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Servitization and the Business Model of Cyber-Physical Networks in the Context of Personalized Production

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Abstract:

Purpose: *The paper's aim is to identify the need to focus small and medium enterprises on the servitization of industrial production and cooperation within cyber-physical networks. The objective of the conducted research was the analysis of the expectations of the modern customers and the challenges of the Industry 4.0 environment in the industrial sector.*
Design/Methodology/Approach: *The study was conducted using a survey questionnaire distributed to potential customers representing the Silesian, Lower Silesia, Greater Poland, and Lubuskie voivodeship in Poland. The survey was performed using the CAWI method (standardized computer-based internet interview). The research tool consisted of 25 questions (closed, complex, filtering, conditional, and tabular). During the survey conducted in 2019 - 2020, we obtained 504 opinions.*
Findings: *Modern consumers are interested in personalizing products, increasingly expect products that will reflect their tastes, needs, adapt to their lifestyle, be unique, and at the price of a mass-produced product. Active participation in the designing and fabrication of products reduces the risk of unsuccessful sales. It contributes to improving the adaptation of the market offer to the current needs of consumers.*
Practical implications: *The article indicates the critical directions of the development strategy of small and medium-sized manufacturing enterprises oriented to the needs of a modern customer. Modern enterprises should focus on implementing servitization strategy and business model of network collaboration using Industry 4.0 technologies.*
Originality/Value: *The value of the paper is the presentation of the concept of the business model of cyber-physical networks taking into account the infusion of services and the growing demand for personalized products.*

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1. Introduction

The Industry 4.0 concept means intelligent technology in enterprises and a new approach to people's lives, in which mobile devices play an essential role in communication. Social networks and unlimited access to information increase the awareness of consumers, which increases their requirements concerning the products offered on the market. A completely new, more modern and innovative approach to production and business management is needed to dramatically increase flexibility, productivity and customer orientation (Bartosik-Purgat and Ratajczak-Mrozek 2018).

Current customers expect products that closely match their personal preferences and want to influence the unique features of products while requiring low prices (Silveira *et al.,* 2001). Nowadays, customers expect that the products will better adapt to the consumer's needs, and they want to be involved in designing and manufacturing products. The demand for personalized products is growing.

During the fourth industrial revolution, the production paradigm shifted towards custom production, tailored to the needs of individual customers (Lampel and Mintzberg 1996). The need to offer customers personalized products at low prices is forcing companies to change how they operate. There was a need for more interaction between the company and the customer. Customers want to take part in the process of creating and even assembling the final product.

Industry 4.0 offers extraordinary technological advancement, which is blurring the boundaries between products and services more and more, enabling the company's transformation from a product-driven approach to a service-oriented approach (Raddats *et al.,* 2019). New tendencies mean that there is a need for changes in the functioning of modern enterprises. They must change the business model and focus on developing the service offered to supplement the product offer. Adding services to the core product offering to create additional value for the customer is defined as "servitization" (Baines *et al.,* 2009; Baines *et al.,* 2017) or "service infusion" (Kowalkowski *et al.,* 2017).

Servitization is a significant change in the company's business model, thanks to which service activities are the driving force behind the company's growth. Service infusion occurs when the relative importance of service offers for a company increases compared to product offers (Kowalkowski *et al.,* 2017). Servitization allows you to build better interaction between the customer and the manufacturer, better resource use, and establish cooperation in the network (Vargo and Lusch, 2017).

Networking is crucial for small and medium-sized enterprises, which often compete with large enterprises that strongly influence the consumer market. In implementing the Industry 4.0 concept, the SME sector should see development opportunities in

narrow specialization and cooperation development. Concentrating on the services of production systems in the network and developing own know-how requires solving several problems resulting, for example, from the lack of business models for cyber-physical networks (Jazdi, 2014; Oks *et al.*, 2017).

Industry 4.0 means the use of intelligent mechatronic CPS products (machines, devices, robots, means of transport, etc.) throughout the product development chain, from the creation of the product concept to the delivery of the product to the customer using IoT and information stored in Big Data and Cloud Computing (Santos *et al.*, 2017; Agostini and Filippini, 2019). The Industry 4.0 concept is focused on a significant improvement in production efficiency thanks to the use of production and human resources of cooperating network partners who have the unused production capacity and expect benefits from such cooperation.

