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Industry 4.0 Readiness in Electrical Companies: Analysing Product Manufacturing and Communication in the Customer and Supplier Chain

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Abstract: This study examines the readiness of electrical companies to adopt Industry 4.0 principles, focusing on the degree of product customization and communication practices within customer and supply chains. Using a questionnaire survey via GoogleForms, data was collected from 28 companies in the electrical industry. The results showed that 63% of companies offer full product customization, indicating advanced technology integration, while 23% of companies only allow partial customization, indicating a transitional phase towards Industry 4.0 adoption. However, 14% stick to fixed product portfolios, reflecting limited flexibility and readiness for digital transformation. The communication analysis further revealed that most companies still rely on traditional methods such as electronic and telephone communication to interact with suppliers and customers, with only 10% achieving fully automated digital integration. This study highlights significant gaps in digitalisation and provides useful insights in terms of technology adoption and communication strategies in line with Industry 4.0 principles.

Keywords: communication; customer; Industry 4.0; product; readiness; supplier chain

1 INTRODUCTION

The Industry 4.0 concept is a revolutionary approach to manufacturing processes that combines digital technology, automation and intelligent systems to achieve greater flexibility, efficiency and personalization. A key aspect of this revolution is the individualisation of products and production, which is closely linked to communication between customers, suppliers and society. Industry 4.0 leverages technologies such as the Internet of Things (IoT), artificial intelligence (AI) and machine learning, cloud computing and big data to enable efficient data collection and analysis, quality management automation and predictive maintenance. These technologies enable efficient processing and analysis of large volumes of data, leading to a better understanding of not only manufacturing processes, but can be used to identify customer preferences. [1] In fact, digital platforms and technologies enable direct communication with customers, leading precisely to a better understanding of their needs and preferences. In addition, the technologies allow for better integration of suppliers into the production process, leading to faster and more efficient product delivery. However, the implementation of these technologies is associated with significant economic costs and, at the same time, the increasing volume of production data increases the need to ensure adequate security measures to protect this information from unauthorised access. Although the transition to Industry 4.0 requires significant investment in new technologies and employee training, it offers companies the opportunity to become more competitive, flexible and customer-oriented. [2]

For these reasons, the aim of the publication was to determine the readiness of enterprises for this concept in terms of the degree of individualisation of products and production and the way in which enterprises communicate with customers and suppliers. Electrical companies operating in the Czech Republic were selected for the research for several reasons. These enterprises are often at the cutting edge of innovation as they are closely linked to the development and application of advanced technologies. In addition, they depend on precise and fast production processes and can therefore benefit most from the innovations associated with Industry 4.0. The electronics sector also faces increasing competition and changing customer demands, which requires the adaptability and flexibility that Industry 4.0 can provide. In addition, businesses in this sector must address safety and sustainability issues, which are also key aspects in implementing the concept. So by examining the readiness of these businesses for Industry 4.0, their needs can be better understood and areas for improvement identified. In contrast to other studies already conducted, this publication offers unique empirical data obtained directly from companies operating in the electrical industry in the Czech Republic. These data provide valuable insights into the manifestation of Industry 4.0 in this specific sector and region, allowing for a deeper understanding of its impacts and applications in the given context. In this context, the following research questions were set:

- Question 1: What is the extent of product and process individualization in electronics manufacturing companies?
- Question 2: How does communication occur within the supplier-customer chain in electrical companies?

2 STATE OF THE ART

The transformation of industrial production in three distinct revolutionary phases has not only fundamentally changed the technological capabilities of production, but has also redefined customer expectations and communication paradigms in the supply and demand chain. This evolution reflects the complex interaction between technological innovation, socio-economic factors and the evolution of market mechanisms, with each industrial epoch bringing

about a specific transformation of the producer-customer relationship; industrial production is currently facing another revolutionary phase that will bring further changes in these areas, as summarised in Tab. 1 below.

