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# Transformation of business models of Russian industrial companies under the influence of digital technologies

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## Abstract

The article presents the results of the influence of digital technologies on the transformation of industrial companies' business models and its analysis. The author has conducted a survey of industrial companies, at which point the most used advanced technologies are identified, the amount of investments and the investment pattern in digital transformation are analysed, as well as the purchase of foreign and domestic technologies, equipment and software by enterprises. The criteria for classifying digital business models used by production companies are formulated and two clusters are specified: platform-based business models and business models of "Factories of the future". For the first time business models of digital transformation of companies in the Russian industry are specified: digital ecosystems, platforms for joint value co-creation, the introduction of a customising product, smart factory, remanufacturing and digital engineering. Digital transformation strategies used by industrial companies are specified for each cluster. The characteristics of digital transformation strategies are determined and the distribution of the strategies over manufacturing sectors are carried out.

**Keywords:** digital transformation, business model, industrial company, strategy, digital technologies.

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# Трансформация бизнес-моделей российских промышленных предприятий под влиянием цифровых технологий

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## Аннотация

В статье представлены результаты анализа влияния цифровых технологий на трансформацию бизнес-моделей промышленных предприятий. Автором проведен опрос промышленных предприятий, в ходе которого выделены наиболее часто используемые передовые технологии, проанализированы объем и направление инвестиций в цифровую трансформацию, а также факты покупки предприятиями иностранных и отечественных технологий, оборудования и ПО. Сформулированы критерии классификации цифровых бизнес-моделей, применяемых промышленными компаниями, и выделены два кластера – платформенные бизнес-модели и бизнес-модели «фабрик будущего». Впервые выделены бизнес-модели цифровой трансформации компаний в российской промышленности: цифровые экосистемы, платформы для совместного создания ценности, внедрение кастомизированного продукта, умная фабрика, фабричный апгрейд и цифровой инжиниринг. Для каждого кластера описаны стратегии цифровой трансформации, используемые промышленными предприятиями. Определены характерные черты стратегий цифровой трансформации и проведено распределение используемых стратегий по отраслям промышленности.

**Ключевые слова:** цифровая трансформация, бизнес-модель, промышленное предприятие, стратегия, цифровые технологии.

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# 俄罗斯工业企业在数字技术影响下的商业模式转型

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## 摘要

本文章介绍了数字技术对工业企业商业模式转型影响的分析结果。作者对工业企业进行了一项调查，突出强调了最经常使用的先进技术。分析了数字化转型的投资数量和方向，以及企业购买国外和国内技术、设备和软件的情况。制定了工业企业使用的数字商业模式的分类标准，突出了两个集群——平台商业模式和"未来工厂"的商业模式。俄罗斯工业企业数字化转型的商业模式首次得到强调：数字生态系统，共享创造价值的平台，实施定制的产品，智能工厂，工厂升级和数字工程。对于每一个集群，都强调了工业企业使用的数字化转型战略。数字化转型战略的特点已经被确定，所使用的战略也分布在各个行业。

**关键词：**数字化转型，商业模式，工业企业，战略，数字技术。

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## Introduction

Digital transformation has become the most significant trend in recent years and has been included in the strategies of most enterprises in Russia, including production ones. Today digital transformation is an essential prerequisite for the sustainable development of the organisation, it allows companies to hold a competitive advantage in conditions of constant process acceleration and dynamic changes. At the same time, the digital transformation can be interpreted as a strategically controlled process of transforming the business model of an organisation with the use of digital technologies, the purpose of which is to create an updated business model that can work effectively and develop steadily within the conditions of the modern digital economy. Among digital technologies for production companies advanced manufacturing technologies claim attention.

The most essential advanced manufacturing technologies, with regard to the digitalisation of the product life cycle, are computer and supercomputer modelling technologies, digital twins of products and their subsequent virtual testing and optimisation. The basis for the implementation of the aforementioned advanced manufacturing technologies are product design software and computing engineering based on mathematical and simulation modelling (CAD, CAM, CAE and others), as well as product life-cycle management (PLM). Besides, the concepts of "Smart manufacturing", "Digital engineering", "Customising product" imply a high degree of automation and robotisation of business processes, real-time control with consideration to constantly changing conditions.

The implementation of the concepts of "Smart manufacturing", "Digital engineering", "Customising product" is impossible without the combination of IoT technologies, big data analysis and management information systems for production and business processes, robots, additive 3D and 4D printing technologies, industrial avatars with control via brain-computer interface. To implement the concept of a "Customising product", it is necessary to switch to the service business model "Product as a service" and predictive maintenance with the use of the technology of IoT devices installed on the product.

According to the study of the consulting PwC company, among European countries the leaders of digital transformation in industry are Germany, Denmark, France, the United Kingdom, among Asian countries – China, Japan, South Korea, as well as the United States and Canada. At the same time, the most used technologies by industrial companies in European countries are cloud services, industrial robots, automated lines, the Internet of Things and artificial intelligence [PwC, 2020].

In modern conditions the execution of digital transformation programmes by industrial companies may be disrupted due to limited access to digital technologies. In this regard, we conducted a survey among 205 production enterprises of manufacturing industries with the number of employees fewer than 250 people (small companies), more than 250 people (medium-sized companies) and more than 500 people (large companies).

The production companies included in the sample are divided into three sectors: low-; medium-; and high-tech business, according to the division of manufacturing industries by Federal State Statistics Service (Rosstat)[1]. Companies that were difficult to answer the questions concerning the impact of digital technologies on the transformation of business models were excluded from the sample. The final sample included 196 companies.

The characteristics of the production companies included in the sample are presented in Table 1.

[1] The division was made according to the recommendations of Federal State Statistics Service (Rosstat). High-tech industries include: the production of pharmaceutical products, the production of office equipment and computer machines, electronic components and equipment for radio, television and communications, medical products, aircraft, including space vehicles. Medium-tech industries include: chemical production, production of machinery and equipment, production of electrical machinery and equipment, production of automobiles, oil products, rubber and plastic products, metallurgical production, production of finished metal products. Low-tech industries include: the production of food products, tobacco products, textile production, clothing production, wood processing and production of wood products, pulp, paper, cardboard production, publishing and printing activities, processing of secondary raw materials.

