Influence of Energy-Saving Technological Changes on the Level of Innovativeness of Agro-Industrial Enterprises in the Conditions of Digitalization

Ihor Petrushka, Olexandr Yemelyanov, Tetyana Petrushka, Orest Koleshchuk

Abstract— The development and implementation of innovations at enterprises should ultimately ensure the growth of their profit at the expense of transition to the manufacturing of new or improved products, changes in technological processes, sales promotion, etc. In particular, an important reserve for increasing the profits of enterprises is the implementation of innovative resource-saving technological changes, first of all, technologies that provide for the saving of energy resources.

At the same time, the question of how significant is the role that energy-saving technological changes play or can play in the future among other areas of innovative activity of enterprises arises. In other words, the problem arises of assessing the impact of energy-saving technological changes on the level of innovation of enterprises, and, accordingly, on their profitability.

The main purpose of this study is to assess the impact of energy-saving technological changes on the level of innovativeness of agro-industrial enterprises in the conditions of digitalization. The indicators of evaluation of the innovativeness of enterprises are systematized. The indicators characterizing the influence of the innovative activity of the enterprise on the economic efficiency of its functioning are proposed.

Keywords: energy-saving technological change, agro-industrial enterprise, innovativeness, profit, profitability, digitalization

I. INTRODUCTION

Among the types of economic activities that have a significant impact on the formation of national income and the pace of economic development in many countries of the world are the production and processing of agricultural products. Global production of these products is limited and there is a general tendency to increase demand for it. Therefore, there is an additional potential for economic growth in those countries in which the conditions for the making and processing of agricultural products are the most favorable. In particular, Ukraine is among these countries. However, on the way of development of agro-industrial

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businesses in Ukraine exist certain obstacles, among which, in particular, it is possible to emphasize the insufficient level of innovativeness of many Ukrainian agro-industrial enterprises. The impact of innovation of any enterprises on the potential of their economic growth is due to the complex mechanism of the relationship between the volume of innovation, the level of competitiveness and the profitability of enterprises. The development and implementation of innovations in enterprises should ultimately ensure the growth of their profits through the transition to the manufacture of new or improved products, changes in technological processes, sales promotion tools, etc. Especially, an important reserve for increasing the profits of enterprises is the implementation of innovative resource-saving technological changes, first of all, technologies that provide the saving of energy resources.

At the same time, the question of how significant is the role that energy-saving technological changes play or can play in the future among other areas of innovative activity of enterprises. In other words, the problem arises of assessing the impact of energy-saving technological changes on the level of innovation of enterprises, and, accordingly, on their profitability. This task is especially relevant for the case of agro-industrial enterprises of Ukraine, many of which are characterized by a sufficiently high energy intensity of their products in comparison with foreign analogs.

It should also be noted that the realization of innovative energy-saving technological changes at agro-industrial enterprises usually requires significant investment costs. Therefore, a reasonable assessment of the feasibility of such production is important, which requires the acquisition and processing of a significant amount of information necessary for this process. In this regard, it is important to take into account modern means of improving the information support of the processes of development, adoption, and implementation of investment decisions at enterprises, in particular, the possibility of using the means of digitalization for this purpose.

II. LITERATURE REVIEW

In the conditions of increasing competition in many commodity markets, in particular, the markets of agro-industrial products, achieving the appropriate level of economic efficiency of economic activity requires enterprises to ensure their competitiveness [1]. Given the extremely important role that innovation plays in achieving competitive advantages by enterprises, improving the competitiveness of the firm requires the development of sound innovation strategies [2], in particular, strategies for technological change [3, 4]. Currently, in many countries of the world, technological changes are the determining factor of economic growth [5, 6]. Among technological changes that are made at the enterprises, it is necessary to emphasize resource-saving technological changes in which the main purpose is the increase of efficiency of use of the corresponding production resources of the enterprises [7, 8]. In particular, in modern economic conditions of many countries the processes of labor-saving [9] and energy-saving [10] technological changes are intensified. Along with it, information, financial and other barriers appear on the way of technological changes [11, 12], the removal of which can give a powerful impulse to accelerate the processes of technological renewal.

The realization of technological changes, especially changes providing the reduction of specific expenses of energy resources, has an essential influence on the majority of parameters of functioning of the enterprises. In particular, it concerns such property of the enterprises as their innovativeness. It should be noted that a number of scientific papers, in particular [13, 14], are devoted to the assessment of the innovative activity of enterprises. However, the mechanism of influence of energy-saving technological changes on the level of innovativeness of firms is currently not sufficiently investigated.

