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The Nature of Lean Manufacturing of Information Economic Products

Oleg N. Melnikov [1], **Nikita A. Gankin** [2]

[1] Bauman Moscow State Technical University, Moscow, Russian Federation
5, building 1, 2nd Baumanskaya street, Moscow, 105005

[2] Russian Presidential Academy of National Economy and Public Administration (RANEPA), Moscow, Russian Federation
82, Vernadskogo prospect, Moscow, 119571

[1] melnikov@creativeconomy.ru
[2] ngankin@yandex.ru

Abstract

In this article a research of the nature of modern enterprises development is presented, characterized by moving from material-based to information-based economic products. It was discovered that economically developed enterprises have almost exhausted their potential for further growth due to organizational improvements, previously affecting mainly the material part of the economic product. Therefore, studies on improving the efficiency of the production organization of information economic products are becoming more and more relevant.

Purpose: *the main purpose of this research is to develop extended principles of lean manufacturing of information economic products. To achieve this goal following tasks were resolved: material intensity analysis was implemented, the structure of information economic product (IEP) was examined, traditional principles of lean manufacturing were reviewed and expanded for information economic product creation.*

The object of the research are modern industrial enterprises that apply the concept of lean manufacturing or similar. The subject of the research are the principles of lean manufacturing for creating an information economic product.

Methods: *the time series extrapolation method and the empirical analysis method were used to calculate the material intensity index of products. Abstract and comparative analysis methods were applied to develop the extended principles of IEP lean manufacturing. In addition, methods of analysis and synthesis, the historical method, as well as elements of factor analysis were used for the study.*

Results: *the material and information structure of the economic product is considered and proposed. The nature of the dynamics of its changes in the process of changing the stages of technological and economic development of scientific and technological progress is justified, which allowed us to argue the vector of changes in the structure of costs for creating a modern material product in terms of increasing information and reducing material components. The constantly rising costs of creating information increasingly characterize it as a market product that has its own cost structure, which gave reason to classify it as an information economic product (IEP). In this regard, the structure of the information economic product was studied and developed, based on the analysis of the term of "information" both from the perspective of the organization and operational management and from the perspective of related branches of knowledge. As a result of the comparative analysis, extended principles of IEP lean manufacturing were developed.*

Conclusions and Relevance: *the analysis of the material intensity index revealed a tendency to a continuous decrease in the material intensity of the economic product and an increase in the information component. As a result of the study of the structure of the information economic product, it was revealed that the potential for increasing the economic efficiency of modern industrial enterprises is primarily laid in improving logical data processing. It is proposed to achieve this by using the developed extended principles of IEP lean manufacturing, among which the main one is the principle of intellectual and creative reciprocity.*

Keywords: *lean manufacturing, information economic product, information, data, knowledge, intellectual and creative resources, trust, confiding relationships*

Conflict of Interest. *The Author declares that there is no Conflict of Interest.*

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Особенности бережливого производства информационного экономического продукта

Олег Николаевич Мельников [1], Никита Алексеевич Ганькин [2]

[1] Московский государственный технический университет имени Н.Э. Баумана (национальный исследовательский университет)», Москва, Российская Федерация

105005, г. Москва, ул. 2-я Бауманская, д. 5, стр. 1

[2] Российская академия народного хозяйства и государственной службы при Президенте Российской Федерации, Москва, Российская Федерация

119571, г. Москва, проспект Вернадского, д. 82

[1] melnikov@creativeconomy.ru

[2] ngankin@yandex.ru

Аннотация

Цель. *Основной целью данного исследования является разработка расширенных принципов бережливого производства информационного экономического продукта. Для достижения поставленной цели были выполнены следующие задачи: проведен анализ показателя материалоемкости экономических продуктов, исследована структура информационного экономического продукта (далее – ИЭП), проанализированы и расширены традиционные принципы бережливого производства для создания информационного экономического продукта. В качестве объекта исследования выступают современные промышленные предприятия, использующие концепцию бережливого производства и ее аналоги. Предметом исследования являются принципы бережливого производства при создании информационного экономического продукта.*

Метод или методология проведения работы. *Для расчета показателя материалоемкости продукции были применены метод экстраполяции временного ряда и метод эмпирического анализа. При разработке расширенных принципов бережливого производства ИЭП использовались методы абстрагирования и сравнительного анализа. Кроме того, для исследования применялись методы анализа и синтеза, исторический метод, а также элементы факторного анализа.*

Результаты работы. *Рассмотрена и предложена материально-информационная структура экономического продукта. Обоснован характер динамики ее изменения в процессе смены этапов технологического и экономического развития научно-технического прогресса, что позволило аргументировать вектор изменения структуры затрат на создание современного материального продукта с точки зрения повышения информационной и снижения материальной составляющих. Постоянно возрастающие затраты на создание информации все больше характеризуют ее как рыночный продукт, имеющий свою структуру себестоимости, что дало основание классифицировать ее как информационный экономический продукт. В связи с этим была исследована и разработана структура информационного экономического продукта, базирующаяся на анализе понятия «информация» как с позиции организации и управления производством, так и с позиций смежных отраслей знаний. В результате сравнительного анализа были разработаны расширенные принципы бережливого производства ИЭП.*

Выводы. *Анализ показателя материалоемкости выявил тенденцию к непрерывному снижению материалоемкости экономического продукта и росту информационной составляющей. В результате исследования структуры информационного экономического продукта выявлено, что потенциал повышения экономической эффективности современных промышленных предприятий заложен, в первую очередь, в улучшении логической обработки данных. Достичь этого предлагается за счет использования разработанных расширенных принципов бережливого производства ИЭП, среди которых основным является принцип интеллектуально-креативной взаимности.*

Ключевые слова: *бережливое производство, информационный экономический продукт, информация, данные, знания, интеллектуально-креативные ресурсы, доверие, доверительные отношения*

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Introduction

Nowadays information has taken a leading place in the economy, and acts as a special economic product that plays a crucial role in the functioning of modern industrial enterprises. Therefore, it is clearly insufficient to consider information only as part of an information product, that is a conventional belief today, without taking into account the specifics of its production. This fact became the basis for specifying the very concept of an economic product in order to improve the quality of information research as an economic product.