Hence the need to research the development of business models and the concept of network formation using intelligent resources to execute specific, personalized products in interaction with the consumer. The article indicates the need to organize e-business platforms where, on the one hand, companies offer services and resources for the joint implementation of "make to order" production. On the other hand, customers expect products tailored to their needs. The paper's main aim is to identify the need to focus small and medium enterprises on the servitization of industrial production and cooperation within cyber-physical networks.

2. Materials and Methods

A survey was conducted to identify the need for new strategies and business models. The survey involved 710 potential customers from Poland, from the following provinces: Silesia, Lower Silesia, Greater Poland and Lubuskie, representing different age categories and different wealth status. Therefore, it can be assumed that it was an infinite population.

The CAWI method (standardized online interview conducted via computer) was used to conduct the study. The research tool was a survey questionnaire that contained 20 questions (closed, compound, filter, conditional and tabular). The questionnaire was validated, and a pilot study was conducted among 10 experts with knowledge of Industry 4.0. With a confidence level of 0.99 and an error of 10%, it was determined that the minimum size of the general population should be 166 customers. Therefore, the information contained in the received questionnaires can be treated as representative.

3. Results and Discussions

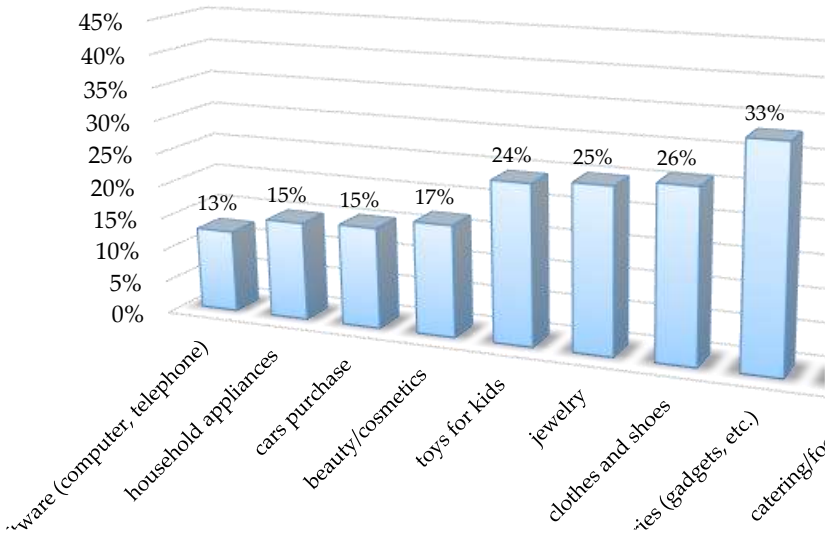
Of the 710 respondents surveyed, 59% were from large and medium-sized cities. Most of the respondents rated their material situation as good (64.1%) and sufficient

(23.24%). About 13.9% of the respondents declared an excellent financial (material) situation, and only 1.8% reported a wrong material situation.

The survey identified the expectations of today's customers to purchase personalized products (52% of respondents). Personalised products are most often purchased by consumers aged 19-25 (38%), 26-35 (15%), 36-45 (16%), rarely by consumers aged 56-67 (8%), very rarely by consumers over 67 (1.5%). Based on these results, it can be seen that the most active group of consumers purchasing personalized products are young people aged 19-45 years. The purchase of personalized products by especially young customers implies a steady increase in interest in personalization in the future.

The products most often personalized by respondents are the purchase of electronics equipment (42%), catering/food (39%), personalized accessories (logo on the case, pens, etc.) (33%), clothes and shoes (26%), jewelry (25%) and toys for kids (24%). The purchase of personalized products by their groups (categories) is shown in Figure 1.

