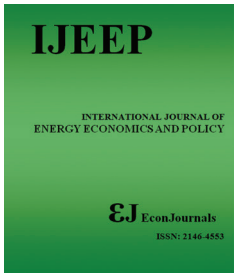

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Modeling the Efficiency of Using Digital Technologies of Energy and Resource Saving Technologies at Petrochemical Enterprises

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ABSTRACT

This article proposes an evaluation approach and carried out modeling of the impact of the introduction of energy saving technologies in the petrochemical enterprises using the DuPont model. The article is relevant due to the fact that the organization of energy and resource saving technologies in the petrochemical complex is still not been fully resolved and require further research of their effectiveness and efficiency evaluation at the sectoral and micro- levels of management. The purpose of this article is to assess the effectiveness of the use of digital energy and resource saving systems in the petrochemical complex. There are used description and comparison methods as the main research methods, which made it possible to identify the trends in the digitalization of the petrochemical industry in the field of energy and resource saving in comparison with the business sector and the manufacturing sector as a whole; analysis of the productional - operation and financial activities of petrochemical industry enterprises, which made it possible to evaluate their effectiveness. The article proposes a methodology for assessing the effectiveness of the use of digital technologies of energy and resource saving at petrochemical enterprises based on the DuPont model and conducted its approbation by the example of the petrochemical sector of the Russian economy. The materials of the article can be used in the development of strategies and programs to improve the efficiency of energy and resource saving systems at petrochemical enterprises in the context of industrial digitalization.

Keywords: Energy Saving, Resource Saving, Petrochemical Enterprises, Digital Technologies, Industrial Digitalization, The Dupont System of Analysis
JEL Classifications: L60, Q43, C21

1. INTRODUCTION

The digital transformation of the industrial complex of the global economy is enshrined in many programming documents that have been developed and approved at various levels of management in the past few years. Digitalization of the industry - is a means of obtaining integrated production, which brings customers - a result, owners of the enterprise – a profit. The concept of the digital industry includes: production management, assessment and achievement of the required level of reliability of the production system, planning, scheduling and analysis of production processes, evaluation of the effectiveness of the implementation of energy and resource-saving technologies. According to the Ministry of Economic Development, Rosstat, the Central Bank of the Russian Federation, Euromonitor International, HIS, McKinsey Global institute (General, 2020) the potential increase in the Russian economy's Gross Domestic Product from industrial digitalization in 2025 will be 19-34%, of which a 4% point increase is projected due to the optimization of production and logistics operations, by 2.9 - due to the efficiency of labor resources, by 1.4% point - due to increased productivity of equipment and by 0.5% points - due to increased R and D productivity and product development.

According to the International Telecommunication Union (2020) and the World Bank (2020), characterizing the level of development of information and communication technologies

(ICT) in industry by two global indices - the ICT development index and the Global cybersecurity index, Russian industry is above average and its positioning is similar to that of countries such as Malaysia and Italy.

Implementing industrial modernization projects, oil refineries and petrochemical enterprises pursue the following goals:

Increase in productivity due to minimizing work breaks, downtime of equipment and personnel

High industrial safety and protection against cyber-attacks

- Reduction of production costs by increasing the manufacturability and the introduction of resource and energy-saving technologies.

At the same time, the digitalization and automation of production processes at petrochemical enterprises should be comprehensive and encompass the entire value chain of the product — supply, production, distribution, maintenance and repair, and after-sales service. Considering the first stage of petrochemical production - geological-prospecting works and extraction of raw materials for production, it is worth pointing out such a trend as the concept of a digital field, suggesting a set of complementary approaches that form an integrated approach to the management of exploration, as the first step in the process of creating the value of the final petrochemical product: refined geological and engineering models, operational management of production processes and assets based on automation, integration between processes with financial, economic and other indicators of activity, teamwork and shared decision-making, stockpiling and use of knowledge, experience and performance. In the infrastructure of a petrochemical enterprise, the following structural levels of the digitalization pyramid can be distinguished, at the base of which are automated process control of technological process, then - information systems for automation, synchronization, coordination, analysis and optimization of production at the enterprise. Integration of the processes of supply, production and distribution of products is carried out within the framework of ERP-systems, integrating production and all operations of production management, human resources, finance and asset management, in order to achieve their optimal use.