Table 1
Descriptive statistics of the companies' distribution under study

| Sector | Investments to R&D (% of companies) | Export marketing activities (% of companies) | Share of proceeds of sale, aimed at the purchase of new technologies (weighted average value) | Standard deviation | Profit on the sale aimed at the implementation of digital transformation projects (weighted average value) | Standard deviation |
|---|---|---|---|---|---|---|
| *Up to 250 people (28 companies)* | | | | | | |
| High-tech sector | 25 | 18 | 0.04 | 0.0037 | 0.09 | 0.003 |
| High-level medium-tech sector | 21 | 13 | 0.08 | 0.0024 | 0.11 | 0.0014 |
| Low-level medium-tech sector | 12 | 9 | 0.04 | 0.0018 | 0.06 | 0.0068 |
| Low-tech sector | 7.7 | 4 | 0.01 | 0.0043 | 0.02 | 0.0023 |
| *250–499 people (88 companies)* | | | | | | |
| High-tech sector | 41 | 17 | 0.1 | 0.0019 | 0.12 | 0.0024 |
| High-level medium-tech sector | 31 | 15 | 0.07 | 0.0028 | 0.1 | 0.0019 |
| Low-level medium-tech sector | 26 | 10 | 0.04 | 0.0021 | 0.08 | 0.0043 |
| Low-tech sector | 14 | 7 | 0.01 | 0.0014 | 0.04 | 0.0053 |
| *500 and more people (80 companies)* | | | | | | |
| High-tech sector | 52 | 26 | 0.15 | 0.0029 | 0.2 | 0.0034 |
| High-level medium-tech sector | 20 | 19 | 0.1 | 0.0042 | 0.15 | 0.0032 |
| Low-level medium-tech sector | 23 | 13 | 0.03 | 0.0045 | 0.06 | 0.0058 |
| Low-tech sector | 15 | 7 | 0.02 | 0.003 | 0.02 | 0.0013 |

*Source:* compiled by the author.

The study was conducted through an online survey from April to September 2022. The respondents were selected taking into account their greatest awareness of the processes of digital transformation and the execution of the digital transformation strategy in companies. The study design implied the participation of one respondent from one company. To analyse the level of implementation of digital technologies the information of the following advanced manufacturing technologies was used:

- industry robots /automated lines;
- additive technologies;
- cloud services;
- IoT;
- radio frequency identification technologies (RFID tags);
- software for creating digital twins;
- software for design and modeling (CAD; CAE; CAM; CAO);
- software for automated production management;
- software for big data analysis;
- artificial intelligence;
- digital platforms;
- ERP systems;
- software for product lifecycle management (PLM systems).

Besides, companies were suggested to provide a form of statistical observation No 3 for 2020–2021, as it reflects the necessary information on the application of the specified technological solutions by industrial companies. Also, the analysis of the data presented in the reports of industrial companies made it possible to conduct an econometric analysis of the impact of advanced manufacturing technologies on the efficiency of industrial manufacturing, to analyse the spread of advanced manufacturing technologies and its speed and compare industrial sectors with each other and with foreign countries.

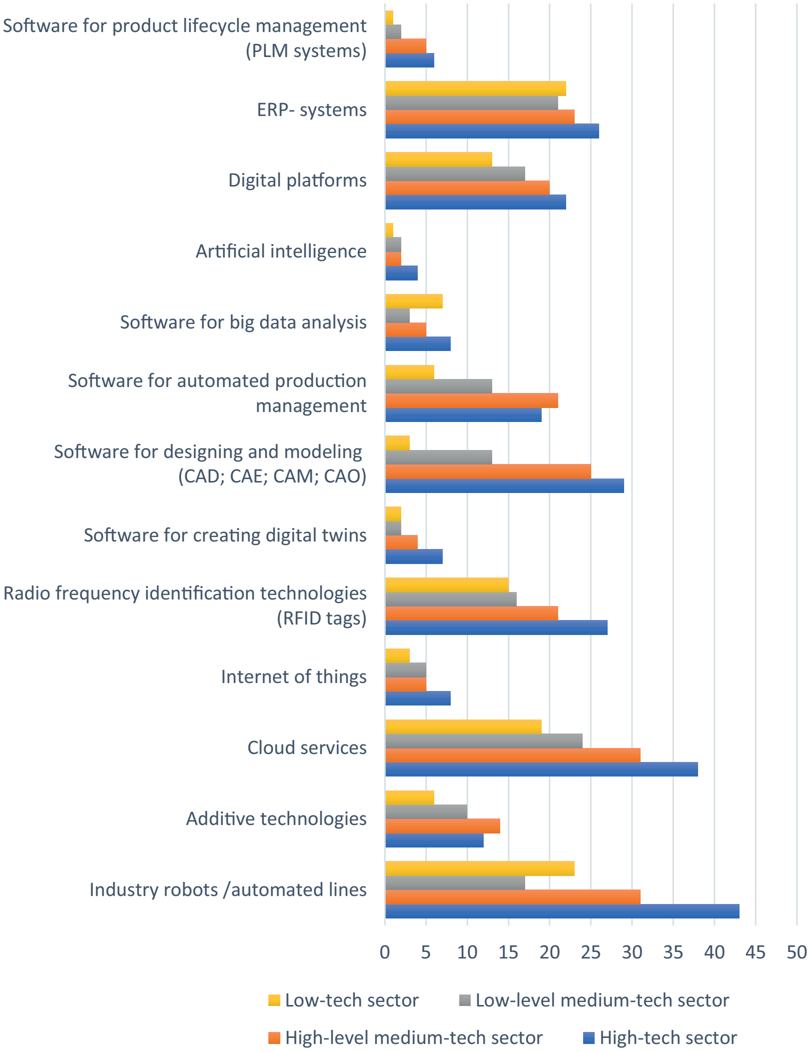
The first poll question concerns studying the popularity of the implementation of end-to-end digital technologies by industrial companies. The respondents' answers are shown in Fig. 1.

As expected, companies in the high level high-tech and medium-tech sector implement advanced manufacturing technologies more often than companies in the low level low-tech and medium-tech sector. The implementation of advanced manufacturing technologies is influenced by the size of the company: larger companies invest more in the purchase of new technologies and implement more diverse technologies. Industry robots are most often implemented among high-level high-tech and medium-tech companies (43 and 32% respectively); cloud technologies (37 and 31% respectively); software for design and modeling (29 and 25% respectively).

Such technologies as radio-frequency identification technologies (27 and 21% respectively); technologies for automated production management (19 and 21% respectively); digital platforms (22 and 20% respectively) are also implemented frequently enough. The least popular are the implementation of digital twins (7 and 4% respectively); artificial intelligence (4 and 2% respectively); software for product lifecycle management (6 and 5% respectively). Among low-level low-tech and medium-tech companies the most popular technologies are: cloud services (19 and 24% respectively); industry robots (23 and 17% respectively); ERP systems (22 and 21% respectively); digital platforms (13 and 17% respectively) and radio-frequency identification technologies (15 and 16% respectively).

