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The problem of interpretation, differentiation and classification of digital products

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Abstract

Digital innovative products often become a significant factor in the revision of companies' business strategies and influence consumer preferences. A key component in the process of formulating such strategies is understanding the implications underlying the attributes of digital products. This requires a good understanding of their nature and characteristics. To date, there is no solid basis for classifying various digital products according to their inherent characteristics. This paper presents a new interpretation of "digital products" based on the analysis of 2954 scientific articles from the Scopus database. It discusses the problems of differentiation of digital products from other types of products (such as "cyber-physical products," "digitized products," "smart products," etc.). We also developed a new classification of digital products by the method of highlighting their key attributes. The purpose of the study is to develop an advanced classification of digital products based on their differentiation from other types of products. The classification we constructed based on the principles of differentiation will allow innovators and businessmen to create more profound and more advanced business models.

Keywords: digital products, digitalization, physical product, classification, cyber-physical products, bibliometric analysis

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Introduction

The popularity of the Internet has given companies around the world many tasks related to the promotion of their products via e-commerce. In particular, an increasing number of companies, including publishers, banks, news and insurance agents, are revising the concepts of their products in order to create and sell digital versions of traditional goods and services [1]. The growing popularity of selling digital products as the main way to make a profit has prompted business leaders and research scientists to study optimal competitive strategies associated with the sale of these products [2]. Interest in digital products is also noted in the number of published scientific articles on this topic. *Figure 1* shows the trend in the number of publications over the past 10 years for the keyword "digital product" (materials from the Scopus article database were used). It can be remarked that the greatest "surge of interest" occurred in the period 2019–2020. This can be attributed to the COVID-19 pandemic, when the demand for digital products increased significantly [3–6].

Different digital products demonstrate different growth rates [7], which largely depend on the main characteristics of the product [8–10] and the market environment [11–14]. Often, even minor changes in the structure of a digital product can seriously affect demand and change the existing market [15]. According to Christensen, innovations that significantly affect the market and break technological cycles are called "disruptive" [16].

Thus, different types of digital products require different approaches in modeling and in ways of implementation in the business process. Despite this, there is no solid basis for classifying various digital

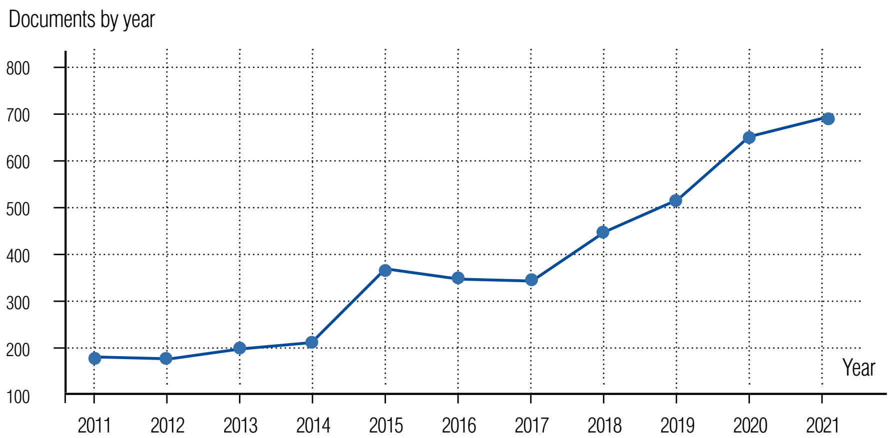

Fig. 1. The number of published articles on the topic "digital products" (based on analysis of articles from the Scopus database).

products according to their inherent characteristics [17]. The impact of digitalization on business and technology has several aspects that directly affect the digital architectures of products and services. Unfortunately, the current modeling approach for developing proper models of digital services and products suffers from the presence of many uncontrolled diverse approaches and modeling structures. High-quality digital models should follow a clear concept of value and service. Next, an attempt will be made to systematize and classify digital products based on their main types and characteristics. The purpose of the study is to develop an advanced classification of digital products based on their differentiation from other types of products.

There is also currently no reliable relationship between digital strategies and business modeling. Value is usually associated with utility and combines such categories as importance and desirability [18]. The concept of value is important in the development of appropriate digital services and related digital products.