Table 1 Comparison of industrial revolutions in terms of communication with customers and suppliers

	Industry 1.0 [3]	Industry 2.0 [4]	Industry 3.0 [5]	Industry 4.0 [6]
Main difference	Craft excellence a local communication networks	Mass production and standardization of communication	Computerisation of production and segmented individualization	Hyper-personalization and integrated communication
Production	Dominated by craft production supplemented by the beginnings of mechanisation	Electrification of production and assembly lines	Computer-controlled manufacturing systems transformed production processes	Characterised by cyber-physical systems and artificial intelligence
Customer expectations	Functionality and durability of products, with personalization being realised through direct interaction with the craftsman	Shifted from artisanal uniqueness to a prioritisation of affordability and product reliability, with personalization taking a back seat	A significant transformation - from acceptance of uniform products to demands for differentiation and market segmentation. Customers have increased their focus on quality and have started to prefer more customised products	Personalised product - manufacturers will be able to anticipate market needs through predictive analysis
Changes in the supply chain	Personal contact or correspondence, with delivery times determined by the physical constraints of transport	The expansion of telegraph and telephone communication accelerated information flows in the supply chain and laid the foundations for global business networks	Communication in the supply chain has undergone a fundamental transformation with the implementation of electronic data exchange, which has eliminated the dependence on paper documentation and manual order processing.	Integrated digital platforms should facilitate an unprecedented level of collaboration between manufacturers and their suppliers through real-time data sharing.

As the table shows, the new revolutionary phase, often referred to as Industry 4.0, is characterised not only by digitisation and automation of production, but above all by a significant shift in customer expectations. The emphasis is shifting to the individualisation of products and services, as confirmed by recent surveys. In fact, McKinsey & Company research from 2021 shows that 71% of customers expect a personalised experience, while 76% express frustration when their individual preferences are not reflected. [7] Deloitte statistics show that 36% of customers are even willing to provide personal information in exchange for a personalised product, while 22% accept a higher price for a personalised solution. [8] However, when it comes to communication and ensuring a stable supply chain, the experience of the Covid-19 pandemic has necessitated the adaptation of these systems to exhibit sufficient levels of stability and resilience to global disruptions. A 2022 World Economic Forum study identifies a critical need to implement hybrid supply chain models that balance the efficiency of Just-in-Time principles with the robustness of more traditional, higher-volume approaches. An analysis of supply chain disruptions during the pandemic showed that companies with advanced digitalization of SCM processes were able to adapt their supply structures to changing conditions faster than companies with lower levels of digitalization. [9] Current trends are therefore towards the implementation of predictive risk models that continuously assess potential vulnerabilities in supply chains and automatically suggest alternative scenarios when imminent disruptions are identified.

In terms of companies' readiness to implement changes not only in production but also in the supply chain or communication with customers related to Industry 4.0, a number of models have been developed since 2015, which differ in their complexity and focus. Some models comprehensively assess the entire enterprise, while others assess only a specific area. The most famous models include RAMI, IMPULS or SIMMI 4.0. In terms of the current state of the art, for example, the GUVEI-Model was introduced in 2022, integrating improvement strategies and Industry 4.0 technologies to optimize key performance indicators (KPIs) and support the long-term sustainability of manufacturing organizations. [10] In addition, the Industry 4.0 Readiness Model, this model includes 10 dimensions and 37 indicators that allow companies to more accurately assess their readiness to implement Industry 4.0 technologies. [11]

Another a comprehensive view of companies' readiness in the area of supply chain digitalization is provided by the "Digital Supply Chain Readiness" diagnostic tool developed by EDGE Digital Manufacturing, Digital Catapult and AI Idea Factory, which is based on the principles of the British Standard PAS 1040 for the adoption of digital technologies in manufacturing. [12] In line with this approach, a recent 2023 study revealed that leadership, processes and culture are key factors for successful digital transformation. [13] Further research from 2024 highlights that digital maturity is essential for optimising production processes and increasing competitiveness. [14] This claim is confirmed by a structured survey [15] conducted among 364 supply chain professionals. The data collected was analysed using structural equation modelling using the Partial Least Squares Method (PLS-SEM). The empirical findings confirm and highlight the importance of real-time digital integration, continuous innovation and improved visibility in leveraging I 4.0 for competitive advantage. Further research [16] has focused on identifying nuanced trends that contribute to supply chain efficiency, waste reduction and environmental footprint. The findings highlight key insights: the adoption of management practices, particularly total quality management