The least popular are artificial intelligence technologies (1 and 2% respectively); software for product lifecycle management (1 and 2% respectively); software for creating digital twins (2% each); the Internet of Things (3 and 5% respectively).

Fig. 1. The results of the survey of production companies on the most frequently implemented advanced manufacturing technologies




*Source:* compiled by the author.

The following poll questions concern the amount of investments and the investment pattern in digital transformation. The answers to the question about the amount of investments in digital transformation from the total gross revenues are shown in Fig. 2.

According to the survey, the costs of implementing digital transformation programmes differ significantly depending on the industry sector.

In high-tech industries investments reach about 10–12%, in medium and low-tech industries they are significantly lower – on average 2–7% of the total proceeds of the company's sales. At the same time, the costs of digital transformation from the total amount of the company's investment are slightly higher.

The companies' response to the types of digital transformation expenditures is presented in Fig. 3.

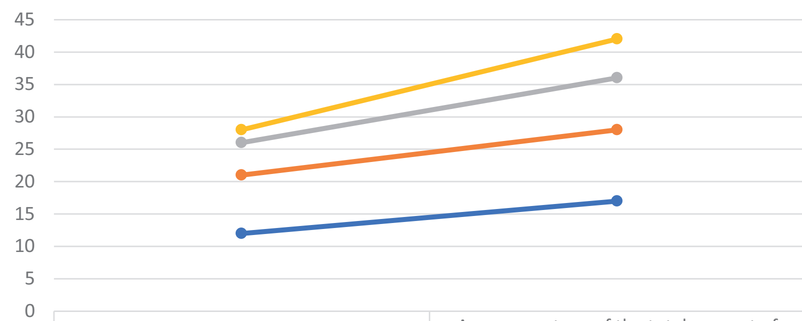
All sectors of the manufacturing industry are characterised by higher expenditures for the purchase of technologies and equipment than by the expenditures for the investments in software. Other costs relate to the organisation of electronic document flow, numerical tagging of goods, etc.

The next question related to the correlation between the purchase of foreign and domestic technologies, equipment and software. The respondents' answers are shown in Fig. 4.

As shown in the figure, both high-tech and low-tech companies mainly use foreign equipment, technologies and software customised to Russian companies.

The main problem of transition to domestic software and technologies is that the technologies and software used are incompatible with

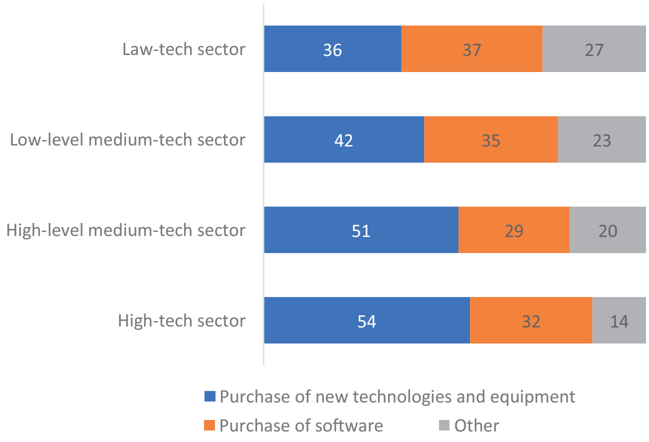
Fig. 2. The expenditures of industrial companies on the implementation of digital transformation programmes (the survey results)




| | As a percentage of gross revenue | As a percentage of the total amount of investments |
|---|---|---|
| Law-tech sector | 2 | 6 |
| Low-level medium-tech sector | 5 | 8 |
| High-level medium-tech sector | 9 | 11 |
| High-tech sector | 12 | 17 |

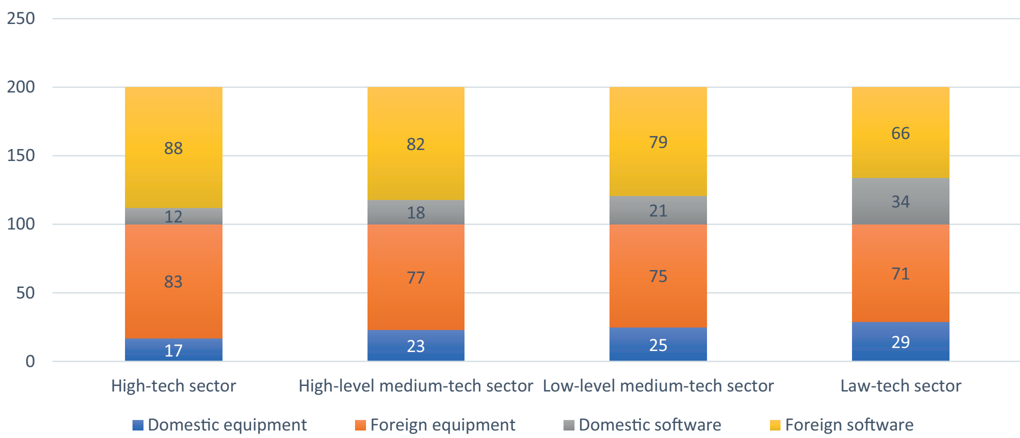
*Source:* compiled by the author.

Fig. 3. Expenditures of manufacturing companies for digital transformation according to type (the survey results)




*Source:* compiled by the author.

Fig. 4. The ratio of domestic and foreign technologies and software used by manufacturing companies (the survey results)




*Source:* compiled by the author.

Russian ones, i.e. during the transition, many software packages and technologies will have to be replaced simultaneously, as well as integrated with all systems in the enterprise. The majority of respondents admit that such expenses, especially in the current conditions, are impossible for them.

Another problem of the transition to domestic technologies and software is their narrow range of choice and incomplete correspondence to all the needs of the company.

The next question concerned the realisation of the projects "Smart manufacturing", "Digital engineering", "Customising product" by manufacturing companies.

According to the Strategy of Digital Transformation of Manufacturing Industries, the Smart Manufacturing project performs tasks aimed at improving the efficient use of fixed assets, raw product, materials, the development and implementation of Russian software and increasing the share of enterprises using predictive analytical technologies and the industrial Internet of Things.

The Digital Engineering project is aimed at accelerating the development and sales of products, increasing the number of companies working with universal marketplaces, reducing the time of the introduction of products to the market, as well as the share of enterprises using digital twins and virtual testing technologies.