In this regard, the study of modeling and evaluating the effectiveness of the development and implementation of digital technologies for energy and resource saving in industrial enterprises, where the petrochemical industry is one of the most significant in the structure of the created world added value. This provision predetermined the purpose and objectives of the study.

2. LITERATURE REVIEW

Issues of the methodology and tools for organizing energy and resource-saving production systems in the petrochemical industry in foreign and domestic scientific literature occupy one of the central positions in the field of industrial production. The organization of planning and control systems for the production processes of petrochemical industries focuses on solving the problem of using resource and energy-saving technologies to optimize the entire production chain of the petrochemical enterprise and related industries. Among the most studied issues in foreign literature in this direction, the works of the following authors should be noted: Tozzi and Jo (2017) conducted a comparative analysis of modeling tools of renewable energy based on the construction of a simulation model of productivity at a petrochemical enterprise and system optimization; Nikolaidis and Poullikkas (2017) – comparative review of hydrogen production processes as an intermediate production in the petrochemical industry; Cucchiella et al. – comparison of environmental and energy indicators of European countries based on the sustainability index; Akhavein and Porkar (2017) paid special attention to the research goals of petrochemical industries using an integrated system for testing the reliability of energy generation and transmission in petrochemicals; Ram et al. (2017) focused on reducing energy consumption in the petrochemical complex; Dellano-Paz et al. (2015) proposed a methodology for assessing the use of renewable energy in petrochemistry based on environmental and social indicators, which was tested in the framework of the program "The European low-carbon mix for 2030"; Sovacool (2015) emphasized the issues of "pollution markets" of the petrochemical complex, developing recommendations for planning energy consumption in this industry; Nasiri et al. (2015) studied innovative aspects of energy consumption in the petrochemical industry; Degtyarev et al. (2014) offered scientific support for energy and resource saving programs, Klochko and Brizhak (2019) evaluated virtual technologies in the field of energy and resource conservation in industry; Savon and Zhaglovskaya (2019) systematize alternative technologies that increase energy efficiency in the oil and gas industry. However, in these works, the key principles of energy and resource saving in chemical-technological systems, which can be considered as basic for petrochemical enterprises when introducing digital control technologies, are not fully reflected.

In our studies, we repeatedly addressed to such aspects of the organization of petrochemical industries as the innovative and digital component of management aspect in the resource saving system, which was reflected in works to increase innovative activity in the field of energy conservation based on the concept of open innovation (Kudryavtseva et al., 2016); the study of the effectiveness of organizational processes in the implementation of energy-saving technologies in the petrochemical complex (Shinkevich et al., 2019); modeling of energy efficiency factors in petrochemical enterprises (Shinkevich et al., 2020); analysis of innovative systems in the digital economy (Jalal et al., 2019) etc.

The indicated circle of unresolved issues predetermined the relevance of the study of the topics of this article.

3. DESCRIPTION OF DATA

Russian ICT indicators in the structure of the production drivers index for 2018 in the block "Technology platform," according to the analytical report of the World Economic Forum "Readiness for the Future of Production Report 2018" (The analytical report of the World Economic Forum, 2018), out of 137 countries that took part in the rating, they were distributed as follows: 39th place with a value of 6.8 (the leader of the rating is the United States with a value of 8.7), according to the assessment of the impact of

ICT on the development of new services and products, Russian industry was 82nd value of 4.2. The intensity of the use of digital technologies in the petrochemical industry among economic activities is one of the highest. So, in general, in the business sector, the intensity of using digital technologies is as follows: Broad Band WL - 80.5% of organizations (in the petrochemical industry - 91.3% of organizations), "Cloud" services - 20.5% (in the petrochemical industry - 23, 2%), RFID technologies - 5.8% (in the petrochemical industry - 8.7%), ERP systems - 17.3% (in the petrochemical industry - 22.1%), electronic sales using special forms, posted on the website/extranet, EDI systems - 12.8% (in the petrochemical industry - 19.3%). Thus, for all types of ICT used, the petrochemical industry sector shows a higher intensity compared to the business sector as a whole. However, it should be noted that the use of RFID technologies, ERP systems, and EDI systems is relatively low. On average, in industrialized countries, the intensity of the use of RFID technologies, ERP systems and EDI systems on average varies from 15-54% (Rosstat, 2020).