and just-in-time, contribute significantly to reducing waste, increasing efficiency and minimizing the environmental footprint in supply chains. At the same time, the integration of Industry 4.0 technologies, such as blockchain, IoT, big data, strengthens data-driven decision-making, transparency and traceability, reinforcing sustainability efforts. Another, empirical research shows that firms implementing advanced supply chain simulation models have higher success rates in implementing individualized manufacturing strategies. [17]

There has been a significant shift in product customization and customer communication in recent years, mainly due to advances in technologies such as artificial intelligence (AI) and big data. The authors of publication [18] highlight the role of these technologies in effectively tailoring products to individual customer needs. Their study also recommends comprehensive models including internal and external integration, technology readiness and statistical validation for successful implementation of product personalization and improved customer experience. In addition, the 2024 3D EXPERIENCE Platform has already been created to enable manufacturers to transform data from connected Industry 4.0 ecosystems into actionable insights for successful mass customization. The platform provides a digital thread that integrates people and information across the organization and value chain, enabling continuous improvement of products and operations. [19] In further research [20], the authors believe that current models do not place enough emphasis on avoiding the development of redundant solutions and focusing on customer needs. Therefore, the presented approach enables organisations to address customer requirements with digital solutions without creating redundancy. In another publication [21], the authors propose a methodology that could help create new software services in line with Industry 4.0 that will change the way customers interact with businesses and the experience they have in doing so. The methodology details a set of phases that are divided into stages, which in turn consist of activities. It places particular emphasis on the integration of semantic descriptions and 3D visualisation into the implementation of these new services.

3 METHODOLOGY

To investigate the degree of product customization and to analyse the communication tools used to communicate with suppliers and customers, the research used the methodological framework shown in the figure below.

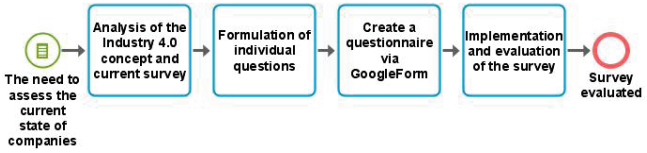


Figure 1 Description of the methodological framework

For the purpose of our investigation, a questionnaire was created using the Google Forms platform. This option was chosen because of its efficiency and speed in reaching a large number of respondents. Google Forms allows for easy distribution of the questionnaire through a shared link that can be effectively disseminated through emails, social networks and other communication channels. In this way, a wide range of respondents can be reached in a minimal timeframe. Another significant advantage of Google Forms is the ability to monitor the current status of questionnaire completion in real time. This feature provides an overview of the number of respondents who have already completed the questionnaire and the time at which completion occurred. Example questions from the survey are shown in the following figure.