The project "Products of the future" has the main purpose of introducing a service model of product realisation and providing wide access to new technologies and also implies the transition to a flexible assembly line production model, the customisation of the product to customer requirements and an increase in the share of enterprises using predictive analytical technologies.

The respondents' answers about the implementation of these projects in their companies are shown in Fig. 5.

The group of companies of high-level high-tech and medium-tech industries implement digital transformation projects, which cover almost the entire life cycle of products from design to production and maintenance.

Besides, such companies use a wide variety of technologies necessary for the implementation of these projects – digital twins, virtual tests, Internet of things, digital platforms, etc.

Among the enterprises of low-level low-tech and medium-tech sectors the projects of "Products of the future" and "Smart manufacturing" enjoy the greatest popularity, but they put more emphasis on the introduction of domestic software rather than companies in high-tech industries.

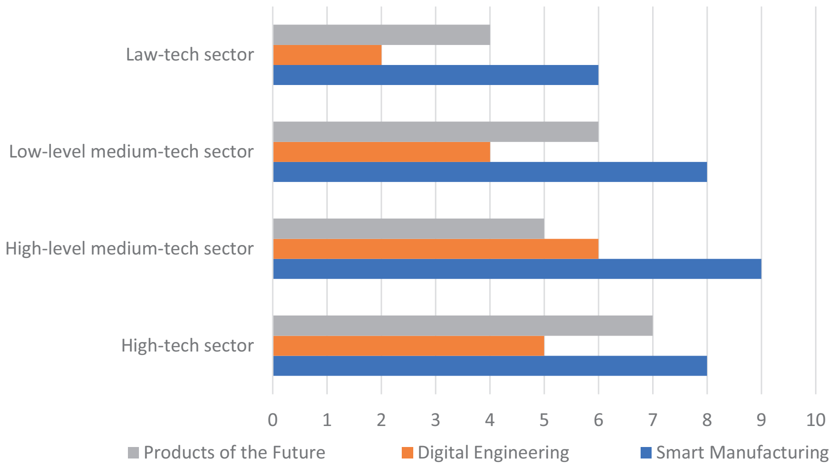
At the same time, there are rather low numbers of the implementation of the specified priority projects in all sectors. It should also be noted that the implementation of these priority projects is carried out only by large companies, while small and medium-sized businesses are undergoing a phase of transformation of separate production and business processes, without creating production ecosystems on the basis of digital platforms (which is a condition for the implementation of all priority projects).

Thus, the improvement of support measures of digital transformation should consist in supporting the implementation of digital technologies, software and priority projects "Smart manufacturing", "Digital engineering", "Customising product" in companies of small and medium-sized industries.

The next question was to analyse the risks for the implementation of the digital transformation strategy under the sanctions imposed in the spring of 2022.

The majority of respondents admitted that the suspension of sales and updates of foreign software, the ban on the supply of components, the rise in loan interest rates, the increase in the cost of equipment will have a negative impact in the medium-term horizon (2–3 years) on the implementation of the digital

Fig. 5. Implementation of priority projects by industrial companies
(the survey results)




*Source:* compiled by the author.

transformation strategy. More than half of the respondents admitted that the sanctions pressure stimulates reverse engineering of equipment and software, and the speed of development of domestic technologies and software will determine the implementation of the digital transformation strategy in the medium-term horizon. Since all the technologies used for the implementation of priority projects are closely interconnected, companies will have to completely switch to domestic equipment and software, which will lead to high financial expenditures, and that seems unrealistic for respondents in the medium-term horizon. Besides, respondents noted a lack of human assets to create basic technologies and software. In this regard, as for us, the most effective measures to support the implementation of the digital transformation strategy among manufacturing companies will be: the creation of reverse engineering centers, including centres on the basis of universities; the creation of centers for the development of domestic software and equipment; reduced-rate lending for the purchase of domestic software and equipment; the creation of a favorable investment and business environment, including granting tax exemptions.

The purpose of this article is to analyse the influence of digital technologies on the transformation of business models of industrial companies.

## 1. Theoretical literature review

Research in the field of digital transformation can be divided into several major directions, which were set by the book that became fundamental for the digital transformation processes: "Guide to digitalisation: How to turn technology into digital transformation" [Westerman et al., 2014]. The authors define digital transformation as "the transformation of three key areas of an enterprise: customer experience, operational processes and business models" [Westerman et al., 2014, p. 13]. All further research in one way or other relates to one of these areas. Digital transformation has generated considerable interest among both scientists and practitioners, considering its huge potential impact on products, services, innovation processes and business models [Andal Ancion et al., 2003; Lyytinen et al., 2016; Nambisan, 2017]. Digital transformation reduces the time required to develop and launch the process of innovations, reduces the lifecycle of new products and services on the market and requires companies to share knowledge related to technologies they are not familiar with. The boundaries between industries and product categories are erasing, and competition is increasingly determined by multilateral platforms and related ecosystems. A successful response to these challenges requires flexibility, as well as dynamic capabilities in the development of products and services [Kock, Gemünden, 2016], which, in their turn, require bold changes in the ways of managing the innovation process, organising and managing innovation activities, as well as the competencies and relationships of those who involved in innovation processes.

The emergence of the economic category "business model" is associated with the work [Teece, 2010] and focused on searching for the answers to three key questions: Why should a customer buy anything from a company? How can a company gain by selling its product? What are the key actions that will allow a company to implement its plan?

The most famous among the studies on the structure of the business model is the work [Osterwalder et al., 2010] in which the authors distinguish nine elements: consumer segments, value proposition, channels of distribution, relationships with customers, income streams, key resources, key activities, key partnerships and expenditure pattern. In the work [Chesbrough, Rosenbloom, 2002] the main components are the value proposition, market segment, value chain structure, expenditure and profit structure, a position within the value chain, competitive strategy. D. Teece distinguishes such elements as technologies and product features, consumer advantage when using the product, target market segments, income streams, mechanisms for obtaining value.

Since the nature of value added has changed, today companies have to adapt their business infrastructure to the new digital era, namely, to rebuild the entire value chain to new digital technologies [Porter, Heppelmann, 2014]. The use of new technologies should be incorporated into new business models that will form competitive advantages [Bharadwaj et al., 2013; Hess et al., 2016; Becker et al., 2018]. Companies will be able to take full advantage of their value creation potential in case they have a well-defined strategic orientation that will help to implement digital business models.

Digital transformation may require a significant change in the business model to maximise benefits and reduce costs. The implementation of digital technologies calls into question the traditional way of business dealing, and therefore companies should reconsider the elements used to create and maintain their competitive advantage [Correani et al., 2020].