As we suggested earlier [1], an economic product should be understood as all the goods that are produced to meet the ever-increasing needs of the market. At the same time, the peculiarity of the proposed approach is the fact that an economic product always has both a material and informational basis. That is why, the economic product, depending on the main need to be met, should be classified as two separate types of economic products: material economic product (MEP) and information economic product (IEP). As a result of this research, clear definitions of these concepts were formulated:

- material economic product (MEP) is a type of economic good, whose main function is the ability to meet the material needs of a person in an open market (examples include cars, furniture, household appliances, food, etc.);
- an information economic product (IEP) is a type of economic good whose main function is the ability to meet the information needs of a person in an open market (examples are software, books, technical documentation, advertising, etc.).

It should be noted that, according to the research of modern authors [1-5], currently there is a tendency to position information not only as a product of intellectual labor, which ensures the transition to the production of high-tech products of a new generation, but also as a tool for increasing labor productivity in the manufacturing of material economic products. In particular, it was noted [3] that manufacturing of an information economic product is "one of the fastest growing sectors of the economy". Consequently, the study of information production in the form of an economic product, which plays a crucial role in improving the economic efficiency of enterprises in the information economy, becomes an urgent scientific task.

At the same time, at the end of the XX century, as part of the transition from an industrial society to an information society, many industrial enterprises that have already become familiar with the Japanese experience of Toyota began to introduce the concept of lean manufacturing. In those times the material component in the structure of the economic product prevailed, the introduction of this concept was primarily aimed at minimizing material losses. It is important to note that lean manufacturing at the end of the XX century made a real revolution in the field of production organization, considerably increasing the efficiency of enterprises [6].

However, according to modern research, nowadays there a tendency of reduction of economic efficiency gained from the use of the traditional concept of lean manufacturing of a material economic product is observed [7]. In our opinion, this is due to the growth of the information component in the structure of the economic product and the corresponding increase in information losses. Therefore, the improvement of the concept of lean manufacturing used in the creation of material economic products should be thoroughly investigated from the standpoint of expanding the use of its principles in the production of information economic products.

Literature Review

Any economic product has two components: material and informational. Based on the structural analysis of E. Toffler [8], who noted that humanity has passed through the agrarian, industrial and post-industrial stages of society development, it can be argued that any material economic product becomes more intellectually saturated with scientific and technological development. That is, the information component of the economic product, which reflects the growth of labor intellectualization when creating a new product, becomes predominant in relation to the material one. And today it is often an independent information economic product. This confirms the well-known scientific conclusion that with the development of the industrial revolution, the information component becomes objectively dominant, sharply reduces the material component of many economic products, and therefore saves material resources, which for many years in the economy were considered as the main factor in increasing the economic efficiency of production and the entire national economy. It is logical that today the main factor in increasing

[1] Melnikov O.N., Gankin N.A., Esipenko D.A. Changing the economic role of the information product in meeting the needs in the process of intellectualization of material production. Journal of Economics, Entrepreneurship and Law. 2019; 9(4):437–438. doi: 10.18334/epp.9.4.41515.

economic efficiency in production, including material economic products, is the economy of information resources. This fact is confirmed by the research of the President of the world economic forum, Professor Klaus Schwab, who concluded that the cost of the information component in modern cars reaches 40% of the cost of the product itself, displacing the material component [9]. Therefore, it is not surprising that, according to earlier research conducted under the leadership of academician Nikita N. Moiseev that currently, more than 80% of time and cost expenditures are spent on working with information [10]. This once again confirms the fact that the role of information as an economic product is currently not just increasing, but becoming crucial. However, despite the increase in the number of researchers of this problem, many authors note that in modern scientific society there is still no common understanding of such multidimensional terms as "data", "information" and "knowledge".

For example, academician Nikita N. Moiseev argued that the term "information" is too broad, and a strict definition cannot be given [10]; Fritz Machlup does not distinguish the concepts of "information" and "knowledge", claiming that information is a part of our knowledge [11]. However, in our opinion, it is necessary to note that there is a fundamental difference between the terms "data", "information" and "knowledge", which many authors refer as synonyms. In particular, the work of the philosopher Tom Stonier notes that "data" is a set of unrelated facts and observations [12], and Peter Drucker believes that only "data" with meaning and purpose becomes "information" [13]. That is, in fact, the raw "data" does not carry any "information" but is a dry display of the physical processes taking place.

Today, many authors are increasingly paying attention to the emerging signs of the fourth industrial revolution, which is based on working with information, its production, processing, storage and transmission. If the production of material of economic output, the main source of losses is always an irrational process, then the production of information of economic output, the main source of losses becomes inefficient organization of data processing that determines the quality of transmission and reception of information. This is what determines the cost-effectiveness of transmission, perception, and, ultimately, practical use of an information product. This, in our opinion, was the reason for the conflict that led to the rupture of relations between two talented founders of the world-famous Apple company, Steven Jobs and Stephen Wozniak. They could not fully understand the logic of transmitting each other's information, which led to almost complete misunderstanding of each other's business problems [14].