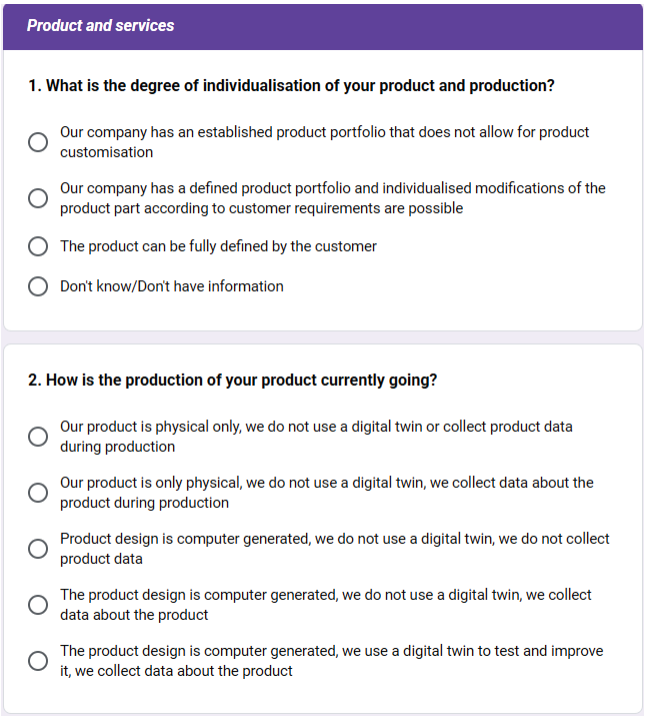


Figure 2 Example of questionnaire

4 RESULTS AND DISCUSSIONS

For the purpose of our empirical investigation, a questionnaire was developed and sent by email to approximately 150 companies specialising in the electrical industry. This selection of respondents was chosen because of the relevance of their expertise and experience in the field of Industry 4.0. In the end, 55 respondents completed the questionnaire on behalf of the companies concerned, but 5 companies were excluded because their main focus did not match the criteria for the electrical industry set for our survey and a further 22 companies were excluded because they answered that they did not have sufficient experience and knowledge in Industry 4.0. This left 28 valid respondents who met the established criteria. Of these respondents, 8% were micro enterprises, 22% were small enterprises, 28% were medium enterprises and 42% were large enterprises. This diversity of respondents by enterprise size provides valuable information on the structure of the electrical industry and allows for a deeper analysis of the responses in the context of enterprise size. This provides a better understanding of the needs and trends in the sector and a comprehensive view of the characteristics and strategies of enterprises in the electrical sector. The following chart

provides an overview of the ability of companies to adapt their products to customer requirements, a key aspect of the modern industrial environment, especially in the context of Industry 4.0.

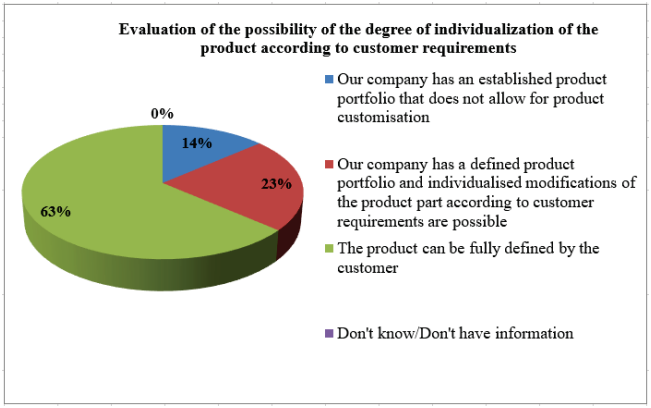


Figure 3 Evaluation of the degree of individualization of the product

According to the chart, 63% of respondents said their products can be fully defined by the customer. This result suggests that most companies have already achieved a high level of flexibility in production, which is in line with the principles of Industry 4.0. The ability to fully tailor products to individual customer needs often requires the implementation of advanced technologies such as digital twins, modular manufacturing systems or sophisticated product design software tools. These companies are likely to be well prepared for the challenges of digitalization and automation of production. A further 23% of enterprises reported that they have a defined product portfolio but allow customization of certain parts of their products according to customer requirements. This approach represents a compromise between standardisation and flexibility. In terms of Industry 4.0, this group of companies can be considered as a transitional phase on the way to the full integration of its principles. They are likely to gradually introduce technologies and processes that allow a greater degree of customization, but still face certain technological or organisational constraints.

Only 14% of respondents said that their company has a fixed product portfolio that does not allow for any form of customization. This group of companies is the least prepared in terms of Industry 4.0 for market changes requiring flexibility and personalization. The absence of the possibility of customization suggests a high degree of standardisation of production, which may be effective in traditional industrial models but less competitive in an environment requiring a rapid response to changing customer needs. An interesting finding is the fact that none of the respondents chose the "Don't know/Don't have information" option. This indicates a high level of awareness among respondents of their companies' capabilities in product customization, which is a positive signal for the implementation of Industry 4.0 principles. The results of the survey, shown in the chart below, provide an overview of the current state of how companies are using modern technologies such as digital twins, computer generated design and in-process data collection. Again, the results show the varying levels of implementation of these elements across industry.