Digitalisation allows to realise cost advantages, fulfil additional sales potential and increase productivity. A strategy that considers the use of digital technologies is crucial for the future business success of companies of any size and industry [Hess et al., 2016].

## 2. Research design

The clustering method was applied to identify digital transformation strategies in manufacturing industry with a use of a two-step procedure. This procedure was applied in the research works [Gokhberg et al., 2010; Trachuk, Linder, 2015; Miles et al., 2017; Linder, 2020]. First, using the principal component analysis the factors that distinguished the enterprises from each other and the factors that were common to the group of enterprises were determined. Then, considering the presence of certain factors, enterprises were assigned to different groups, so that each group of enterprises (cluster) consisted of enterprises with a particular set of characteristics and at the same time each cluster differed from each other.

The key factor in the division of industrial companies was the factor "the participant composition of digital services and business processes based on the principles of mutually beneficial relationships." To analyse it respondents were asked two questions:

– Are external participants involved in the business processes of the organisation? (technology SSO or single sign-on technology) (if yes – 1, otherwise – 0);
– Are digital services unified by a common brand? (if yes – 1, otherwise – 0);
– Do digital services allow to increase the user base and generate profit from non – traditional businesses? (if yes – 1, otherwise – 0).

In terms of the factor "Implemented digital technologies", respondents were asked the following questions:

– Is the full range of Industry 4.0 technologies implemented throughout the value chain being applied? (if yes – 1, otherwise – 0);
– Are modular production lines that can be quickly delivered, assembled and connected being implemented? (if yes – 1, otherwise – 0);
– Are intelligent services ensuring the appearing of a "seamless user experience" being implemented? (if yes – 1, otherwise – 0).

In terms of the "Reach of transactions" factor (this factor stands for the breadth, complexity and consistency of the value proposition, how many goods and services are included in the value proposition, how interconnected they are and whether they can lead to repeat purchases). To analyse it, respondents were asked the following questions:

– Do the digital technologies implemented in the company allow to form a value proposition that has breadth, complexity and consistency? (if yes – 1, otherwise – 0);
– Does the implemented business model allow to develop digitised channels? (if yes – 1, otherwise – 0);
– Are goods and services, within the value proposition, interconnected and lead to repeated purchases? (if yes – 1, otherwise – 0);
– Do the digital technologies implemented in the company allow to customise the value proposition for clients? (if yes – 1, otherwise – 0).

In terms of the "Cost optimisation" factor, respondents were asked to estimate the direction of digital technology influence: reduction in expenditure on quality assurance (if yes – 1, otherwise – 0), cost reduction (if yes – 1, otherwise – 0), acceleration of bringing a product to market (if yes – 1, otherwise – 0), acceleration of the manufacturing cycle (if yes – 1, otherwise – 0), reduction of time for prototyping (if yes – 1, otherwise – 0), reduction of time spent for logistics (if yes – 1, otherwise – 0), reduction in expenditure on customer capture and increase in the the user base (if yes – 1, otherwise – 0).

Descriptive statistic is presented in Table 2.

To determine the companies' clusters the hierarchical cluster analysis method was used, according to which the distances between arbitrary pairs of clusters are determined and then the

Table 2
Descriptive statistic of variables the study variables

| Variables | The number of enterprises | Average value (1 - answer "yes," 0 - answer "no") | Standard deviation |
|---|---|---|---|
| The company invests in digital technologies | 196 | 0.341 | 0.671 |
| The company invests in quality assurance and creation of a new product | 196 | 0.231 | 0.462 |
| The company invests in value creation together with the consumer | 196 | 0.649 | 0.671 |
| The company transforms its business model | 196 | 0.44 | 0.473 |
| The company transforms managerial decision-making | 196 | 0.33 | 0.55 |
| The company has the opportunity to implement digital innovations independently | 196 | 0.473 | 0.528 |
| The company creates a digital ecosystem | 196 | 0.616 | 0.627 |
| The company manage risks and provides cybersecurity | 196 | 0.264 | 0.583 |
| The company controls the resource allocation | 196 | 0.33 | 0.561 |
| The company rationalises production and improves business processes | 196 | 0.396 | 0.594 |
| The company digitalises commercial processes and supply chain management | 196 | 0.638 | 0.495 |
| The company is receptive to new technologies, transfer of technology | 196 | 0.319 | 0.528 |
| The company performs maintenance of equipment according to the condition | 196 | 0.209 | 0.517 |
| The company manages the effectiveness with the use of digital technologies | 196 | 0.143 | 0.572 |

*Source:* compiled by the author.

Hamming distance can be used as a means of the homogeneity, reflected in Formula (1), calculated as the ratio of the number of matching values to the number of all variate values:

$$d_{ij} = \sum_{k=1}^{m} |x_{ik} - x_{jk}|, \quad (1)$$

where $d_{ij}$ – is a distance between $x_{ik}$ and $x_{jk}$, $x_{ik}$ – is a value $k$-th property of $x_i$, $x_{jk}$ – is a value $k$-th property of $x_j$.

Using this methodology, the strategies of digital transformation in the Russian industry will be further distinguished.

## 3. Business models of digital transformation: The research results

Table 3 presents the results of a factorial analysis, in which four factors with eigenvalues greater than 1 were analysed, in summation explaining 68.27% of the dispersion.

Indicators on risk management and cybersecurity, as well as control over resource allocation, were not included in the results of the factor analysis, as they are approximately equal for all respondents and make it difficult to identify strategies for digital transformation of enterprises.

The first factor is “The participant composition of digital services and business processes based on the principles of mutually beneficial relationships”. The availability of external participants implies the company’s desire to transform the business by creating platforms or an ecosystem. In the absence of external participants, the company considers closed business models of “Smart factories” and “Digital production” to be a successful solution. It should also be noted that if a company has large volumes of its own incoming traffic, with a significant number of leads, companies strive to create their own ecosystems, optimise business processes and engage partners to provide related services to customers. A limited flow of applications determines the formation of companies’ own marketplaces or integration into global marketplaces with their goods or services.

The factor “Implemented digital technologies” shows which focus areas and business processes are digitised by the company most particularly: business processes aimed at developing “smart production”, improving existing technological processes, ensuring the rationalisation of production considering its type (mass, serial, one-off or single-item) or the implementation of new technologies contributes to increasing in user base, reducing the expenditures on customer capture, the success of the brand.