There are many studies, the authors of which seek to use the successful experience of applying lean manufacturing at the end of the XX century in the current situation [15–19]. Indeed, this concept would allow many enterprises to significantly increase their labor productivity and efficiency, and therefore improve the main performance indicators [20–24].

Let's look at this concept in more detail. It is known that it is based on two basic principles laid down by its founders, Japanese engineers Sakichi and Kiichiro Toyoda [25]:

- The first principle – "jidoka" (translated from Japanese as "built-in quality"), is aimed at ensuring the production of exclusively high-quality products. The idea is that if defective products appear, the equipment will be automatically stopped and not started until the root cause of the defect is identified and eliminated.
- The second principle – "just-in-time", is necessary to ensure the timely production of products necessary for the consumer. The idea is to produce only the products that the consumer needs at a given time, in the required quantity and in the required time frame.

Efficiency is achieved by reducing costs while significantly improving the quality of manufactured products using the minimum possible amount of material resources [2] and eliminating 7 types of major losses [25]: inventory, overproduction, unnecessary operations, unnecessary movements, defects, transportation and waiting.

As you can observe, in this list there are only losses associated with physical (material) processes occurring in enterprises, which can be easily identified within the framework of routine work. However, today, in developed industries, the situation has changed dramatically. Intellectual (information) processes are playing an increasingly important role, and it is very difficult to find and measure losses from inefficient use. In particular, Jeffrey Liker was one of the first to draw attention to one missing type of loss – the unused creative potential of employees [26].

[2] Melnikov O.N., Larionov V.G., Gankin N.A. The main stages of the production organization of innovative development from the standpoint of the dynamics of lean manufacturing principles application. *Russian Journal of Innovation Economics*. 2016; 6(3);239-258. doi: 10.18334/vinec.6.3.36996.

Materials and Methods

A number of general scientific methods (abstraction, comparison, analysis and synthesis), as well as special methods (extrapolation, historical) of research were used.

The methods of abstraction and comparative analysis were used in the development of the principles of lean manufacturing of an information economic product, since it was assumed that their nature is largely similar to the principles of lean manufacturing of a material economic product.

To study the structure of the economic product, methods of analysis and synthesis were used, based on a comprehensive study of the works devoted to the concept of "information".

The historical method was used to describe stable trends in the development of industry, based on fundamental theoretical works in this field of research, for further analysis of the structure of the modern economic product.

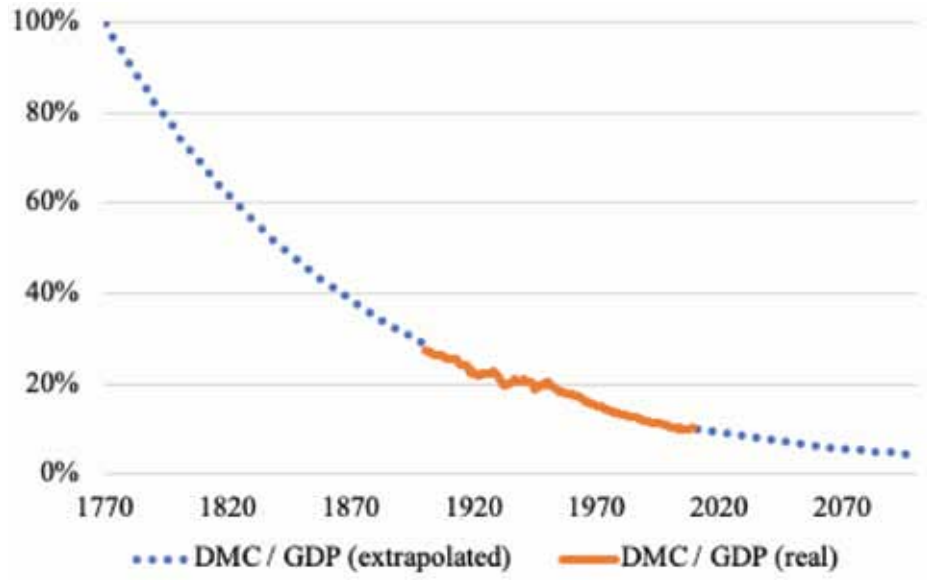
The study also used methods of extrapolation and analysis of the time series of the material consumption index. The empirical basis of this analysis was the study of Fridolin Krausmann, devoted to the analysis of historical data for the DMC (Domestic Material Consumption) [27], as well as recommendations for calculating the United Nations industrial development organization (UNIDO) material intensity indicator.

In addition, factor analysis was used to assess the impact of each component of the information product on the efficiency of modern industrial enterprises.