1. Interpretation of digital products

What is a digital product? From the point of view of economic theory, most digital products are public goods delivered privately with all the consequences that follow from this: "the problem of the stowaway" and "tragedy of the commons" [19]. With the transition to the digital format, these problems are only getting worse, and the problem of combating media piracy on the Internet is becoming more complex than in the former analog world. Another definition is given in study [20], where the representation of a digital product as visual and verbal elements from the point of view of mental images was additionally studied. In article [21], the concept of a digital product is a complex scientific category that is subject to change.

Initially, when digital technologies were developed, they themselves were digital products [22]. This logic implies that digital products include digital devices (for example, mobile devices) and related (complementary) goods and services (for example, software). In the course of the spread of digital technologies, the typologization of digital products has also become more complicated. At the moment, these include not only digital devices, but also digital services, as well as manufactured and sold goods. However, such a classification of digital products closely intersects with the definitions of "intelligent products" and "cyber-physical products," which does not allow us to fully disclose the meaning of "digital products".

The interpretation of digital products also depends on who is the beneficiary of the introduction of a digital product to the market. The attitude of stakeholders to the digital product is contradictory [23]. For the state, this product is a means of developing the digital economy, stimulating an increase in the global competitiveness of the economic system and accelerating its economic growth. An example of the macroeconomic advantages obtained by replacing traditional (pre-digital) products with digital ones is to increase the transparency of economic activity and prevent tax evasion [24]. Another example is the reduction of government spending on the money supply during the transition to electronic money [25].

In turn, it is also beneficial for entrepreneurs to support the popularization of digital products, since they create business benefits. One of these advantages is the reduction of business risks and costs in the long term [26]. For example, online trading helps us to minimize reserves (logistics optimization) and more accurately predict demand (marketing optimization). Another advantage is associated with the expansion of activities: diversification of sales markets and obtaining "economies of scale." For example, e-commerce companies can conduct business cooperation and sell their products in remote markets, which is very difficult in the case of conventional retail. As a result, the importance of network effects is growing.

Modern consumers are showing increased interest in a digital product due to its greater availability and lower price compared to a pre-digital product. Thus, the popularity of online commerce, online finance and online public services is growing. However, consumers prefer a digital product only if it is of high quality [27]. Although consumers do not always take advantage of the lower price of a digital product, in most cases they face such disadvantages of a digital product as a high risk of its purchase and use (due to novelty, ambiguity of the legal field and other reasons).

This contradiction – high demand with high uncertainty indicators – constrains the production and sale of digital products and slows down the development of the digital economy. Attempts to overcome this by improving the quality of a digital product in the conditions of the modern digital economy are ineffective due to the weak development and underdevelopment of the scientific vision of the quality of a digital product as an economic category [28]. Therefore, an important scientific and practical task is to overcome the existing contradiction with the most complete, accurate and correct definition of the quality of a digital product as an economic category. To do this, it is important to identify the factors that can be used to distinguish between "digital" and "physical" products.

Digital products can be distributed without loss in a purely digital form (for example, using computer networks.). A digital product serves a specific purpose, is intended for sale or exchange, and can satisfy the user's desire or need. Other criteria that help distinguish digital products from physical ones can be found in *Table 1.*

Industrial standard items are static. Only a small amount of alteration is possible with them. Digital products, on the other hand, are dynamic. They include both cloud services and software. Through network connections, they can be updated. As a result, the functionality of the products can be modified to meet the evolving demands and wants of clients. Digital goods and services might be produced gradually or offered momentarily. Digital products can be copied almost free of charge and are subject to non-commercial copying by end consumers. Since the quality of the copy usually does not deteriorate, copies can become available on a large scale. At the same time, the problem of online piracy is becoming more acute. Article [34] analyzes the basic models of piracy, models with indirect assignment, models with network effects and models with asymmetric information.

Digital products are able to capture their own state and present this information in related contexts [35]. The so-called "servitization of products" is based on this. The buyer is not being sold a physical product, but a service. The supplier can remotely determine if the product is working and initiate maintenance and repair if necessary. Evaluation of the status information and analysis of the product usage history allow you to predict when a malfunction is likely. Maintenance or replacement of the product is performed before the predicted failure. The collected data also provides information for on-site repairs, so that a high speed of problem solving can be achieved the first time. Thus, it is possible to significantly reduce unplanned shutdowns of products.

Digital products also allow network effects [36], which grow exponentially with the number of participating devices [37, 38]. Increasing the number of digitized products increases incentives for additional service providers. At the same time, it makes further product digitization more appealing. Network effects arise not only to enhance functionality, but also for the analytical use of data collected by digitized products (network intelligence). It is feasible to spot patterns considerably earlier and more accurately by merging data from numerous devices.

