may be a possible justification for a slow reversal of traditional production processes for Industry 4.0. However, the numerous opportunities and their high implementation potential are preponderant for the adoption of the 4.0 industry in the production processes of the future.

Conclusions: This research shows that currently, there is still a high percentage of companies in the German SME sector that have not implemented Industry 4.0. However, the opportunities presented throughout the study, overcome the possible challenges posed in this context, as Industry 4.0 can considerably increase the profitability and efficiency of production as well as the overall competitiveness of the organization.

Keywords: digitization; industry 4.0; mittelstand; SME.

1 INTRODUCTION

Currently, the "digitalization" concept represents one of the most discussed topics worldwide regarding the future conceptions of organizational processes (Bittighofer, Dust, Irslinger, Liebich, & Martin, 2018). Considering the constant changes and innovations motivated by the new technological developments, there will be a revolution of the traditionalist structures driven by the digital world (Feng, 2017).

The digitalization concept represents the context of the fourth industrial revolution, being also called Industry 4.0, where the digital changes are recognized as preponderant in the production sector (Bittighofer, Dust, Irslinger, Liebich, & Martin, 2018). The productive processes, as we know them today, are largely more efficient and effective due to the introduction of Industry 4.0 in the sector, through changes in the technological level, organizational structures, strategies and business models, which allows organizations to respond more adequately to changes in today's highly competitive market (Feng, 2017). This technological trend provides various advantages especially to SME's, which are usually characterized in a more traditional way, adding great potential for future business (Bahrin, Othman, Azli, & Talib, 2016), being possible to identify enormous opportunities and, on the other hand, several challenges, which will be discussed later in this article.

Germany has the sixth highest Gross Domestic Product in the European Union with 56,305 US dollars/capita, significantly above the OECD average (Organisation for Economic Co-operation and Development, 2020). Data from SME's in Germany (2018) indicate a total of 2,522,890 companies representing 99,5% of the German business fabric. However, the number of SME's, employees and value added in Germany is lower than the European Union

average (European Commission, 2019). Thus, it becomes predominant to understand the role of Industry 4.0 in German SME's.

In this article, a literature review and statistical data analysis will be used as a research methodology. Initially, the concepts of Industry 4.0 and Mittelstand will be analyzed and defined for a better understanding of the subject under study. Then, the current situation of Industry 4.0 in the German SME sector will be analysed. Based on the results, opportunities and challenges will be discussed. In this way, the respective conclusions will be established to assess whether the concept of Industry 4.0 can be successful in the SME sector in Germany.

2 LITERATURE REVIEW

2.1. Concepts

2.1.1 Industry 4.0

The concept of Industry 4.0 was first presented during the Hanover Fair in 2011, representing a German strategic initiative for a digital revolution in the manufacturing sector (Xu, Xu, & Li, 2018; Bauer, Schlund, Hornung, & Schuler, 2018). Thus, this concept can be considered the fourth industrial revolution, oriented towards intelligent digitalization and automation of products and processes along the value chain (Bauer, Schlund, Hornung, & Schuler, 2018). In addition, it allows the connection and link between real and digital production, where products, facilities, human resources and objects are combined through an intelligent system operated through a software (Bauer, Schlund, Hornung, & Schuler, 2018). In this course, Industry 4.0 can be understood as the integration of complex physical machinery with networked sensors and software, with the aim of predicting, controlling and planning better

overall results (Lu, 2017).

However, according to the authors Lasi, Kemper, Fettke, Feld, & Hoffmann (2014), defining the concept in a broader sense leads to an intelligent industrial production using the combination of Internet benefits and new technological developments, which will provide a change in the paradigm of today's industrial production.