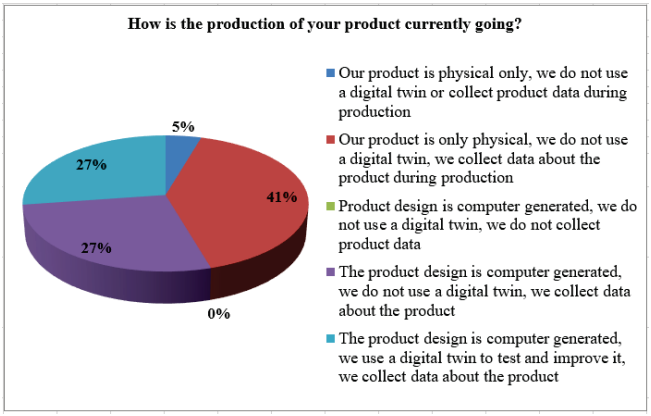


Figure 4 Evaluation of current production

In terms of implementing Industry 4.0 principles, it is clear from the results of the survey that most companies are still at a lower level of digitalization. In fact, the largest share is made up of enterprises with physical production without any data collection (41%), which indicates significant reserves in the area of innovation and technological development. Enterprises that already collect data or use computer generated design (54% in total) show some progress towards digitalization. However, only a small proportion (5%) have achieved full integration of technology through digital twins.

Effective communication with suppliers is a key factor in ensuring smooth production, optimizing the supply chain and minimizing risks associated with material shortages or delivery delays. In the context of Industry 4.0, it is important to analyse how companies use modern technologies to automate and digitise processes, which can significantly increase their competitiveness. Finding out the current state of communication between businesses and suppliers thus provides valuable information on the readiness of businesses for digital transformation and their ability to adapt to new trends.

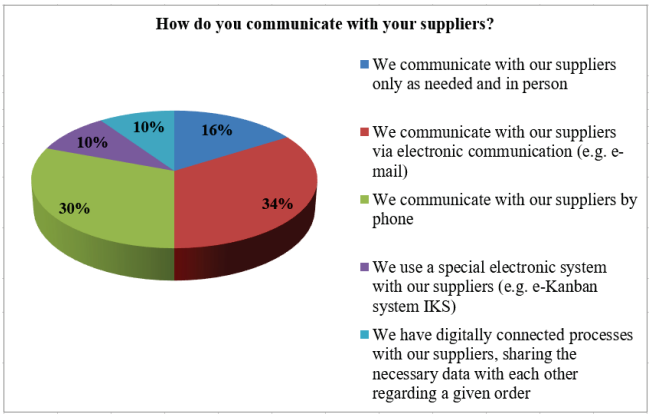


Figure 5 Evaluation of the communication between companies and suppliers

From the results it was found that most companies use a combined method of communication with suppliers, mainly

electronic and telephone communication. In terms of actual shares for each communication option, the largest share (34%) is accounted for by enterprises that communicate with suppliers via electronic communication such as e-mail. While this method is simple, fast and widely available, it often lacks a higher degree of automation and data integration. In second place (30%) are businesses that prefer to communicate by telephone. Telephony allows for quick resolution of urgent situations, but can be time consuming and less efficient when sharing complex data or documents. Only 16% of businesses use face-to-face communication on an 'as needed' basis. This method is suitable for specific situations, such as dealing with strategic issues or building long-term relationships, but is not practical for day-to-day operations.

In addition, 10 % of businesses use specialised electronic systems such as the IKS e-Kanban system. These systems enable automated inventory and order management, which significantly increases process efficiency and reduces the risk of human error. The smallest share (10%) is made up of enterprises that have fully digitally connected processes with suppliers. This approach represents the most advanced level of integration in line with Industry 4.0 principles, where data is shared automatically and in real time between all relevant parties. The way businesses and customers communicate plays a key role in the efficiency of production processes, customer satisfaction and building long-term relationships. In the context of modern manufacturing, especially in the context of the Industry 4.0 concept, it is important not only to ensure direct communication, but also to integrate digital tools that enable automation, personalization and real-time monitoring of processes. For this reason, the next section focused on exploring how companies communicate with their customers.