Digital products and services become part of an information system that accelerates learning and cognition processes in all products [39]. In parallel, a number of other useful effects can be achieved, such as network optimization, maintenance optimization and improved recovery capabilities when considering individual systems [40]. The consumer turns into a "co-producer" [41]. Platforms complement products that interact through standardized interfaces.

Table 1.

The difference between a "physical" and a "digital" product

Criteria	Digital product	Physical product
Product properties		
Value after use	After the first use, they are identical to new ones, and in some cases even better (for example, for digital games, the achieved levels add value). Only "moral" wear and tear is relevant (for example, obsolescence, going out of fashion, etc.) [29].	Usually depreciated after purchase and use ("used product"). For these products, the concepts of "depreciation" and "physical and moral" wear are relevant.
Product flexibility and service delivery speed	Flexible products. Changes can be easily and quickly implemented in the product. However, this may cause certain difficulties in the context of intellectual copyrights. The possibility of instant "delivery" of the order (or access).	Static products: the composition, idea, appearance, design of the product are usually clearly defined, and the introduction of any changes is accompanied by a change in the product itself. There are delays in the delivery of products: additional difficulties are created in logistics issues.
Costs		
Fixed and variable product costs	High fixed costs for R&D. A small or practically zero cost of delivery per unit of product. Low overhead.	There are certain fixed costs. Non-trivial unit delivery cost.
The costs of "audience building," the problem of network effects	Audience growth depends on the influence of the network effect and "accumulates" faster than for a physical product. This reduces the cost of attracting an additional audience.	High costs. The effect of the "network effect" depends on the type of product.
Transaction costs	Low, completion of purchase and sale agreements "in a few clicks".	High.
The costs of product search, "menu", switching and copying	Low. Piracy and copyright issues arise when copying.	High. Copying requires copying directly the physical object itself.
Risks		
Risk for the developer	The risk can be high for products such as digital games, because market demand and reaction to it are very volatile. To mitigate risks, development managers usually use non-cascading business process methodologies: Agile [30] or Scrum [31] project management methodologies.	Depends on the nature of the product. For seasonal products, market demand is very unstable, and the risk is high. Cascading project management methodologies are mainly used for product output, plus there is a need to create "roadmaps" for product development.
Risk to consumers	It may be high, since consumers may have to learn how to use the product, and they may not know about it long before buying.	May be available for touch and detailed visual examination before purchase.
Information asymmetry	Low information asymmetry. The occurrence of the principal-agent problem is less likely [32].	High information asymmetry. The high significance of the principal-agent problem.

Criteria	Digital product	Physical product
Market factors		
Price discrimination and market segmentation	Price discrimination is possible, but unlikely due to the lack of information asymmetry. It is preferable to use Big Data analysis for audience and market segmentation. Moderate accuracy, significant role of quantitative marketing research [33].	Price discrimination of all three types is likely. Audience analysis is carried out mainly with the help of various surveys, focus groups and other methods of marketing analysis. Low accuracy, high error, high influence of subjective factors (for example, cognitive distortion such as "observer error/bias").
Profitability	Higher profitability compared to "physical products": there are no recurring costs for goods, hence saving most of the profits.	Profitability is usually lower than that of "digital products": usually due to high fixed production costs.
Disintermediation	Intermediaries are often excluded from the service provision process.	Often, the active participation of 1–2 intermediaries is necessary.

Producers will not simply rely on supply and demand according to marginal revenue and marginal cost pricing. Based on the characteristics of the digital products themselves, the cost price, the network market environment, the characteristics of consumer behavior and network expansion, the theory of group pricing follows [42], on the basis of which a business strategy is put forward and a business model is built.

2. Differentiation of digital products from other types of products

Based on the identification of the definition of digital products and their differentiation from physical products (an attempt to solve the "interpretation problem"), it is possible to build models of digital business strategies. However, there are currently no articles in the scientific community that would clearly distinguish between such concepts as intelligent products, digitalized (digitized) products, cyber-physical products, digital products, etc. *Table 2* presents definitions of these concepts, and *Fig. 2* shows a comparison of terms in Euler circles (an attempt to solve the "differentiation problem").