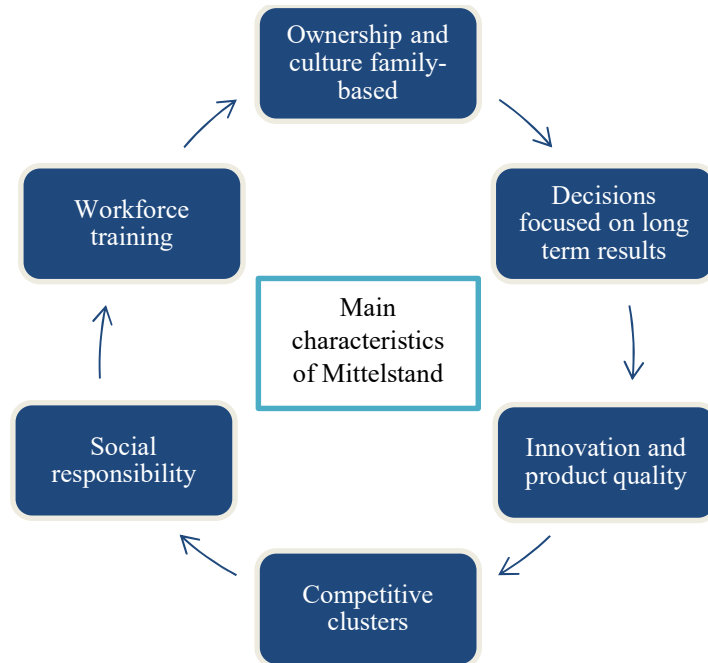
2.1.2 Mittelstand

The German economy is fundamentally supported by companies called Mittelstand, where the concept has been introduced in Germany since World War II (Parella & Hernández, 2018). According to the authors Massis, Audretsch, Uhlaner, & Kammerlander (2018), Mittelstand concept “is widely recognized as connoting a subset of private German enterprises internationally known for their quality and innovation.”

However, its excessive use in the media has led to a less clear definition of the concept. Mittelstand can thus identify a German company, usually small to medium sized, controlled and owned by a family, which is an agent in the global market and, assumed as a Mittelstand (Massis, Audretsch, Uhlaner, & Kammerlander, 2018).

But what are the criteria that distinguish a SME from a Mittelstand? While SME's are defined through criteria related to their size, Mittelstand is characterized by the specific structure of ownership and company management (Welter, 2018). The figure below identifies the main characteristics of the Mittelstand.

Figure 1: Main characteristics of Mittelstand.



Font: Parella & Hernández (2018).

Very often the German Mittelstand is a world market leader in a small niche market and therefore being called Hidden Champions. The Hidden Champions “are leading companies of medium size, highly internationalized, technified and strongly linked to the territory” (Parella & Hernández, 2018). In this regard, they represent an important part of the internationally successful German industry (Ludwig, et al., 2016), given that “the overall market share of German companies in that segment is 48%” (Parella & Hernández, 2018). A main part of the national value-added is produced by companies from the Mittelstand (Becker, Ulrich, & Botzkowski, 2017).

A company can be called “Mittelstand” when it has less than 500 workers and annual

revenues of under 50 million Euro (Goeke, 2008; Parella & Hernández, 2018). Data from SME's in Germany (2018) indicate a total of 2,522,890 companies representing 99,5% of the country's economy (European Commission, 2019). The authors Parella & Hernández (2018) add that 99% of German companies are Mittelstand and these are responsible for 68% of German exports.