Describing the effectiveness of the petrochemical industry complex, it should be noted that with a decrease in the total number of enterprises in this industry from 17.3 thousand units in 2010 to 12.8 thousand units in 2018 (a decrease of 26%), the volume of reflected products increased 3 times - from 4949446 million rubles in 2010 to 14037917 million rubles in 2018. Per one petrochemical enterprise, the volume of reflected products increased from 286 million rubles in 2010 to 1097 million rubles in 2018 (an increase of 3.8 times), which generally characterizes the productivity of the petrochemical industry in terms of the volume of products shipped (Table 1 and Figure 1).

Table 1: Shipped products of the petrochemical industry

Year	Volume of products shipped, million rubles	Number of enterprises thousand units	The volume of shipped products per 1 enterprise, million rubles
2010	4949446	17.3	286
2011	6366473	17.4	366
2012	7160901	17.1	419
2013	7916927	16.5	480
2014	8950348	16.4	546
2015	9827927	17.7	555
2016	9612512	13.2	728
2017	10945398	12.8	855
2018	14037917	12.8	1097

We believe that this indicator - the volume of products shipped per petrochemical enterprise, can act as the resulting indicator of the petrochemical industry's activity, and we will use the intensity of the use of digital technologies in industrial enterprises as independent simulated variables, as explanatory factors for integration into the supply chain and the formation of unified related chains of knowledge, information, products between suppliers, the focus company, consumers and intermediaries, allowing to provide an increase in the production of petrochemical products.

Result thus, a dynamic analysis of the development of the petrochemical industry showed, along with an increase in the indicators of shipped petrochemical products while reducing the number of enterprises, a steady tendency to increase the introduction of digital technologies, including in the field of energy and resource saving, to increase the efficiency and effectiveness of productional-operation and financial activities.

4. METHODS AND MODELS

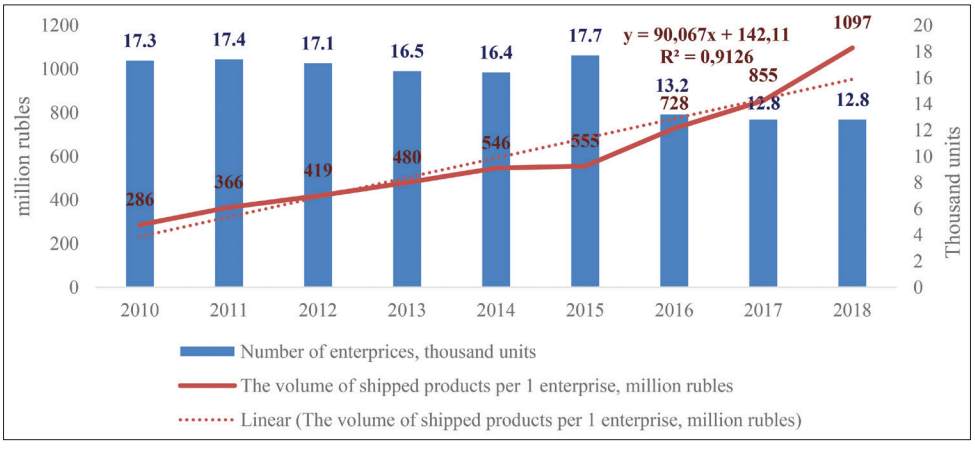
As a research method to assess the effectiveness of the introduction of digital energy and resource saving technologies at petrochemical enterprises, it is proposed to use an economic approach based on the DuPont model.

The DuPont model (or DuPont formula) is a modified factor analysis that allows you to determine due to what factors there was a change in profitability.

The name comes from the company DuPont.