Results

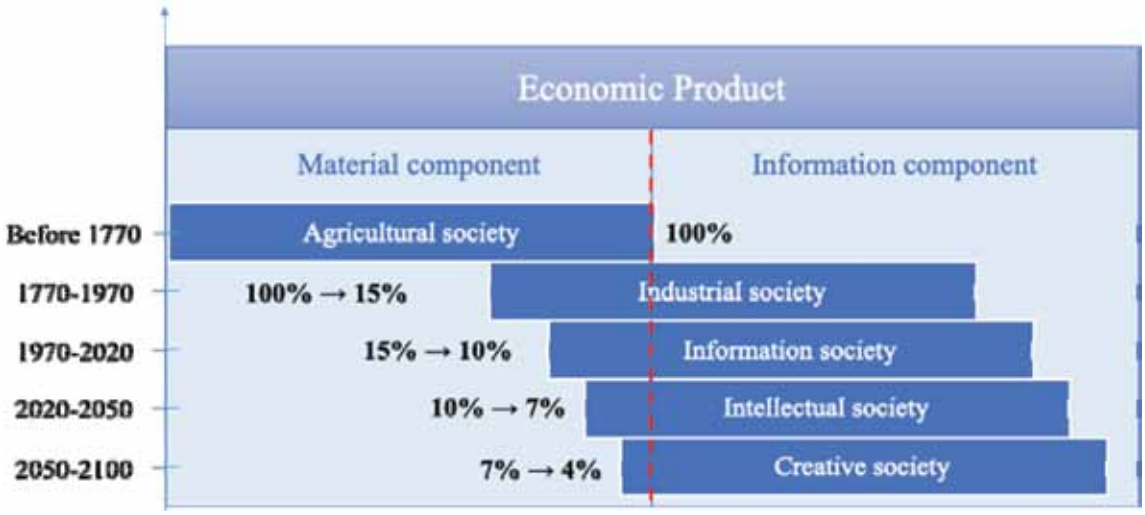
In our opinion, nowadays a number of aspects of the lean manufacturing concept are significantly outdated and do not take into account the historical features within which modern society operates. Particularly, the constant growth of the information component in the structure of the economic product. This trend was shown in [27], where the author analyzes, among other things, the dynamics of the values of the accumulated indicator of material intensity, which, according to the recommendations of the United Nations Industrial Development Organization (UNIDO) [28], can be used to judge the material intensity of products. The study [27] provides calculated data for the period from 1900 to 2009 for the global economy, using which we selected the function that most correctly describes the resulting trend. In our case, an exponential function was chosen, since the approximation confidence value was R^2 = 97,5%. As a result, we were able to construct forecast values of the material intensity index for 100 periods ahead, up to 2100, and for 130 periods back, up to 1770 (see figure 1). At the same time, the obtained values were normalized relative to the earliest value (1770) for clarity of the results.

Analyzing the data illustrated in Fig. 1, it can be argued that the material consumption of products



Developed by the authors based on the empirical research data [27].

Fig. 1. Extrapolated and normalized values of the product material intensity index (1770–2100)



Developed by the authors based on the empirical research data [27].

Fig. 2. The dynamics of changes in the share of material and information components in the structure of economic product

has been continuously decreasing since the end of the XVIII century to the present day. In our opinion, this is due to the replacement of the material component of the economic product with the information one.

Let's consider the dynamics of changes in the share of material and information resources in the structure of economic product production from the perspective of changes in the social responsibility of the producer during the change of economic epochs (Fig. 2).

The information component of the economic product has always existed, starting from the agrarian society. At this stage of economic development, it appeared in the form of traditions that reflected the result of long-term observations of changes in natural phenomena and were transmitted in the form of religious knowledge from generation to generation. They expressed the level of social development of society and regulated the social responsibility of producers of an economic product, which was controlled by Ministers of religious cults. At that time, information accounted for a smaller share of the economic product compared to its material component. According to our research presented in figure 1, in the early period of time, approximately before the first industrial revolution in 1770, the material consumption of products was close to 100%. In other words, the information component was practically absent.

The transition from the agrarian to the industrial era was due to the growth of the intellectual and creative component, which allowed to increase the productivity of not only industrial, but also agricultural labor. At the same time, knowledge developed simultaneously in both types of activity, which made it possible to switch from manual labor to mass production of material economic products, primarily in the agricultural sector of the economy. It follows that the development of each subsequent economic stage is due to the fact that there is a significant, sometimes explosive growth of knowledge (intelligence) within the previous stage. And, as a rule, this applies to either mechanization or automation of manual (physical) labor.

In the era of industrial society, structures and technologies became the main (basic) information components of an economic product and met not the requirements not of traditions, as it was in the era of agricultural development, but those of standards and regulations. At the same time, production responsibility for their compliance is determined by the state (up to criminal liability), and social responsibility is assigned to the manufacturer.

This made it possible to organize mass and large-scale production of goods and largely balance the ratio between the material and information components. In other words, in the era of industrial society, after the first and second industrial revolutions [9], accompanied first by the replacement of manual labor with machine labor, and then by the organization of in-line production, there was a tendency to a significant increase in the information component of the economic product.

According to our research, in this period (1770–1970) there is the greatest decrease in the material intensity of the economic product – from 100% in 1770 to 15% in 1970. This is due to the fact that during this time there were three industrial revolutions that determined this trend.

The change of the industrial stage of society's development to the informational one is also accompanied by a significant increase in labor productivity in the production of a material economic product, which makes it possible to switch from cost-intensive to lean production and release a mass product with individual properties. A striking example is additive, or 3-D technologies, which are, on the one hand, the result of significant intellectual and cognitive costs, and on the other hand, they are a subject of considerable impact of standards. This type, as well as similar high-tech technologies, should be attributed to the transition period of scientific and technological development of the economy – from the industrial stage to the information stage.

Finally, after the third industrial revolution, it is information technologies that begin to be widely used [9], which determine the transition to the era of the information society, where the norms of information ethics come to the fore as an information component instead of standards – since the social responsibility of the manufacturer is regulated by society, which requires the production of a high-quality information economic product. In other words, the quality control functions of economic products are objectively transferred to the consumer society, while reducing the material component of the economic product to a minimum. A striking example here is the changes in computer technology that have occurred in front of the modern generation. Thus, it can be argued that in present the era of dominance of the information component in the structure of modern economic products has come [3]. It follows that the share of the information component of the modern economic product increases irreversibly. Moreover, its growth is becoming more and more intense, which proves the justice of the society's transition to the information stage of its development.

This is also confirmed by the results of our research, according to which the indicator of material consumption of products for the period from 1970 to the present day has decreased from 15% to 10% and is accompanied by the emerge of the fourth industrial revolution.