2.2. Current Status

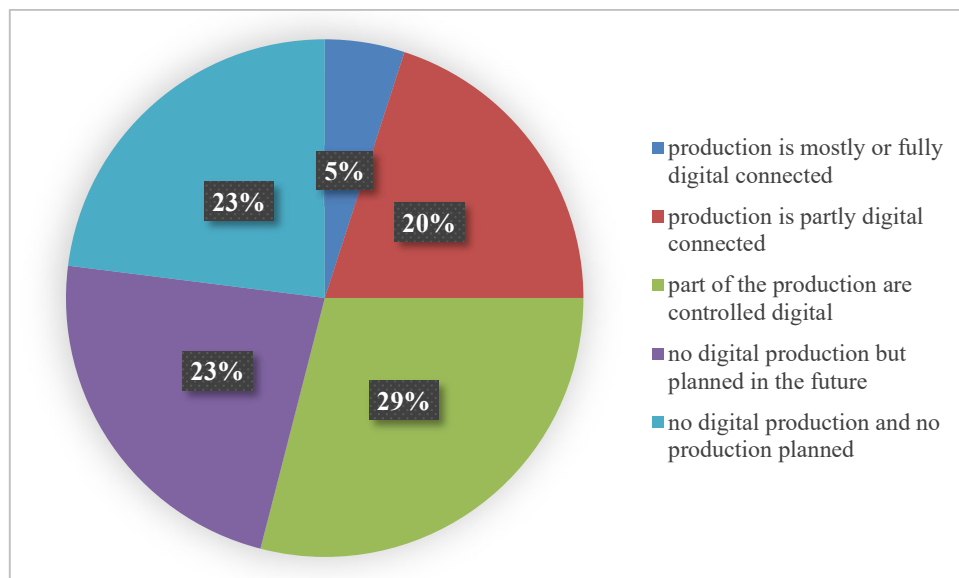
Following the review and analysis of the concepts of Industry 4.0 and Mittelstand, it is necessary to establish their interconnection. Most SME's are overloaded, which does not allow them to have access to the time needed to consider revolutionary changes. SME's strategy is often based on flexibility, responsiveness and proximity to their current and potential customers. In this sense, it is essential that SME's constantly improve their industrial processes. Although Industry 4.0 can be considered expensive and difficult to implement, its benefits represent added value for these organizations, as they increase flexibility by decentralizing information and decision-making processes (Galati & Bigliardi, 2019). The authors Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray (2018), add that the Industry 4.0 strategy implemented in a SME, allows the connection between business partners, as it enhances the synchronization of flows and customization of different products.

The literature points out that Industry 4.0 is considered fundamental for German Mittelstand. According to the authors Niemann & Donatelli (2018), more than 90% of the companies surveyed do not see digitalization as a threat, but rather as an opportunity to enhance their processes and offer new products and services. In addition, 74% of the organizations highlight the opportunity to expand and conquer new markets.

These facts underline that the management is aware of the future importance of Industry 4.0, but have they already implemented the new digitalized production in their company?

The data highlights that the management of these organizations are aware of the importance of Industry 4.0 concept. However, it is essential to evaluate the degree of implementation of digitized production in organizations. In the graphic below are present the results of the levels of connected digital production.

Graphic 1: Levels of digital connected production.



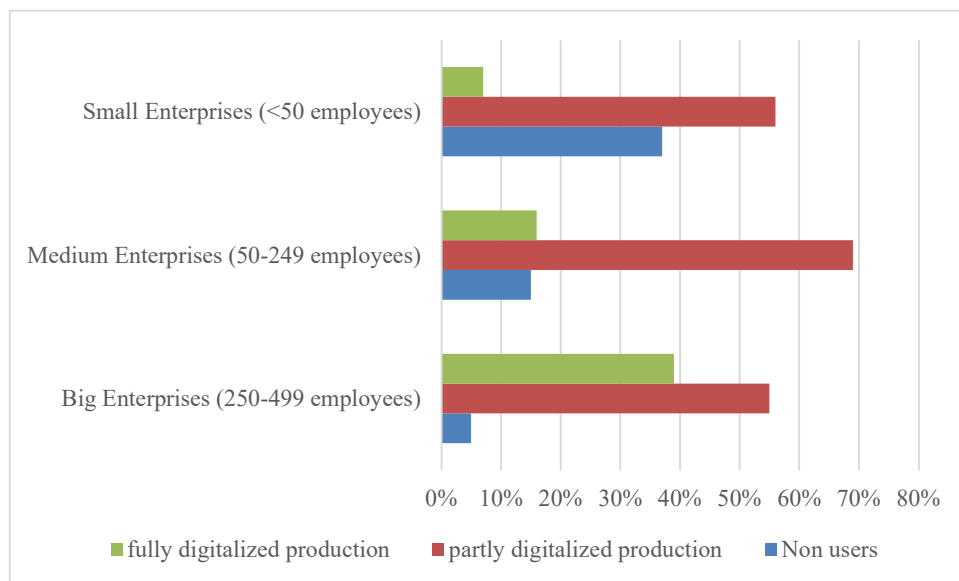
Font: Marbler & Bley (2018).