At the base of the factor model in the form of a tree structure is an indicator of return on equity (ROE), and signs - characterizing factors of production and financial activities of the enterprise. In other words, the factors affecting ROE are fragmented in order to find out: which factors to a greater or lesser extent affect the ROE. The main three factors:

Figure 1: Dynamics of shipped petrochemical products



Operating margin (measured as the profit rate)
Asset utilization efficiency (measured as asset turnover)
- Financial leverage (measured as a capitalization ratio).

ROE = (Net income/Revenue) × (Revenue/Assets) × (Assets/Equity) = (profit rate) × (asset turnover) × (capitalization ratio). The purpose of the financial analysis conducted by the company is to find ways to maximize the profitability of invested capital for owners and shareholders. The profitability of the enterprise and the growth of its value for shareholders is reflected in profitability ratios. Profitability management is becoming a key task for all levels of management: strategic, tactical and operational. The company "DuPont" proposed a simple way to manage profitability by decomposing the profitability coefficient into factors that reflect various aspects of the enterprise. The three-factor DuPont model is to use the ROE as an integral indicator of an enterprise's performance and present its formula in the form of three factors. So, the formula for calculating the ROE is as follows:

$$ROE = ROS \times Kao \times LR,$$

where:
ROE: Return on equity
ROS: Return on sales
Koa: asset turnover ratio
LR: Leverage ratio (financial leverage ratio).

The three-factor DuPont model shows the impact on the company's profitability of operating activities (sales), investment and financial. As we see, the effectiveness of the enterprise's sales system directly determines the ROE and, consequently, the investment attractiveness of the enterprise. To assess the production and financial efficiency of using digital technologies in petrochemical enterprises based on the obtained production function (see more details in the work: Shinkevich et al., 2019), we consider it appropriate to apply an integrated strategic profit model (The DuPont System of Analysis - model of the company). The final indicator of the model is the ROE, and the constituent elements are the factors of production, economic and financial activities of the enterprise, which are divided into lower order components (Figure 2).

5. RESULTS AND DISCUSSIONS

For calculations we will use the following composite indicators of the model. Gross sales will be equal to the volume of shipped petrochemical products, which in 2018 amounted to 14037917 million rubles, and considering the introduction of digital technologies, they increase to 18662400 million rubles (based on the forecast of shipped petrochemical products per enterprise based on the production function model: 1458 million rubles ×12800 enterprises of the petrochemical industry). According to Rosstat, the net profit of petrochemical industries in 2018 amounted to 931952.9 million rubles. We believe that its growth due to the introduction of digital technologies will be similar to the growth rate of shipped petrochemical products and will amount to 30%, therefore, the expected net profit from digitalization of the petrochemical industry will increase to 2,870,673 million rubles. The cost of capital fund of the petrochemical industry

Figure 2: Strategic profit model (The DuPont System of Analysis - model of the company)