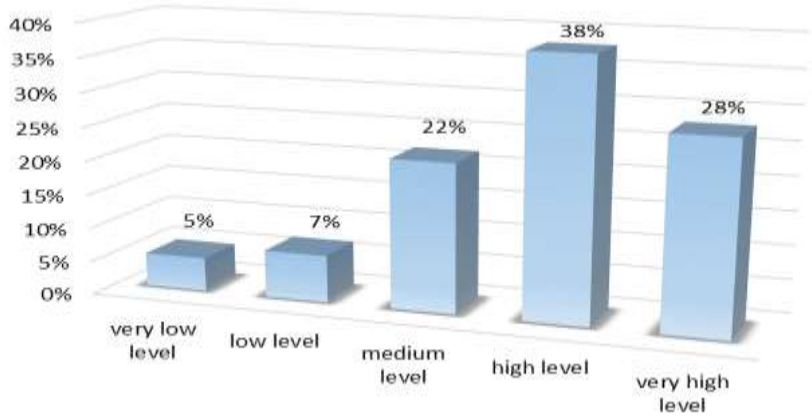
Figure 1. *Customer preferences by product category*



Source: *Own study.*

Figure 2 shows the level of emotional involvement in creating personalized products. As many as 38% of respondents rated their level of participation in creating personalized products as very high, 28% as high, 22% as a medium, 7% as low, and only 5% of respondents selected the answer very low. These results further support the need to develop personalized manufacturing and increase customer involvement in creating new products through, for example, specialized information systems that connect the consumer with the manufacturer.

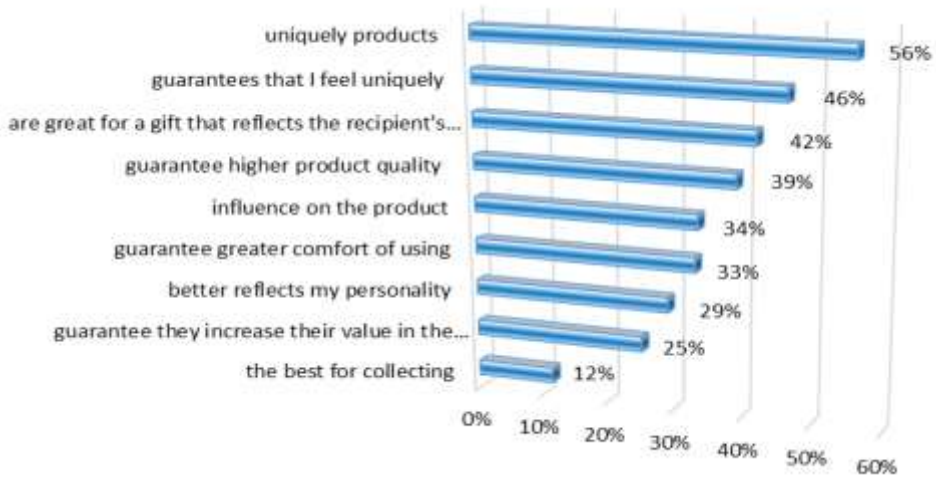
Figure 2. *Level of emotional involvement in creating personalized products*



Source: *Own study.*

The phenomenon of personalization can be defined as the consumer's emotional involvement in creating the desired product (Ciechomski, 2015). This is supported by the evaluation of the rationale for purchasing personalized products shown in Figure 3. Customers choose to buy personalized products because they are unique (52%), guarantee that they feel special (46%), are great for a gift that reflects the recipient's expectations (42%), ensure a higher quality product (39%), influence the product (34%), guarantee more comfort in use (33%), better reflect their personality (29%), guarantee an increase in value in the future (25%), best for collecting (12%).

Figure 3. *The rationale for purchasing personalized products*



Source: *Own study.*

4. Servitization of Industrial Production as a Result of Modern Customer Requirements

In manufacturing companies, servitization consists in developing and providing new services or complex systems that integrate the supplied goods and services (product-service solutions). For manufacturing companies, servitization means a significant change in the perception of their business and a need to modify the business model. It involves a shift from a model that focuses on a physical, one-time sold product to one that relies on regular services around that product (Lay, 2014). Instead of focusing solely on selling the product, manufacturers are redefining their strategy to meet customers' growing needs, resulting in the sale of an entire service system around the product (Raddats, 2019).