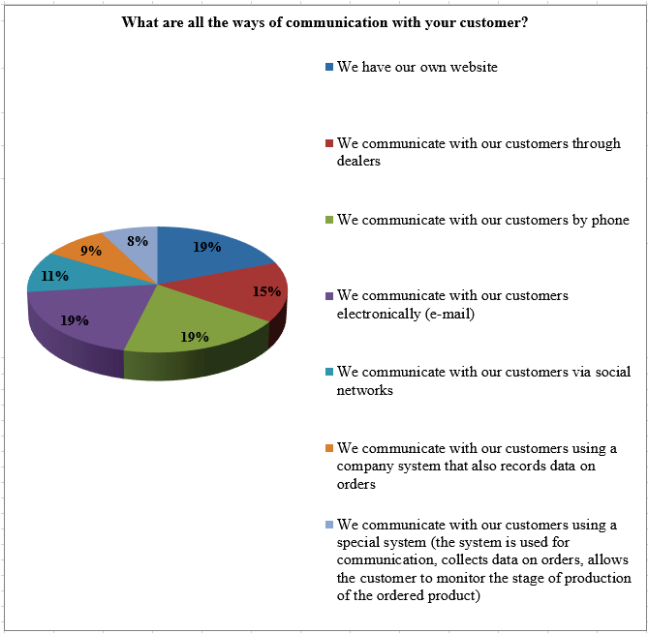


Figure 6 Evaluation of communication between companies and customers

Respondents were able to choose more than one method of communication, most often a combination of telephone and electronic communication. However, the individual results show that the most frequently used methods are the own website (19%), telephone communication (19%) and electronic communication via e-mail (19%). These methods represent the basic channels for direct interaction with the customer, allowing for a quick exchange of information and flexibility. Another important form of communication is the use of social networks (11%), indicating a growing trend towards digitalization and the use of modern technologies for marketing and interaction with clients. Only 9% of businesses use internal company systems that record order data, which can be considered insufficient in terms of digital integration. The lowest share (8%) is for communication through dedicated systems that allow customers to monitor the production status of their orders.

5 CONCLUSION

This study aimed to analyse the readiness of electrical companies for Industry 4.0 by investigating product customization capabilities and communication practices within customer and supplier chains. The research utilized a structured questionnaire distributed via Google Forms to gather data from a diverse sample of electrical enterprises. The findings provide valuable insights into the technological adoption, operational flexibility, and digital communication strategies employed by these companies, highlighting their current position in the journey toward Industry 4.0 integration. The analysis revealed significant variability in the ability of electrical companies to adapt their production and products to customer requirements, a core principle of Industry 4.0. Approximately 63% of respondents demonstrated full customization capabilities, indicating advanced technological integration such as modular manufacturing systems and digital twins. These companies are well-positioned to leverage Industry 4.0 technologies for enhanced competitiveness and responsiveness to market demands. In terms of digitalization levels, the study found that most companies remain at lower stages of technological integration. While 54% collect data or utilize computer-generated design tools, only 5% have implemented advanced solutions such as digital twins—a critical technology for optimizing production processes and bridging physical and virtual systems. This indicates substantial room for improvement in adopting Industry 4.0 technologies across the sector. Communication practices between companies and suppliers and customers still rely mostly on traditional methods such as email and telephone. Only a minority have achieved fully automated digital communication systems that are in line with Industry 4.0 principles. The findings highlight that while some businesses are showing advanced capabilities for adaptation and technology adoption, the majority remain at a lower level of digitalization.

Future research will build on the results of this research and will focus on assessing the economic and operational impacts of introducing advanced technologies, such as digital twins or IoT systems, in electrical manufacturing. And customer-centric innovation, which will mainly focus on analysing how improved communication tools can increase

customer satisfaction and support demand for customised products in line with Industry 4.0 principles.

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