The “Reach of transactions” factor is focused on understanding the formation of a value proposition for customers by companies, supplementing the value proposition with services and increasing the level of its customisation. Most commonly platform-based business models tend to increase the reach of

Table 3
The analysis of factors to identify digital transformation strategies

| Indicators | Factors | | | |
|---|---|---|---|---|
| | The participant composition of digital services and business processes based on the principles of mutually beneficial relationships | Implemented digital technologies | Reach of transactions | Cost optimisation |
| Investments in digital technologies | 0.35 | 0.35 | 0.35 | 0.35 |
| Investments in quality assurance and creation of a new product | 0.17 | 0.17 | 0.17 | 0.17 |
| Investments in value creation together with the consumer | -0.1 | -0.1 | -0.1 | -0.1 |
| Transformation of business models | 0.78 | 0.78 | 0.78 | 0.78 |
| Transformation of managerial decision-making | 0.14 | 0.14 | 0.14 | 0.14 |
| The company has the opportunity to implement digital innovations independently | 0.12 | 0.12 | 0.12 | 0.12 |
| The company creates a digital ecosystem | 0.1 | 0.1 | 0.1 | 0.1 |
| The company rationalises production and improves business processes | 0.25 | 0.25 | 0.25 | 0.25 |
| The company digitalises commercial processes and supply chain management | 0.65 | 0.65 | 0.65 | 0.65 |
| The company is receptive to new technologies, transfer of technology | 0.28 | 0.28 | 0.28 | 0.28 |
| The company performs maintenance of equipment according to the condition | 0.21 | 0.21 | 0.21 | 0.21 |
| The company manages the effectiveness with the use of digital technologies | 0.13 | 0.13 | 0.13 | 0.13 |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | 0.646 | | |
| | Approximate square value | 592.697 | | |
| | Number of freedom degrees | 20.9 | | |
| | Significance | 0.000 | | |

*Source:* compiled by the author.

Table 4
Results of Hamming distance calculation

| Step | Coefficient ($d_{ij}$) | Step | Coefficient ($d_{ij}$) |
|---|---|---|---|
| 103 | 0.213 | … | … |
| 104 | 0.215 | 163 | 1.532 |
| 105 | 0.236 | 164 | 1.565 |
| 106 | 0.527 | 165 | 1.576 |
| 107 | 0.554 | 166 | 2.512 |

*Source:* compiled by the author.

transactions and ecosystem business models simultaneously combine the reach of transactions with an increase in the level of customisation. Meanwhile, business models aimed at improving the production process are accompanied by a small expansion of the reach of transactions do not imply the formation of digitised channels for promoting value proposition and adapting to customer needs.

The "Cost optimisation" factor allows to determine the key effects of the implementation of the target digital business model. If the key effects are focused on reducing the expenditure on quality assurance, reducing the prime cost, accelerating the introduction of products to the market, productivity gain and accelerating the production cycle, mostly common such companies build business models of "smart production". If the expectation effects are connected with a reduction of expenditures on searching for new customers, with more accurate identification and satisfaction of their needs, with forecasting demand fluctuations with maximum precision, the company strives to build digital platforms or ecosystems.

To identify clusters of industrial companies implementing certain digital business models, the methodology described in the article [Trachuk, Linder, 2015] was used. According to this methodology, the maximum local distance equation is used to determine the distances between clusters. The calculation results are presented in Table 4.

As was shown above, 196 companies were surveyed, 82 of which use platform business models. As a result of the calculations, we can see two spikes, highlighted in italics in the table: the first split occurred at step 105, the second one at step 166, which means that the selected set according to the factor "the participant composition of digital services and business processes based on the principles of mutually beneficial relationships" can be divided into 2 clusters.

According to the methodology applied within these two large groups, we also distinguished clusters of enterprises with common characteristics according to the indicators highlighted in Table 3. We used the *k*-means method presented in Formula (2) to group clusters:

$$V = \sum_{i=1}^{k} \sum_{X \epsilon S} (x_j - \mu_i)^2, \quad (2)$$

where $k$ – is a number of clusters, $s$ – specified clusters, $x_i$ – individual characteristics of the analyzed factor, $\mu_i$ – mean characteristic of the analysed factor in the group, $i$ – number of iterations from 1 to $k$.

Based on the calculations in each of the two large clusters other groups of enterprises with common characteristics according to the factors were distinguished with reference to the factors as presented in Table 3.

Thus, Cluster I and Cluster II differ only in the participant composition of digital services and business processes based on the principles of mutually beneficial relationships, and Clusters 1, 2, 3, 4, 5 differ in the following factors: the availability of an ecosystem, consumer involvement in joint value co-creation, the ability to implement a customising product, building a model of "smart factories", the ability to implement remanufacturing and digital engineering. It means that distinguished clusters are digital business models implemented by industrial companies.

The division into Clusters I and II is due to the possibility of building platform business models. The companies of each distinguished Cluster 1, 2, 3, 4, 5 have similar characteristics of business models of digital transformation.

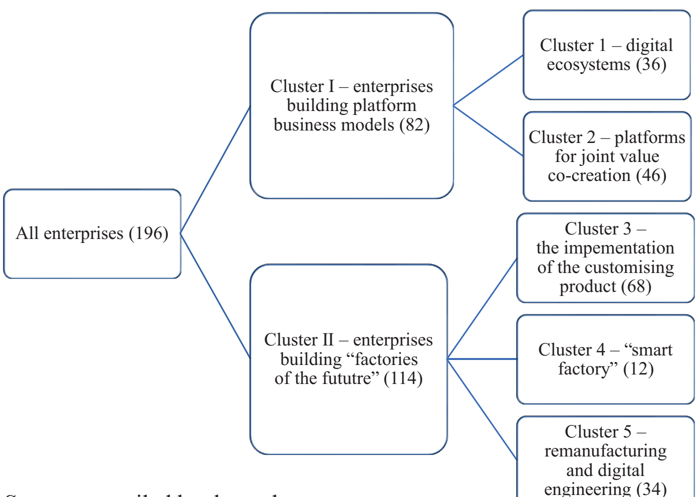
The distinguished Clusters are shown in Fig. 6.

Cluster I – enterprises building platform business models – companies included in this cluster are distinct in the fact that they unite a large number of participants on the principles of mutually beneficial relationships, services and business processes, both around one company and with many players. Platform business models contribute to:

- ensuring higher competitiveness of all participants due to the synergetic effect, which is absent if companies work alone;
- generation of profits from the concentration of a variety of services (own or partner ones) and additional types of business;
- the increase in user base and reduction in the expenditures on customer capture, including by means of collecting big data and customising the value proposition;
- increasing the success of the brand by means of high-quality integration of all services and ensuring a high level of platforms innovativeness.