Following the assessment of the current state of digital production by German SME's, a survey was conducted by Ernst & Young in 2018. The results in graphic 1 indicate that 5% of SME's surveyed declared that their production is almost or totally digitally connected, followed by 20% of companies that indicate that they are mostly digitally connected. However, 46% of the companies declared that they have not integrated any digitalization, but are planning to do

so or have nothing planned (Marbler & Bley, 2018).

The survey also shows that almost half of all SME's surveyed do not use any type of digitalized production in their company, which refers us to the investigation of a potential justification for the current state. According to the analysis of graphic 2, it can be seen that the level of digitalization is dependent on the size of the company.

Graphic 1: Level of digitalization by company size.



Font: Lerch, Jäger, & Maloca (2017).

The analysis of graphic 2 shows that there is a significant difference between the different sizes of companies. In general, large companies have a greater willingness to introduce Industry 4.0 in their production than small and medium enterprises, since almost 40% of large companies are using digitalized production (Lerch, Jäger, & Maloca, 2017).

Another important aspect of digital production is the existence of a worldwide customer base. In this sense, the percentage of digitalization increases proportionally with a larger sales market. Thus, companies operating globally face more intense competition and are therefore forced to keep their production as efficient as possible (Zimmermann, 2018).

At this moment, companies are aware of the need for innovation and change for Industry 4.0, however, only the largest companies have invested in digital production. However, approximately 50% of all SME's have not invested in new technology. In this sense, SME's have to define new strategies to keep up with the current technological evolution, in order not to be disadvantaged in the world market. The companies that have already invested in Industry 4.0 have been mainly forced by global competition or customer demands.

3 METHODOLOGY

This study is intended to evaluate the current situation of Industry 4.0 in the German SME sector. The analysis of this research data is based on a combination of quantitative and qualitative approaches, in which researchers obtained the data in the form of statistical data and literature review.

4 RESULTS AND DISCUSSION

4.1. Challenges

4.1.1 Economic Challenges

The Industry 4.0 implementation is linked to considerable economic and financial decisions. In this sense, the development of automated processes and procedures or the establishment of reliable networks, require that the return on investment be compensated as soon as possible (Mittal, Khan, Romero, & Wuest, 2018).

The return on investment must be carefully calculated so that the great opportunities do not turn into considerable risks for the organization (Müller, Buliga, & Voigt, 2018). Each organization should analyze and evaluate whether its products and business model are up to date for a successful implementation of Industry 4.0 (Braun, 2017).

4.1.2 Data Protection and IT Security

Data security is considered another major challenge for the implementation of the Industry 4.0 concept. In the current reality, there are large volumes of data in network connections, through various technologies and devices, and it is necessary to highlight technical vulnerabilities and computer attacks (Braun, 2017).

The authors Mittal, Khan, Romero, & Wuest (2018) point out that so far many German SME's are not highly networked and familiar with the computer security of their networks. In this context, it is necessary to highlight the role of the IT partners, since any error in this area involves considerable costs and losses (Feng, 2017).

4.1.3 Stakeholders Acceptance

The acceptance of the Industry 4.0 concept by all the organization's stakeholders is fundamental to its success, being particularly relevant the role of its employees (Önday, 2018). In this sense, it is necessary to emphasize that employees need to receive new training to take on new areas and functions and to adapt to the new working environment (Ludwig, et al., 2016).

In addition to the challenges inherent to the organization's employees, it is necessary to ensure the adaptation of current and future clients (Mittal, Khan, Romero, & Wuest, 2018). The SME should consider that some customers are satisfied with the current products and services and do not want a modernization of the organization (Ludwig, et al., 2016).

The author Feng (2017) highlights that before implementing the digitalization of production processes, an acceptance test should be carried out previously to the different stakeholders, to analyze and evaluate the added value of a possible conversion to Industry 4.0.