The upcoming fourth industrial revolution will be characterized by the widespread use of technologies that allow us to process quickly large amounts of data (artificial intelligence). There will be a transition to an intellectual society, where the information component will play a dominant role in the structure of the economic product. Further, in the transition from an information society to an intellectual one, the increase in labor productivity will be achieved through the production of an information economic product. This growth will be achieved through the transition from cost-intensive MEP production to IEP lean manufacturing.

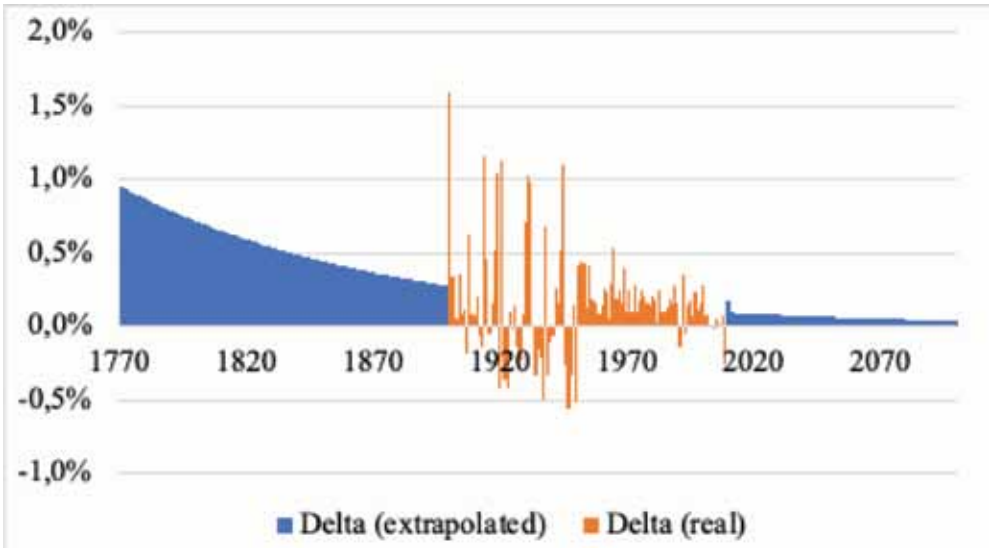
In our opinion, this stage of development of the society will last from 2020 to 2050. During this period, according to our research, the material intensity index will decrease by 3%, and will reach 7% by 2050.

As a result, in our opinion, our society should move to the creative stage of its development, characterized by the leading role played by the creative class in the economy. First of all, it will require efforts from the new generation of management, which will have to create an atmosphere of special confiding relationships in the team, contributing to the creative emancipation of employees. A change of intellectual epoch to the creative one when the creative activity from the economic perspective becomes not only the primary one, but also causing the need of its performance by the majority of workers, will be accompanied by growth of productivity of intellectual labor, while minimizing intellectual costs, which will lead to maximizing the use of development of knowledge and create an opportunity for limitless expansion of creative abilities. That means, the "economy of creation" will come.

The period of existence of the creative society, according to our research, will last from 2050 to 2100 and during this period the indicator of material consumption of products will decrease by another 3%, and, as a result, will achieve the level of 4% by 2100.

Throughout the entire study period, from 1770 to the projected year 2100, the indicator of material consumption of products shows a continuous decrease.

[3] Melnikov O.N., Gankin N.A. Technological prospects of the lean manufacturing of information economic product as the basis of economic growth in the information economy. *Technological perspective within the Eurasian space: new markets and points of economic growth.* Saint-Petersburg: Asterion, 2018. P. 49–53.



Developed by the authors based on empirical research data [27].

Fig. 3. Dynamics Of increments in material consumption of products from 1770 to 2100

In our opinion, this drop in material consumption of products is determined both by the development of technologies and by the reduction of production losses. Moreover, according to our research, this trend satisfies the principle of decreasing marginal material consumption, that is, over time, a further decrease in material consumption by 1% is achieved with increasing labor costs (see Fig. 3).

If at the end of the XX century it was quite easy to achieve an increase in efficiency by reducing physical actions, today this potential has significantly decreased. It is obvious that, due to the growth of the information component of the economic product, it is necessary to pay attention to this aspect as a new potential for a significant increase in the efficiency of enterprises.

Let us look at the main components of information in more detail. From our point of view, "data" can be considered as an analog of raw materials, which, before reaching the end user, must go through a certain sequence of operations in order to acquire the required characteristics to meet the need. Developing the approach of Marc Porat in relation to the definition of "information", by which he meant processed and transmitted "data" [29], our previous research has shown [4] that, regardless of what phenomenon "information" describes or displays, it always includes conditionally constant (transmitted "data") and conditionally variable (logical processing and data transmission) components.

It follows that data becomes meaningful if and only if the subject who seeks to transmit it "packs" it into the logic of events in order to achieve a solution to a specific problem. It follows that "information" (I) should be considered as the logical product of two components – C and V [5]. This can be called a universal information formula:

$$I = C \wedge V ,$$

where C (constant) is data that acts as a certain part of knowledge that one person wants to transmit directly (through direct contact) or virtually (in writing) to their environment or society as a whole (contact or contactless);

V (variable) – the logic of data representation, which acts as a logical component of communicating data to the understanding of those to whom this data is intended (contact or contactless).

[4] Melnikov O.N., Gankin N.A. Technological prospects of the lean manufacturing of information economic product as the basis of economic growth in the information economy. *Technological perspective within the Eurasian space: new markets and points of economic growth.* Saint-Petersburg: Asterion, 2018. P. 49–53.