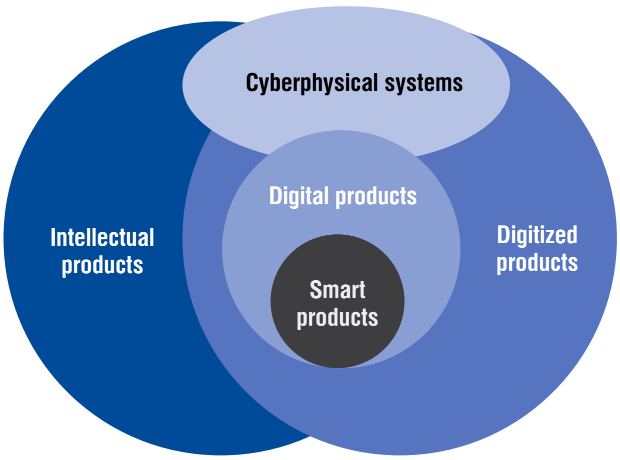

Fig. 2. Differentiation of terms related to different types of digitalized products.

Table 2.

Separate concepts and concepts related to "digitized products"

Concept	Description
Digitized products	"(...) digitization makes physical products programmable, addressable, intelligent, sociable, memorable, traceable and associated (...)" [43]. Such products combine physical and digital attributes. The inclusion of the physical shell in the definition is an important factor. When building various models, it is necessary to take this into account.
Cyberphysical systems	"(...) represent the integration of computing with physical processes. Embedded computers and networks monitor and control physical processes, usually with feedback loops when physical processes affect calculations and vice versa (...)" [44]. Cyber-physical products, in addition to the physical shell, take into account the internal "physical processes" of the product.
Intelligent products	"(...) contain the possibilities of perception, memory, data processing, reasoning and communication (...)" [45]. Intelligent products are separated from being classified as physical matters; here the "content" of the product comes to the fore, namely the ability of the product to store, process and transmit information.
Smart objects	"(...) have a unique identity, are able to communicate effectively with the environment, can store data about themselves, use language and are able to make decisions (...)" [46]. The definition is very similar in meaning to the definition of "intelligent products." Smart objects are part of the "smart products" system. The key point here is the ability to make decisions and communicate to the external environment [47]. They know not only about the steps of the process that have already been completed, but are also able to determine future steps [48]. Sensors allow you to record physical measurements, cameras – to receive visual information about the product and its surroundings in real time.
Smart, connected products	"(...) consist of physical components, intelligent components (sensors, microprocessors, data storage, controls, software, operating system) and connection components (ports, antenna, protocols) (...)" [49]. The definition is close in meaning to the definition of "digitalized products." However, the definition is narrower: these products refer specifically to "smart objects."
Internet of things	"(...) everyday objects can be equipped with identification, recognition, networking and processing capabilities that will allow them to communicate with each other and with other devices and services via the Internet (...)" [50]. The definition emphasizes the systemic nature of such products. Objects can make decisions and interact with both humans and other robotic objects.

3. Classification of digital products

The problem of "digital products" is being dealt with by scientists from different fields of life. One of the ways to classify objects is to classify them by scope of application. Data from the Scopus website was used to construct the following tables and figures. From *Fig. 3* and *Table 3* it can be noted that the most popular areas where the theoretical foundations and practical methods of using digital products are studied are computer science, engineering, social sciences, management and business, mathematics, etc.

The complexity of identifying clusters for classification is observed when clustering terms based on the