4.1.4 Implementation and Expectations

Any implementation introduced in an unplanned manner is a challenge and may even call into question its success. In this sense, besides the need to plan the implementation of the concept with the human resources of the organization, it is also necessary to plan the production processes and the acceptance of the different stakeholders (Bittighofer, Dust, Irslinger, Liebich, & Martin, 2018). The planning of the implementation of Industry 4.0 in an organization should consider its objectives and the results obtained and not only implement tools quickly (Muhuri, Shukla, & Abraham, 2019).

In addition, expectations should not be too high, but appropriate to the situation and real

goals (Önday, 2018). In the context of implementing this strategy in an SME, an adjusted and correct time management is necessary, which represents for the managers a sensitive point in a highly competitive market (Mittal, Khan, Romero, & Wuest, 2018).

4.2. Opportunities

4.2.1 Higher Production and Resources Efficiency

The digitalization of processes and value chains of SME's can improve their different areas of value creation (Önday, 2018). In this sense, it becomes possible to reduce redundancies in the process models, minimize quality losses, increase transparency in the area of planning and capacity utilization (Ludwig, et al., 2016).

Digitalization also allows a better functioning of the processes in network, which provides a better organization and allows to reach higher productivity gains (Braun, 2017). The data provides immediate information on how to accelerate production and which elements are using too much time and resources. Similarly, employees can be alerted to carry out necessary maintenance and repairs to the equipment (Bahrin, Othman, Azli, & Talib, 2016).

4.2.2 New Digital Business Models

In the course of Industry 4.0, traditional business models will be changed, giving way to new digital business models, being possible to increase the benefits for current and future customers, offering value-added solutions (Ludwig, et al., 2016).

The data collected by the organizations in the current context are fundamental for their development, as they can be reported to the manufacturer to introduce improvements to the products or can be used in the scope of additional services (Ancarani, Mauro, & Mascali, 2019).

The author Braun (2017) adds that the data allow SME's to develop complementary services and new combinations of products and services, such as remote access in support of telecommunications networks. Consequently, remote access deconstructs the need to be physically present in the organization's facilities, which allows services to be provided more quickly, with lower costs and effort (Önday, 2018).

4.2.3 Flexibility and Individualized Production

The networking of all the components of the process promotes the creation of a high flexibility and allows an individualized and, at the same time, accessible production (Feng, 2017). The trend towards individuality is especially noticeable in SME's according to Feng (2017).

The introduction of Industry 4.0 takes away the concept of mass production to reduce production costs. In this new production paradigm, customer needs or the introduction of improvements can be more easily integrated into production, without associated losses (Ludwig, et al., 2016). Consequently, there are significant advantages for customers, as well as for the manufacturer, since the data collected allows access anywhere and at any time (Bittighofer, Dust, Irslinger, Liebich, & Martin, 2018).

4.2.4 Process Optimization

Transparency in organizations is fundamental for the improvement of product processes and for smaller decision making processes. In this context, data analysis is essential for the successful implementation of Industry 4.0.

The collection and analysis of data over longer periods of time allows detailed

predictions to be made about the behaviour of different components, which allows an early view of situations that may directly influence the processes (Braun, 2017). In the context of process optimization, maintenance of components and equipment can be scheduled before failures occur, replacement components can be ordered in advance and consequently downtimes can be avoided (Bittighofer, Dust, Irslinger, Liebich, & Martin, 2018). Employees also play a key role in the optimization processes, since obtaining important information and data about the equipment allows all levels and production sites to benefit from the information transmitted to human resources (Bahrin, Othman, Azli, & Talib, 2016).

5 CONCLUDING REMARKS

Industry 4.0 allows the networking of various production processes in SME's. As evidenced by this study, so far there is still a high percentage of companies in the German SME sector that have not implemented Industry 4.0.

The challenges analyzed and discussed above may be a possible justification for a slow reversal of traditional production processes for Industry 4.0, together with resistance to change by entrepreneurs.

However, in the future, the numerous opportunities and great potential will be essential arguments to follow the 4.0 trend that we presented in this article. Undoubtedly, Industry 4.0 can significantly increase the profitability and efficiency of production, as well as the competitiveness of the organization.

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