[5] Melnikov O.N., Mashninova Y.V. The fundamental model of knowledge exchange organization in market conditions. *Russian business.* 2012; 13(14):94–99.

At the same time, it is important to note once again that "data" is classified as a conditionally constant value, since it reflects the objectively recorded result of a particular physical or intellectual process chosen by the subject of information transmission, which in his opinion is objective and can be transmitted to an object or group of objects.

The "logic" of the representation of these data is a conditional variable, since the choice of linguistic reception of transmission (logical explanation) depends on the level of intellectual and creative potential and the subject as a source transmitting information, and the object receiving information (receiver).

As for "knowledge", in our opinion, it is an ordered and structured internal information for a person, which can be finally presented in the form of his new knowledge. A similar view of the concept of "knowledge" was described in the works of Daniel Bell [30]. In fact, information is the first derivative of knowledge, and data is the first derivative of information:

$$K = I' = C''$$

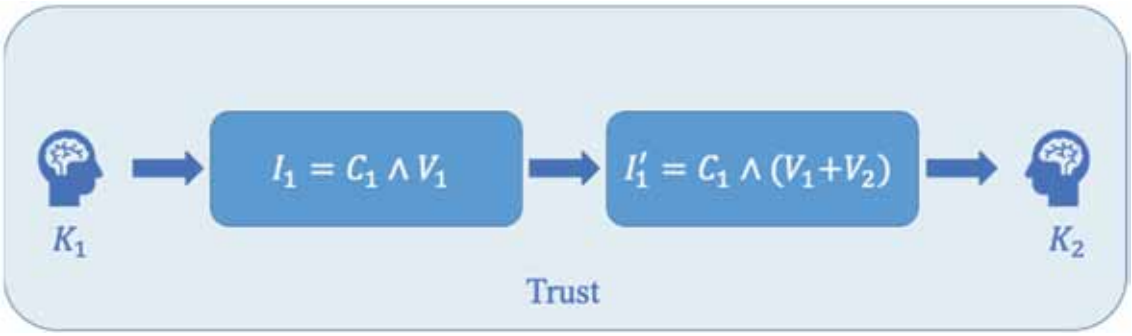
where K – knowledge, I – information, C – data.

It is interesting to consider the process of creating an information component of an economic product. This process is much more diverse than the process of creating a material component. In particular, a new information component can be created in the process of exchanging information from person to person. This model of information exchange organization in the market conditions is shown in Fig. 4.

The source of knowledge (subject 1) has some information, which consists, as discussed above, of data (C_1) and logical connections (V_1), with which the subject processes the available data. It should be noted that the value of the final information depends on the quality of the logical representation of data, which, in turn, being the value of a conditional variable, depends on the theoretical knowledge and practical experience of the subject 1 and is the most expensive component in the process of creating and transmitting information. Accordingly, in order to transfer some of its knowledge (K_1) in the form of information (I_1) to object 1, subject 1 needs to "pack" the transmitted data into logical connections (V_1). then object 1 interprets the received information, imposing its logical connections V_2 on it, which also depend on its level of training. As a result, the information processed and structured in this way turns into the knowledge of object 2 (K_2), which will differ in the case of a different level of training or an insufficient level of trust between subject 1 and object 1, which will lead to an asymmetry of information considered in the work of Nobel laureates in Economics George Akerlof, Michael Spence, and Joseph Stiglitz [31–33].

Except for the cases of direct communication between people – between the subject transmitting information and the object receiving it directly – information can be created within the framework of human-machine interaction. For example, a programmer who imposes his logical connections in the form of code for writing a website uses computer technology to do this.

Taking into account the above-described mechanism of information exchange, we will proceed to the



Developed by authors.

Fig. 4. Model of information exchange in the market conditions

[6] Melnikov O.N., Mashninova Y.V. the role of information ethics in creating economic products. *Scientific periodicals problems and solutions.* 2013; (3):6–13.

study of how to increase the productivity of modern enterprises through more efficient production of an information economic product.

Our research has shown that, by analogy with the concept of MEP lean manufacturing, the concept of IEP lean manufacturing can be developed. The mission of this concept is the successful transition of modern society to the next stage of development (industry 4.0). The main goal remains the same – maximizing value for the customer. Despite the fact that the goal has not changed, there is a number of differences between the concepts of value in lean manufacturing of MEP and IEP (Table 1).

Table 1

Main differences between the concepts of value in MEP and IEP lean manufacturing

MEP lean manufacturing	IEP lean manufacturing
Minimization of physical labor losses	Minimize loss of intellectual labor (the decrease in information entropy)
Reduced time to perform physical operations	Reduction of information exchange time
Ensuring the required product quality	Ensuring compliance with information ethics
MEP manufacturing on time and in full	IEP manufacturing on time and in full
Creating an atmosphere of trust between the manager and his subordinate	Creating an atmosphere of trust between the subject of transmission and the object of receiving information

Developed by authors.

The essence of the proposed concept is to substantially improve the quality of information produced using the minimum possible quantity of information resources. Under the quality of information, we understand its compliance with the norms of information ethics [6].

Consider what can be attributed to the elements of information ethics. Some of them, in particular, are given in Table 2.

All listed norms of information ethics in the Table 2 are controlled by a person, their openness and control by society today largely determines its information development.

Thus, the sufficiency of information contained in an information economic product is determined by the level of development of education, since a more educated population requires a minimum

Table 2

Usage of informational ethics norms regarding to the stages of society development

Norm	Agricultural society	Industrial society	Informational society
Sufficiency	±	+	+
Truthfulness	-	+	+
Availability	+	+	+
Reliability	-	±	+
Usefulness	-	+	+
Timeliness	±	+	+
Accuracy	-	±	+
Stability	±	+	+
Value	+	+	+

Developed by authors.

of information about the product. Conversely, the information must be maximum, otherwise this product will not develop its own market in a given country.