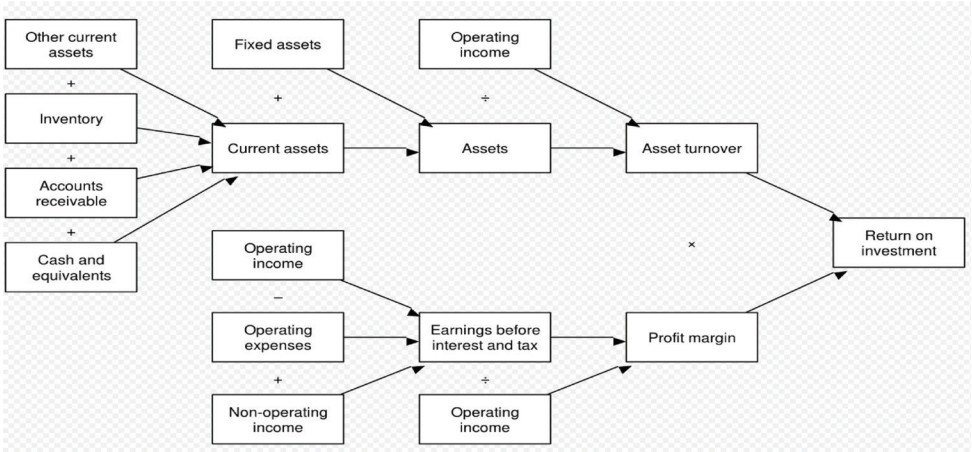
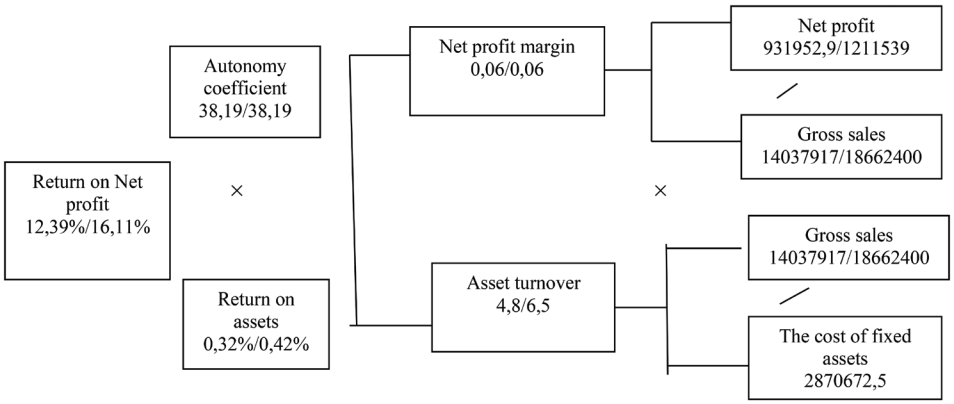


Table 2: Initial indicators for calculating the return on equity of petrochemical enterprises

Indicator	Amount before industry digitalization	Amount after industry digitalization
Shipped products, million rubles	14037917	18662400
Net profit, million rubles	931952.9	1211539
The cost of fixed assets, million rubles	2870672.5	2870673
Autonomy coefficient, %	38.19	38.19
Net Profit Margin (Net Profit / Shipped Products)	0.06	0.06
Asset turnover (shipped products / value of fixed assets)	4.8	6.5
Return on assets (net profit margin × asset turnover), %	0.32	0.42
Return on net profit (autonomy coefficient × return on assets), %	12.39	16.11

Figure 3: Model of strategic profit of petrochemical enterprises before and after digitalization of the industry



is 2,870,673 million rubles. Instead of the indicator of financial leverage, we will use the aggregate indicator of official statistics on the petrochemical industry - the autonomy coefficient, which amounted to 38.19%. Summarize the intermediate indicators for calculation in Table 2.

Represent a schematical illustration of the resulting model strategic profits (Figure 3).

Thus, the resulting effect of the digitalization of the petrochemical industry will lead to an increase in asset returns from 0.32 to 0.42, which will affect the growth of income by net worth (ROE), the value of which will increase from 12.39% to 16.11%.

6. CONCLUSION

Thus, the implementation of the goals and objectives formulated in the framework of this study allowed us to obtain a number of new scientifically-based results and test them to improve the organization of production of a number of petrochemical enterprises. Based on an improved methodology for organizing resource-saving production systems, management technologies for organizing resource-saving at petrochemical enterprises have been supplemented to increase the production efficiency and competitiveness of petrochemical plants, the quantitative effect of which is calculated by the increase in shipped petrochemical products per enterprise per year in absolute terms of 150 million rubles, in relative - by 114%. The main ways to ensure energy and resource saving at petrochemical enterprises can be systematized as follows: the method of the best use of the driving force of chemical-technological processes, the method of the best use of raw materials, the method of the best use of fuel and energy resources, the method of the best functional and structural use of instruments and machines, the method of increasing reliability and safety, risk reduction, a way of rational energy-efficient installation configuration, recycling water supply system, a method of logistic management of energy and resource efficiency of chemical-technological systems.

Prospects for the further development of the topic include the development of: multi-level logical-informational, mathematical models of production functions, applied software products for the sphere of organization of production; study of energy and resource-saving production systems for the chemical industry; development of a methodology for energy and resource saving; development of specific digitalization projects for petrochemical enterprises.

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