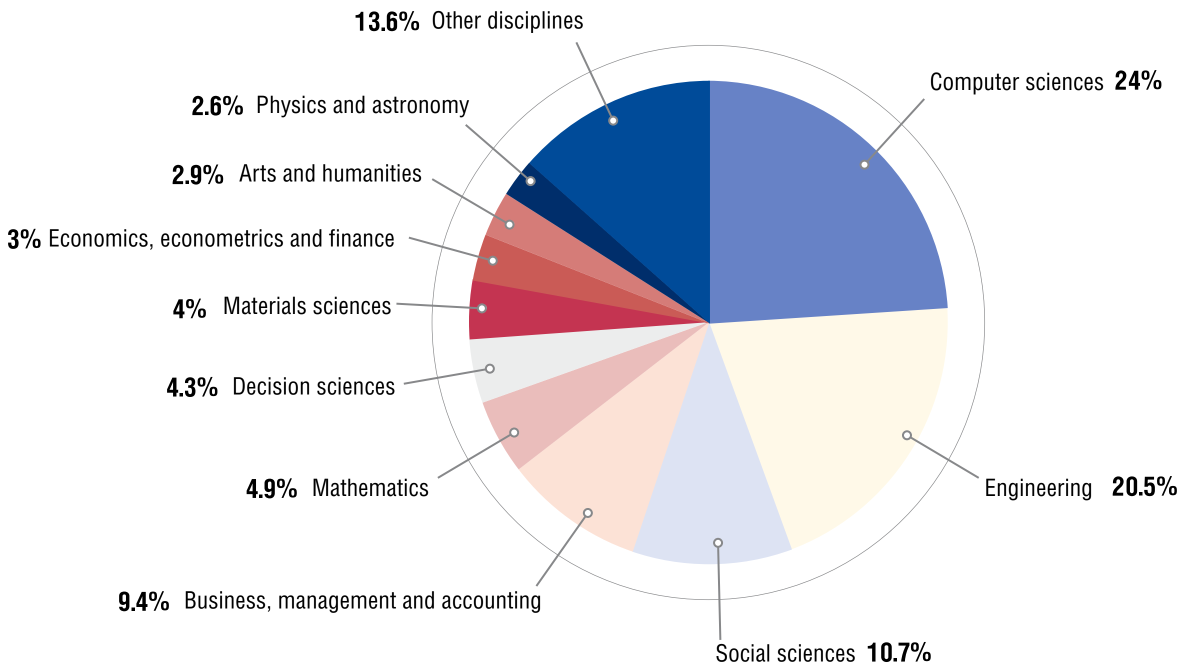

Fig. 3. Distribution of publications on digital products by research categories based on bibliometric analysis of the Scopus database.

processing of 2954 articles from the Scopus database (*Fig. 4*). The methodology proposed in the article [51] was used to build a term map. To cluster terms, the VOSviewer program was used, which identified five large clusters.

The first cluster includes terms from the field of digital technologies. Digital technologies, such as additive manufacturing, artificial intelligence, cloud computing, data analysis, social networks and wireless sensor networks [52, 53], open up unprecedented opportunities for the development and release of new products [54]. Rather, this cluster reflects the applied nature of the use of digital products in the context of digital production. Digital production is a digital representation of the entire production process. It includes three main components: a digital factory, a virtual factory and the corresponding data management. The second cluster includes areas of application of digital products (for example, in the field of sales). The third cluster highlights the spheres of interaction between a machine and a person. The fourth cluster reflects measures to protect digital products. The fifth cluster emphasizes the importance of digital innovation.

Figure 4 also shows a heat map of keywords by year. Such a map allows you to highlight the basic (fundamental) concepts within the digitalization process, as well as new elements that relate to the topic under study. New directions in this area are digital twins, digital transformation, added reality, digital innovations within the concept of "Industry 4.0".

Some authors, among them [55–57], distinguish a separate niche in the classification of digital products in the form of "digital data". In 2018, a new measure emerged based on the foundation of data citation: data

Table 3.

Number of articles on the term "digital products" by research disciplines

Sphere	Number of articles	Sphere	Number of articles
Computer science (Informatics)	3812	Energy and energy systems sciences	251
Engineering	3259	Chemical engineering	179
Social sciencies	1706	Psychology	159
Business, management and accounting	1492	Agricultural and biological sciences	155
Mathematics	786	Chemistry	119
Decision sciences	679	Biochemistry, genetics and molecular biology	110
Materials science	636	Multidisciplinary directions	70
Economics, econometrics and finance	483	Health sciences	68
Arts and humanities	464	Neurology	40
Physics and astronomy	418	Dentistry	21
Environmental science	373	Nursing	19
Earth and planetary sciences	316	Pharmacology, toxicology and pharmaceuticals	16
Medicine	253	Immunology and microbiology	12