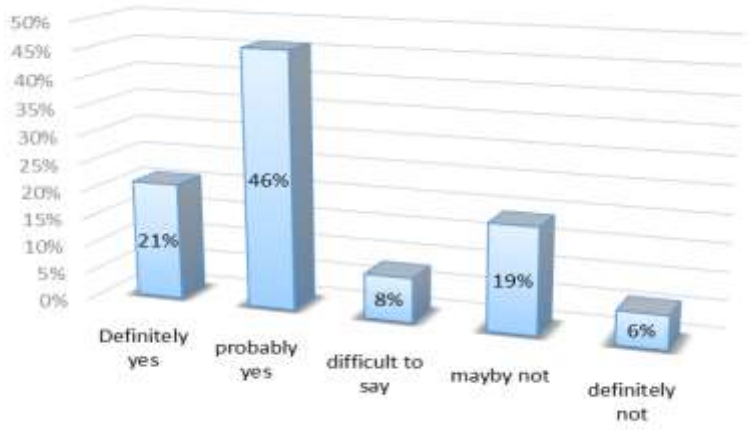
Therefore, the servitization of industrial production is the improvement of an organization's ability to better generate value by moving from selling products to selling production-service systems (Product-Service Systems). A key element of a servitization strategy is strong customer orientation, offering customers a variety of solution options that differentiate the product from its competitors (Rabetino *et al.*, 2017; Opresnik and Taisch, 2015).

Therefore, it is an excellent way to match the growing customer expectations for product personalization and greater customer involvement in the product design and manufacturing process. Given the high level of interest in customized product manufacturing declared in the research, contemporary companies should orient themselves towards developing know-how in the production operations of disposed of systems, from product design, manufacturing to delivery to the customer (Kumar, 2007; Hu, 2013). Modern technologies of Industry 4.0 identified with the digitalization of processes enable easy customer integration with the manufacturer through various product configurators.

They also allow for autonomous reconfiguration of intelligent production system resources to produce a customized product. Due to some products' high level of complexity, cooperation is required between companies, which are forced to develop narrow competencies and combine know-how and resources into temporary cyber-physical production networks (Lee *et al.*, 2015). The service orientation of networked production systems while utilizing Industry 4.0 technologies will allow small and medium-sized enterprises to remain profitable and competitive.

Servitization requires significant changes in many areas of a company's operations and a change in the business model. Today's product must be viewed as a platform for delivering individualized services. A positive effect of personalized production can be the extension of the life cycle of manufactured products and an increase in the level of sustainable production and consumption. This thesis is supported by the survey of respondents who declare a more extended period of use of a personalized product compared to a standardized product (Figure 4).

Figure 4. *Declaration of a more extended period of use of a personalized product compared to the period of use of a similar standardized product*



Source: *Own study.*

5. The Business Model of a Network of Cooperating Enterprises in the Environment of Industry 4.0

The ongoing development of the economy expressed in the intensive transfer and diffusion of technological innovations significantly affects the changes in business models and business processes (Grabowska, 2020). New forms of competitiveness and cooperation emerge in the face of changing customer expectations and growing demand for personalized products. This means the need to abandon the patterns of the past and transform the enterprise into a smart, virtual and networked one. Creating networked forms of cooperation is an excellent opportunity to dynamize business models within the concept of Industry 4.0 and increase enterprises' competitiveness.

In the cyber-physical network, each company is seen as a specific intelligent module that offers various possibilities that can be used throughout the entire value creation chain within the concept of Industry 4.0. The size of the company is then irrelevant. In contrast, the role of the technologies used, the level of highly qualified personnel and the openness to unrestricted communication using increasingly widespread technologies such as Cloud computing, Big data or the Internet of Things are constantly increasing.

The idea of a cyber-physical production network means the production of common production orders using fully automated processes of individual network partners. Communication occurs via the Internet, and the necessary data is stored in the cloud (cloud technology) (Saniuk and Grabowska, 2021). Such a network organization using modern communication technologies provides all partners with access to necessary information from anywhere in the world. This allows the development of

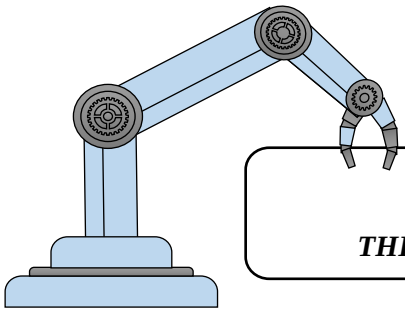
partnerships based on the combination of core competencies and a better orientation to the customer's growing expectations, thus effectively obtaining a competitive advantage in the market (Baraldi *et al.,* 2012).