As a result of the analysis, the following business models can be distinguished in Cluster I: *Cluster 1 – Digital ecosystems* that are characterised by access to all services through a single account (single sign-on technology) and the unification of services under

Fig. 6. Clusters of production companies by type of digital transformation strategy




*Source:* compiled by the author.

Table 5
Digitalisation strategies of enterprises using the "Digital ecosystems" business model

| Strategies | The number of enterprises using the strategy |
|---|---|
| Customisation and personalisation strategy | 12 |
| Strategy of a new revenue stream with a low cost-price | — |
| Digital promotion channels strategy | 5 |
| Strategy of digitalisation of goods and services | 3 |
| Cost optimisation strategy | 8 |
| The strategy of creating a completely automated mass production of goods at low prices | — |
| Strategy of rapid response to changes in customer preferences | 4 |
| Strategies of a personalised offer creation | 4 |
| Total | 36 |

a common brand. Digital ecosystems are characterised by the emergence of a "seamless user experience" that allows the client to seamlessly switch between various services included in the ecosystem. At this time, the services in the ecosystem can be own, acquired or partner ones. The main purpose of the additional inclusion of the service in the ecosystem is to ensure synergy between businesses. Table 5 presents the strategies used by companies when implementing digital ecosystems.

*Cluster 2 is a platform for joint value co-creation* – these business models are aimed at the interaction of two or more companies, which somehow need each other. Platforms create value by driving down the cost of searching, distributing, and conducting transactions with each other. Industrial companies use platforms as part of the exchange of materials and resources, joint logistics, ensuring the sharing of knowledge and skills or creating mutual value with consumers. The specifics of creating digital business models for industrial companies are that the "winner takes all" principle does not work, and combining a large amount of data and digital platform participants leads to greater potential to stimulate innovation and increase productivity. Table 6 presents the strategies used by companies, which implement a joint value co-creation model.

Cluster II – combines business models aimed at enhancement of operational activities, changing production processes and technologies used, gaining competitive advantages by means of significantly reducing production expenses, reducing the time to bring new products to market, releasing high-tech products, increasing flexibility of production (and the ability to manufacture one-of-a-kind items industrially). In Cluster II three key business models used by industrial companies can be distinguished as follows:

*Cluster 3 – implementation of a customising product.* Companies implementing such business models strive to adapt their products to the preferences of individual customers, most commonly as part of the promotion and product sales. At the same time, companies can use both extensive customisation and adapt products to the requirements of various customers, and narrow customisation to adapt products to the requirements of individual customers. At this time, narrow customisation creates more value for the client, but is characterised by higher expenditures. As a general matter, companies using these business models prefer to create more value for customers, but at the same time, the increased diversity significantly increases the product cost. Companies implementing this business model most commonly use such technologies as 3D printing (allows to create products with an unlimited number of projects), digital models and twins (allow to accurately reflect and use the specification of individual customers), 3D scanning and modelling, big analytics algorithms that allow to collect a large amount of data about customers, artificial intelligence that

Table 6
Digitalisation strategies of enterprises using the platforms for joint value co-creation model

| Strategies | The number of enterprises using the strategy |
|---|---|
| Customisation and personalisation strategy | 12 |
| Strategy of a new revenue stream with a low cost-price | — |
| Digital promotion channels strategy | 2 |
| Strategy of digitalisation of goods and services | 4 |
| Cost optimisation strategy | 10 |
| The strategy of creating a completely automated mass production of goods at low prices | — |
| Strategy of rapid response to changes in customer preferences | 8 |
| Strategies of creation of a personalised offer | 10 |
| Total | 46 |

Table 7
Digitalisation strategies of enterprises using the "Implementation of a customising product" business model

| Strategies | The number of enterprises using the strategy |
|---|---|
| Customisation and personalisation strategy | 16 |
| Strategy of a new revenue stream with a low cost-price | — |
| Digital promotion channels strategy | 9 |
| Strategy of digitalisation of goods and services | 5 |
| Cost optimisation strategy | 13 |
| The strategy of creating a completely automated mass production of goods at low prices | — |
| Strategy of rapid response to changes in customer preferences | 11 |
| Strategies of creation of a personalised offer | 14 |
| Total | 68 |

Table 8
Digitalisation strategies of enterprises using the "Smart factory" business model

| Strategies | The number of enterprises using the strategy |
|---|---|
| Customisation and personalisation strategy | — |
| Strategy of a new revenue stream with a low cost-price | 3 |
| Digital promotion channels strategy | 2 |
| Strategy of digitalisation of goods and services | — |
| Cost optimisation strategy | 5 |
| The strategy of creating a completely automated mass production of goods at low prices | 2 |
| Strategy of rapid response to changes in customer preferences | — |
| Strategies of creation of a personalised offer | — |
| Total | 12 |

Table 9
Digitalisation strategies of enterprises using the "Remanufacturing and digital engineering" business model

| Strategies | The number of enterprises using the strategy |
|---|---|
| Customisation and personalisation strategy | 6 |
| Strategy of a new revenue stream with a low cost-price | — |
| Digital promotion channels strategy | — |
| Strategy of digitalisation of goods and services | 2 |
| Cost optimisation strategy | 12 |
| The strategy of creating a completely automated mass production of goods at low prices | — |
| Strategy of rapid response to changes in customer preferences | 10 |
| Strategies of creation of a personalised offer | 4 |
| Total | 34 |

Table 10
Characteristics of Digital business models in industry

| Characteristics | Digital ecosystems | Platforms for joint value co-creation | The implementation of a customising product | "Smart factory" | Remanufacturing and digital engineering |
|---|---|---|---|---|---|
| Availability of external users | + | — | — | — | — |
| Types of implemented digital technologies | | | 3D printing, digital models and twins, 3D scanning and modelling, big data analysis, artificial intelligence | | |
| Personalisation of the output | + | + | + | +/- | +/- |
| Cost optimisation | To attract customers and partners | To attract customers and partners | By means of improving the understanding of the customer and reducing the cost of their retention | By means of the implementation of technologies throughout the value chain | By means of resource optimisation and reusing materials |
| Increase of efficiency of innovation activities | By means of creating a platform for the production of research and experiments | The use of digital platforms for joint research, discussion of new ideas | By means of "short" communication with the customer, faster testing of new products | Artificial intelligence and computer-assisted teaching stimulate innovation in all functioning areas of industrial manufacturing | By means of creating virtual models by combining dynamic sounding and visualisation data on a real time basis |
| The resulting effects | Creating more value with the use of a number of additional services | Increasing customer and partner loyalty by means of value added activity based on personal specifications, accompanied by repeat purchases, and the increase in the number of recommendations | The increase of customer lifetime value | The improvement in the quality of production which leads to the willingness of customers to pay a higher a price | Improving competitive positions by optimising resources, cost improvement and reusing materials |
| Financial results | The increase by means of reduction of stocks and more accurate identification of need satisfaction | By means of accelerating the introduction of products to the market | By means of reducing the expenditures on quality assurance, reducing the production lot size, more accurate identification of need satisfaction | By means of increasing the product output, acceleration of the production cycle, increasing the overall effectiveness of equipment and reducing the product cost in general | By means of reducing the time to develop prototypes, reducing the expenditure on re-release of defect products and reducing the expenditure on the quality assurance |

*Source:* compiled by the author.

allows to use flexible, dynamic pricing. Organisational methods and customisation tools include modular production, product lifecycle management, lean production, and co-design, which implies deep involvement of customers in product development processes. Table 7 presents the strategies used by companies implementing a customising product.