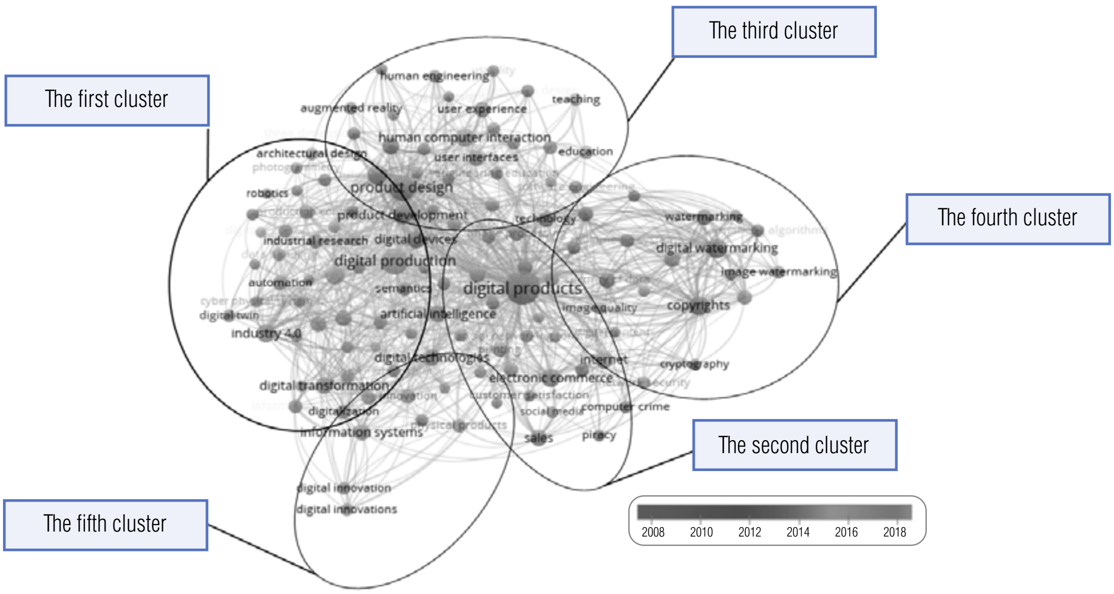

Fig. 4. Cluster map and keyword heat map.

reliability is a real value reflecting the importance of data cited by a research organization [58].

There is such a phenomenon as digital information products (DIP), which are a subset of digital products. DIP is a special type of digital product, the main advantage of which is the provision of information [59]. DIPs often consist of a mixture of information and software. The difference between DIP and pure software is that DIP is focused on delivering information. In this respect, only a limited set of software systems can qualify as DIP [60]. DIP is widely distributed, for example, electronic magazines, films, electronic weather reports, digitized educational programs, textbooks and lectures.

The main limitation of all existing classifications is a vague idea of the object under study: there is no clear opinion on how digital products differ from other types of products. In this article, about 2 954 articles were studied to highlight this problem. Thanks to the differentiation of products, it is possible to build a better classification. *Figure 5* shows an approximate division of digital products into categories. The constructed classification is based on "differentiated criteria": only those types of digital products that differ markedly from other categories of digitalized products are included in the classification. In future works, it is planned to expand the existing classifications. To enhance the depth of the construction of classifiers of digital products, it is necessary to identify additional criteria that determine the differentiation of one category by a product from others. For example, article [62] suggests several classifications of digital products based on the allocation of various criteria: 1) digital products based on content; utilities and tools; online services; 2) categories based on the concepts of 4P, 4S and 4S; 3) based on the possibility of litigation and the degree of detail. Despite the fact that the authors create a systematic view of the problem and strive to