The trustworthiness of information ensures the constancy of sales of an information product, since it forms a confiding relationship between its manufacturer and consumer.

Availability of information is also one of the most important norms of information ethics, which, being essentially an integral characteristic, ensures both the functioning of the IEP market and the development of society as a whole.

The reliability of information ensures the stability of the IEP market; it affects both the preservation of consumer confidence in the reputation of the manufacturer of a particular information economic product, and the consumer properties of information (the lemon market [31]).

The usefulness of information determines its practical significance and the possibility of wide, including market distribution among consumers.

The timeliness of information entering the IEP market determines the quality and duration of its life cycle as an important information component of any new material or informational economic product.

The accuracy of information determines the effectiveness of the practical application of the IEP and its economic feasibility, which, in the end, determines the economic efficiency of its practical use.

Information stability determines the safety of using an IEP and the stability of its life cycle.

The value of information is one of the most important norms of information ethics, since it combines both the cognitive and social significance of information and is often first perceived at the level of feelings, and only then tested in practice.

Based on the above requirements, by analogy with the production of a material economic product, three key principles of IEP lean manufacturing were identified:

Principle 1. Principle of ethics to ensure the quality of information product manufacturing. Its essence is that before getting to the consumer, the information must be checked for compliance with the norms of information ethics (see Table 2).

Principle 2. "Just-In-Time" principle, which logically also should be applied to the production of information economic product. It consists in providing the product at a certain time and in the required volume.

Principle 3. Principle of intellectual and creative reciprocity means that both the subject (source of information) and the object (receiver of information) must meet the principle of equivalence of their creative abilities in the exchange and practical use of transmitted knowledge. Failure to comply with this principle will lead to information asymmetry and the problem of an insufficient level of trust.

As already mentioned, "leanness" in the production of a material economic product, first of all, is achieved by reducing the 7 main material losses while eliminating actions that don't add value to the final product. In the production of an information economic product, "leanness" consists in accelerating the object's perception of the logic of the information transmitted to him so that he could make optimal decisions either on its processing and further transfer to the next object, or on its independent practical use.

At the same time, a special role is played by the level of trust between the subject and the object, which is a significant factor that will largely determine the degree of leanness in the production of an information economic product. A good example is the "Dieselgate" scandal that occurred in 2015 with the Volkswagen automobile company and led to such a decrease in the level of trust that consumers preferred to lease the car rather than buy it, thereby shifting the risk of further resale of the car to the leasing company. The consequences of the loss of consumer confidence cost the us market $ 6.44 billion [34].

Conclusions and Relevance

Using the conducted research of the accumulated indicator of material intensity, it was found that the information component in the structure of the modern economic product plays a dominant role. This leads to the fact that society moves first to the intellectual, and then to the creative stages of its development, when creative activity begins to play a leading role in the economy.

Considering the information component, it was found that "information" (I) should be considered as a logical product of two components – data (C) and the logic of their communication (V), which can be recommended as a universal information formula.

Moreover, the main source of information losses in the IEP production is precisely logical data processing.

Thus, it is proposed to consider the IEP production taking into account the possibility of applying the concept of lean manufacturing. The developed extended principles of the concept of lean manufacturing are aimed at reducing information losses associated with the logical transmission of information from the subject to the object of transmission for making optimal decisions. At the same time, a special role is played by the atmosphere of trust, which should be maintained both within companies and in society as a whole.

By analogy with the MEP production, 3 key principles of IEP lean manufacturing are identified, the use of which will significantly reduce the information losses of modern industrial enterprises:

- the principle of ethics;
- the "just-in-time" principle;
- the principle of intellectual and creative reciprocity.

As a result of the research, the concept of lean manufacturing was expanded, the use of which will allow modern industrial enterprises to reduce the cost of creating information economic products by reducing information losses and subsequently enter a new round of economic efficiency growth.