This business model is most often found among the industries of construction materials, food, machine engineering, textile and clothing.

*Cluster 4 – a "smart factory".* The feature of this business model is the intelligent control and optimisation of business, digital and production processes throughout the value chain in real-time mode. The implementation of the "Smart factory" business model implies achieving a level that makes it possible to have functions of self-organisation in production and in all processes related to production. This business model assumes minimal interference in the production process, optimised electric power consumption, improved product quality, reduced idle time and increased flawless operation of equipment. "Smart factory" involves end-to-end digitisation of the production process: product design, production, distribution and sale. The use of this business model implies the implementation of a whole range of digital technologies, such as virtual modeling, cloud storage of data, the internet of things, cloud computing, artificial intelligence, robot engineering, predictive analytics, additive manufacturing. Table 8 presents the strategies used by companies implementing the "Smart factory" model.

Cluster 5 – remanufacturing and digital engineering. Companies implementing this business model are aimed at upgrading old devices or introducing new modules into old devices. Recycling of products is also a part of this business model and companies implementing non-waste production and recycling can get additional profit by optimising resources or reusing materials. The technologies used in the implementation of this business model are: robot engineering, 3D modelling of products, including simulation modelling, simulation, debugging and control, 3D scanning or 3D laser scanning and the creation of digital twins. Table 9 presents the strategies used by companies implementing the Remanufacturing and digital engineering model.

The characteristics of the distinguished digital business models in industry are presented in Table 10.

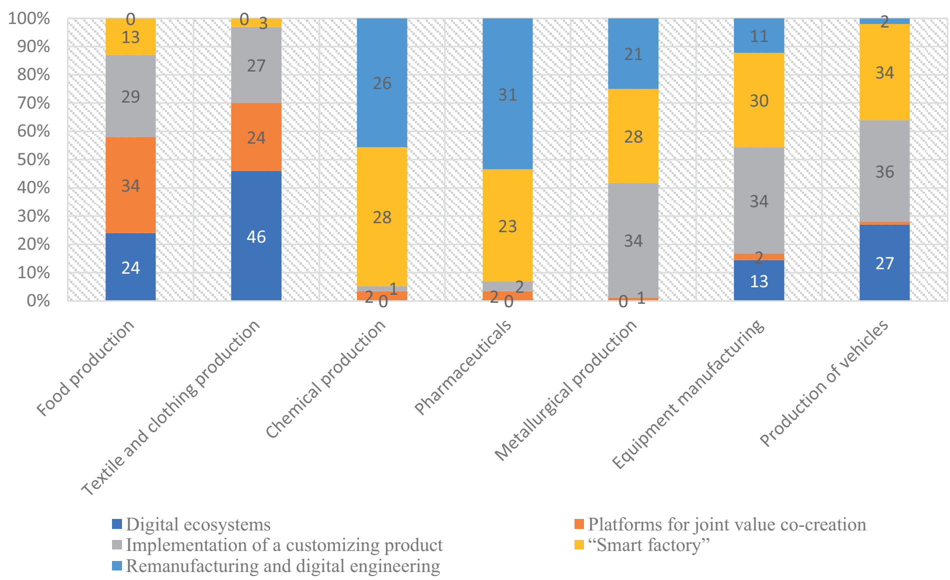
## 4. Conclusions and the future research trends

Due to the development of digital technologies, growing competition, constantly increasing customer requirements, the emergence of new solutions for the optimisation of business processes, the transformation of business models has become an integral part of the functioning of industrial companies.

In the survey conducted among production enterprises of manufacturing industries the most frequently implemented technologies were identified, among which: industry robots and automated lines, cloud services, the industrial Internet of Things and FRID technologies. The effects of the implementation of digital technologies were determined: cost reduction, improvement of product quality, increased flexibility of production, reducing the time for the introduction of new products to the market. It was found out that all sectors of the manufacturing industry are characterised by higher expenditures on the purchase of technologies and equipment than investments in software. The key problem of the transition to domestic software and technologies was identified, which lies in the fact that the technologies and software used are incompatible with Russian ones, i.e. during the transition, many software packages and technologies will have to be replaced simultaneously, as well as integrated with all systems of the enterprise.

The cluster analysis method was used to identify digital transformation strategies in industry. The key factor in the division of industrial companies was the factor of "the participant composition of digital services and business processes based on the principles of mutually beneficial relationships." The factors "Implemented digital technologies", "Reach of transactions" and "Cost optimisation" were also distinguished. As it follows from the analysis, two large clusters were identified – enterprises building Platform business models (I) and enterprises building "Factories of the future" (II), which differ from each other in the participant composition of digital services and business processes based on the principles of mutually beneficial relationships. These clusters, in their turn, were reanalysed in terms of the implemented digital business models, at which point five other clusters were distinguished that differed from each other in terms of the availability of the ecosystem (1),

Fig. 7. Presents the availability of certain Digital business models among Russian manufacturing sectors




*Source:* compiled by the author.

consumer involvement in joint value co-creation (2), the ability to implement a customising product (3), building of a "smart factories" model (4), the ability to implement remanufacturing and digital engineering (5). Thus, the division into Clusters I and II is due to the possibility of building platform business models, and the companies of each distinguished Cluster 1, 2, 3, 4, 5 have similar characteristics of business models of digital transformation. Within each cluster digitalisation strategies of enterprises using a particular business model were selected, and the digital business models used by industrial companies were also characterised.

In further research we plan to analyse how the implemented business model affects the financial results and the efficiency of industrial companies. Also, in further studies, it would be possible to expand the survey sample and include not only industrial manufacturing, but also other industries. In addition, it seems advisable to analyse how the implemented business model affects the financial results and efficiency of industrial companies.

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