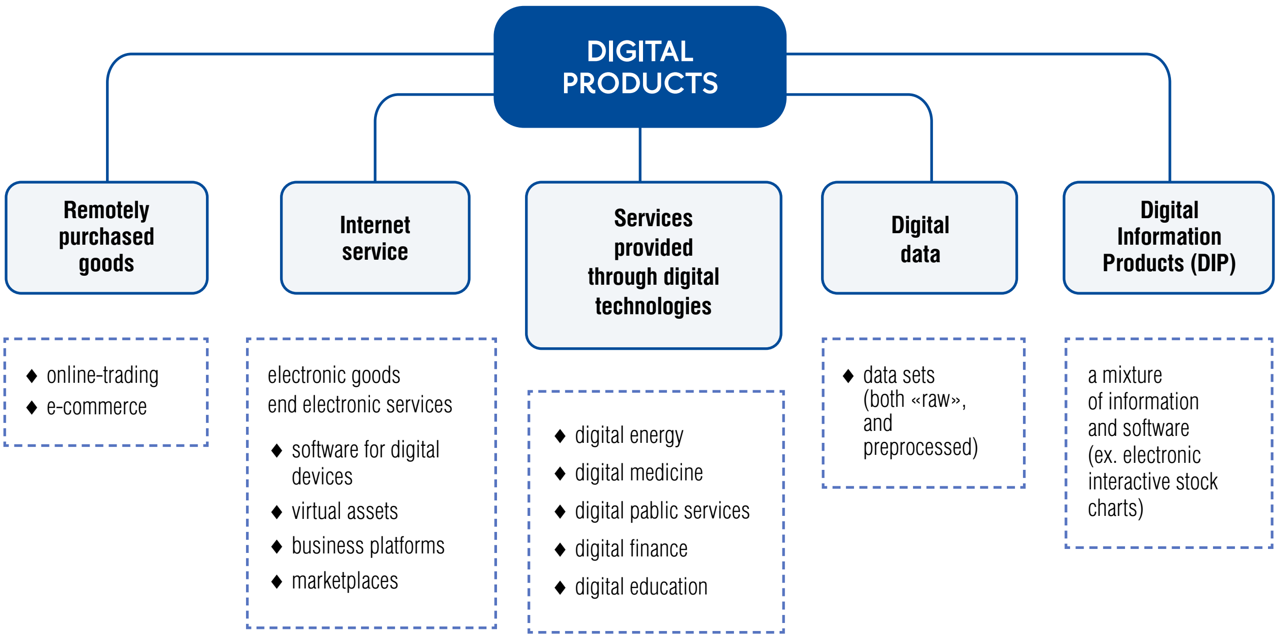

Fig. 5. Classification of digital products based on their differentiation from other types of digitalized products.

combine all the criteria into a single structure, the proposed classification does not take into account the nature of digital products, as well as differences between digitalized products. To further develop the concept of "digital products," it is necessary to study the methods of modeling classifiers.

Among the methods of classifier modeling, we can distinguish: sentimental methods, the Rocchio method, the probabilistic classification method (Bayes method), clustering methods, etc. Future articles may also be devoted to the issues of comparing the effectiveness of using the above modeling methods.

The next stage in the development of this topic is the construction of various business models where digital products are used. Understanding the specifics of digital products for modeling is extremely important, since business models often include a description of product characteristics. Digital products do not have a physical form as such. As we can see, there are certain factors that can significantly affect the quality of models. Those rules that are optimal, for example, for physical products, may not be relevant for digital products.

Article [61] uses a hybrid system based on fuzzy modeling to identify dependencies between user characteristics and the evaluation of digital products in order to develop a dynamic pricing system. Currently, industrial companies are gradually moving from a product-oriented business model to a service-dominant logic. Such logic offers personalized products and services in the form of a set of solutions to meet individual customer needs.

Conclusion

Digital product development has been booming in recent years due to the maturity of the entire environment. However, most e-commerce research still focuses on physical products and misses the value of the digital wave. In this article, criteria were proposed by which it is possible to distinguish between physical and digital products. To further build a product development strategy, it is critically important to understand the main characteristics by which one type of product differs from another. Among the criteria that make it possible to distinguish between physical and digital products, the following can be distinguished: the properties of the product itself, the costs of production, distribution, support, etc. of products, risks and market factors. Understanding the structure and properties of the product, as well as key attributes, will make it possible to commercialize them more efficiently and fit them more harmoniously into the country's economic system.

The development of digital product platforms is a prevailing trend in many industries. As firms introduce digital technologies into established product categories, they need to cope with tensions at several organizational levels, including strategy, technology and structure. A new fundamental paradigm shift in industrial production is brought about by the integration of Internet technologies and cutting-edge technology in the area of "smart" items, which is based on the digitization of factories. The future of production envisions modular and effective production systems as well as scenarios where goods manage their own manufacturing processes.

There is an evolution of Internet systems combining features of both technical and economic aspects. In this regard, there is a problem with solutions related to modeling and managing various aspects of the organization of the system. This article presents options for interpreting digital products, as well as their differentiation and classification. The differentiation of digital products from other types of digitalized products allows you to differentiate the areas of research, and also helps to investigate individual categories of certain forms of products based on their differentiation. The implication is that understanding these differences can create a clearer picture of the perception of a complex technological world.

Innovations in the digital world are increasingly being developed in the field of open platforms consisting of basic technology and a large number of additional products developed by an ecosystem of independent complementary companies. The literature on the platform ecosystem mainly focuses on indirect network effects arising from the number of add-ons, with little attention to the quality of add-ons. Joint actions of platform owners and users are needed to respond to opportunities, failures and obsolescence. ■

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