References

1. Petryashov D.V. Information benefits: concept, economic content and specifics. *RISK Resources, Information, Supply, Competition*. 2013; (4):281–286. URL: https://elibrary.ru/item.asp?id=21144802 (In Russ.)
2. Glozman A.B. Modern production: expansion of information and the principle of inversion determination of reality. *Philosophy and society*. 2011; (1):110–129. URL: https://elibrary.ru/item.asp?id=16220605 (In Russ.)
3. Skripkin K.G. Economics of information products and services. Moscow: faculty of Economics, Lomonosov Moscow state University, 2019. 192 p. (In Russ.)
4. Bobkov S.P., Vlasov A.P., Ioffe A.Y. Formalization of the concept of "information product". *Information resources of Russia*. 2005; 6(88):17–18. URL: https://elibrary.ru/item.asp?id=11592166 (In Russ.)
5. Olatoye M.E. "Information products" and "information services" in modern society. *Vestnik Moscow State Institute of Culture*. 2009; 5(31):196–201. URL: https://elibrary.ru/item.asp?id=13023271 (In Russ.)
6. Womack J.P., Jones D.T., Roos D. The Machine that Changed the World: The Story of Lean Production. New York: Harper Perennial, Free Press, 1990. 352 p.
7. Scheel O. et al. Digital Lean: The Next Stage in Operations Optimization // A.T. Kearney. 2015. P. 7. URL: https://files.kf5.com/attachments/download/31133/7357588/0015d7a0775e9ff36528186cc6b2b
8. Toffler A. The Third Wave. New York: Bantam Book, 1980. 448 p.
9. Schwab K. The Fourth Industrial Revolution. Geneva: World Economic Forum, 2016. 116 p.
10. Moiseev N. N. Parting with simplicity. Moscow: Agraf, 1998. 480 p. (In Russ.)
11. Machlup F. The Production and Distribution of Knowledge in the United States. New Jersey: Prinston University Press, 1962. 444 p.
12. Stonier T. Information and Meaning: An Evolutionary Perspective. London: Springler, 1997. 249 p.
13. Drucker P. The Coming of the New Organization. *Harv. Bus. Rev.* 1988; Vol. Jan-Feb. P. 1–11. URL: https://hbr.org/1988/01/the-coming-of-the-new-organization
14. Isaacson W. Steve Jobs: A Biography. Simon & Schuster Inc, 2011.
15. Trstenjak M., Cosic P. Lean Philosophy in the Digitalization Process // MOTSP2018 Conference Proceedings. Zagreb: FSB, 2018. URL: https://www.researchgate.net/publication/327542498
16. Mrugalska B., Wyrwicka M.K. Towards Lean Production in Industry 4.0. *Procedia Engineering*. 2017; 182:466–473. https://doi.org/10.1016/j.proeng.2017.03.135
17. Küpper D. et al. When Lean Meets Industry 4.0. *Bost. Consult. Gr.* 2017; (12/17):15. URL: https://www.bcg.com/publications/2017/lean-meets-industry-4.0
18. Wagner T., Herrmann C., Thiede S. Industry 4.0 Impacts on Lean Production Systems. *Procedia CIRP*. 2017; 63:125–131. https://doi.org/10.1016/j.procir.2017.02.041
19. Mayr A. et al. Lean 4.0-A conceptual conjunction of lean management and Industry 4.0. *Procedia CIRP*. 2018; 72:622–628. https://doi.org/10.1016/j.procir.2018.03.292
20. Mourtzis D., Papathanasiou P., Fotia S. Lean Rules Identification and Classification for Manufacturing Industry. *Procedia CIRP*. 2016; 50:198–203. https://doi.org/10.1016/j.procir.2016.04.097
21. Sutari O. Process Improvement Using Lean Principles on the Manufacturing of Wind Turbine Components

– a Case Study. *Mater. Today Proc.* 2015; 2(4–5):3429–3437. https://doi.org/10.1016/j.matpr.2015.07.318

22. Santos Z.G., Vieira L., Balbinotti G. Lean Manufacturing and Ergonomic Working Conditions in the Automotive Industry. *Procedia Manufacturing.* 2015; 3:5947-5954. https://doi.org/10.1016/j.promfg.2015.07.687
23. Yang T. et al. Lean production system design for fishing net manufacturing using lean principles and simulation optimization. *Journal of Manufacturing Systems.* 2015; 34:66–73. https://doi.org/10.1016/j.jmsy.2014.11.010
24. Das B., Venkatadri U., Pandey P. Applying lean manufacturing system to improving productivity of airconditioning coil manufacturing. *The International Journal of Advanced Manufacturing Technology.* 2014; 71(1–4):307–323. https://doi.org/10.1007/s00170-013-5407-x
25. Ohno T. Toyota Production System: Beyond Large-Scale Production. M.: Institute of integrated strategic research, 2005. 192 p. (In Russ.)
26. Liker J. The Toyota Way: 14 Management Principles From the World's Greatest Manufacturer. Moscow: Tochka group, 2017. 400 p. (In Russ.)
27. Krausmann F. et al. Growth in global materials use, GDP and population during the 20th century. *Ecological Economics.* 2009; 68(10):2696–2705. https://doi.org/10.1016/j.ecolecon.2009.05.007
28. Upadhyaya S. Material intensity – a key indicator of sustainable industrialization // EGM on the Indicator Framework for the post-2015 Development Agenda. New York, 2015. P. 1–5. URL: https://unstats.un.org/unsd/post-2015/activities/egm-on-indicator-framework/docs/Presentation by UNIDO- Example of Sustainable Industrialization SDG Indicator_EGM-Feb2015.pdf
29. Porat M.U. The Information Economy: Definition and Measurement. Washington, 1977. 319 p.
30. Bell D. The Coming of Post-Industrial Society: A Venture in Social Forecasting. New York: Basic Books, 1973. 620 p.
31. Akerlof G.A. The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics.* 1970; 84(3):488–500. https://doi.org/10.2307/1879431
32. Spence M. Job Market Signaling. *The Quarterly Journal of Economics.* 1973; 87(3):355-374. https://doi.org/10.2307/1882010
33. Rothschild M., Stiglitz J. Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information. *The Quarterly Journal of Economics.* 1976;. 90(4):629-649. https://doi.org/10.2307/1885326
34. Hachenberg B., Kiesel F., Schiereck D. Dieselgate and its expected consequences on the European auto ABS market. *Economics Letters.* 2018; 171:180–182. https://doi.org/10.1016/j.econlet.2018.07.044

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About the authors:

Oleg N. Melnikov, Faculty of Engineering Business and Management, Bauman Moscow State Technical University (BMSTU) (5, building 1, 2nd Baumanskaya street, Moscow, 105005), Moscow, Russian Federation, Doctor of Economic Sciences, Professor, **ORCID: 0000-0002-9488-7241**, melnikov@creativeconomy.ru

Nikita A. Gankin, Postgraduate, Economic Faculty, Russian Presidential Academy of National Economy and Public Administration (RANEPA), (82, Vernadskogo prospect, Moscow, 119571), Moscow, Russian Federation, **ORCID: 0000-0003-3749-9469**, ngankin@yandex.ru

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