A prerequisite for the development of networked forms of cooperation is developing a model of enterprise cooperation through the creation of future cyber-physical systems (CPS). CPS systems should ensure the collection, processing and influence of data on physical processes in the entire production network through unlimited network connections of intelligent, mechatronic resources (machines, devices, robots, means of transport, etc.) communicating with each other. The construction of such a model, therefore, requires the development of a set of conditions related to the way of functioning of the enterprise in the production network, the creation of temporary networks oriented to the joint production venture, load planning of geographically dispersed resources, production control or financial settlements of partners providing resources for production.

Companies can produce more economically and respond more quickly to individual customer needs through networking and data exchange. Time spent adapting machines to new requirements is reduced to a minimum, while flexibility is increased. Production tools can (in most cases) modify their operation on their own, adapting to new tasks - all it takes is to apply the appropriate command from the machine software (Cheng *et al.,* 2016). The command also automatically turns on modules needed for a given process and turns off those no longer needed. This allows manufacturers to fulfil low-volume orders and even produce individual pieces at the cost of standard volume production. This means increased production efficiency since any inefficiencies and waste are detected thanks to greater transparency in the value chain, and this, in turn, enables the manufacturer to gain a decisive competitive advantage. One of the key problems is network planning. Hence the proposal of a concept based on building capability exchange platforms oriented towards personalized production.

One of the ways of integrating small and medium-sized enterprises and their resources to carry out joint ventures oriented to the needs of the modern customer is building e-business platforms, whose task is, on the one hand, to contact the consumer specifying a personalized product and, on the other hand, to integrate the resources of enterprises and organize a cyber-physical network for the purpose of carrying out the order. The platform is thus the interface between the customer and the product manufacturer. Through the proposed offer of both products and services, the customer can specify the product and even participate in designing a new product online. With their know-how, the companies around the platform offer design, manufacturing, and transport services to temporarily established networks. The resources of those companies are selected that are available at a given time and guarantee the timely execution of the order. Figure 5 presents the business model of a network of cooperating enterprises in the Industry 4.0 environment schematically.

Figure 5. *The business model of a network of collaborating enterprises in an Industry 4.0 environment*



THE BUSINESS MODEL OF A NETWORK OF

COLLABORATIVE MODEL OF ENTERPRISES CREATING CYBER-PHYSICAL SYSTEMS (CPS) OF COMMUNICATING INTELLIGENT RESOURCES

IDENTIFICATION OF NEEDS

(IDENTIFYING REQUIRED RESOURCES AND COMMUNICATION

Assessment of a company's technological potential

Cost calculation and implementation of investments in new technologies

DEFINITION OF STRATEGIC OBJECTIVES ORIENTED TO NETWORKING

A PLATFORM FOR DESIGNING TEMPORARY PRODUCTION NETWORKS FOCUSED ON PERSONALIZED CUSTOMER NEEDS

Source: *Based on Grabowska and Saniuk 2021, Grabowska 2021.*

6. Conclusion

Intense competition and rising customer expectations in today's marketplace are driving product personalization along with increased production efficiency. Modern customers are already accustomed to the large selection of products available on the market and the privileged position; they expect more than just the best quality product at the lowest price. Customers increasingly expect products that reflect their tastes, needs, adapt to their lifestyles, are unique and at the cost of a mass-produced product.

In the new business landscape, the reorientation of the manufacturing enterprise towards an enterprise focused on servitization becomes essential. Incorporating servitization into the offerings of a manufacturing enterprise has a substantial impact on building its competitive advantage. Of particular note in the cyber-physical network business model are:

- the role of the customer as a partner in the design process;
- partners working together in a cyber-physical network, forming agile teams to deliver a specific project;
- automated production in line with personalized customer expectations;
- manufacturing as a service;
- eliminating unused manufacturing capacity by making spare capacity available to cyber-physical network partners;
- offering personalized products, maximally tailored to customer preferences, at the price of a mass-produced product with complementary services;
- partnering with the customer throughout the product life cycle, having a positive impact on sustainable consumption;
- servitization.

The presented research results and development directions of the small and medium-sized enterprise sector constitute the basis for further research on developing the Industry 4.0 technology implementation framework. It also seems essential to create a detailed network formation methodology focused on rapid prototyping using e-business platforms and scheduling the production flow in conditions of logistic constraints throughout the entire supply chain. An interesting issue is the development of interfaces enabling the customer's integration with the cyber-physical network when designing new personalized products.

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