III. FORMULATION OF RESEARCH OBJECTIVES

The main purpose of this study is to assess the impact of energy-saving technological changes on the level of innovativeness of agricultural enterprises in the conditions of digitalization. To achieve this goal have been determined following tasks: indicators assessment of innovativeness of enterprises was systematized; the indicators characterizing the impact of innovative activity of enterprises on economic performance of its functionality was proposed; a methodological approach to assessing the impact of energy-saving technological change on the level of innovativeness of the enterprise was substantiated; this approach on the example of agricultural enterprises of Ukraine was implemented.

IV. PRESENTATION OF THE MAIN RESEARCH MATERIAL

The concept of enterprise innovativeness is complex and multifaceted. This necessitates the use of a multi-indicator approach to assessing the level of innovativeness of firms. According to this approach, the assessment is carried out using not one, but a number of indicators. At the same time, it seems expedient to divide the indicators by which the level of innovativeness of the enterprise is estimated into such groups:

1) indicators characterizing the volume of innovative activity of the enterprise for a certain period of time. These indicators should primarily include the following: the total number of innovations developed by the company during the reporting period; the number of innovations developed by the company during the reporting period, by type (food, technical, marketing, etc.); total number of changes introduced by the enterprise during the reporting period; number of innovations implemented by the enterprise during the reporting period, by type; volume of investments made by the company in the development of innovations; volume of investments made by the company in the introduction of innovations; the share of investments made by the company in the development and implementation of innovations in the total amount of incurred investment expenses in the reporting period; cost volume of production enterprise of innovative products in the reporting period; cost volume of sales by an enterprise of innovative products in the reporting period; the proportion of the value of production of the enterprise of innovative products in the reporting period in the total value of manufactured products during this period; the share of value sales by company for innovative products in the reporting period in the total monetary volume of sold products in this period; the number of patents for objects of industrial property, received by the company during the reporting period; the number of licenses issued by the company to use the owned objects of industrial property;

2) indicators characterizing the volume and quality of innovative resources of the enterprise. Among others, these indicators include: the initial cost of the enterprises fixed assets, which are involved in the development and implementation of innovations; the area of research laboratories of enterprises, number of employees involved in the development and implementation of innovations; the level of the technical state of the enterprises fixed assets, which are involved in the development and implementation of innovations; the level of qualification of employees involved in the development and implementation of innovations;

3) indicators of the level of novelty of innovations developed and implemented at the enterprise. This level can be estimated, using the methodology of the expert survey and the use of such quantitative indicators as the ratio of prices of improved and old products; the ratio of unit costs of resources for new and old resource-saving technologies of production; the ratio of specific profit from the production and sale of improved and old product; the ratio of specific profit from the production and marketing of products manufactured by innovative resource-saving technologies, and of the same products subject to the production of it using the old resource-intensive technologies;

4) indicators characterizing the impact of innovative activities of the enterprise on the economic efficiency of its operation. In particular, it is reasonable to use such indicators for this purpose:

- indicator of the share of profit of the enterprise from the implementation of its innovative activities in the total value of its operating profit in the reporting period:

$$I_1 = 1 - \frac{P_{ni}}{P} \tag{1}$$

where: I_1 – indicator of the share of enterprise profit from implementation of innovative activities in the total amount of its operating profit in the reporting period, shares of unit ; P_{ni} – value operating profit (loss) of the company in the reporting period which would be received by the company, if it generally did not implement innovation activity, monetary units; P – the actual value of the operating profits of the enterprise in the reporting period, monetary units;

- an indicator of the relative growth of the profitability capital of the enterprise on its operating profit as a result of innovative activities:

$$I_2 = 1 - \frac{P_{ani}}{P_a} \tag{2}$$

where: I_2 is the indicator of the relative profitability of the capital of the company by its operating profit through the implementation of innovative activities, the share of units; P_{ani} – level of profitability (loss) capital in the reporting period, which the company would have, if it generally did not implement innovation, shares of unit; P_a – the actual rate of profitability of capital of the company by its operating income in the reporting period, the share units;

5) indicators characterizing the impact of innovative activity of the enterprise on its competitive advantages. In particular, these indicators could include the following: the ratio of prices for innovative products of the investigated company and similar companies ' products – its competitors; the ratio of the specific cost of resources in the new resource-saving technologies of production, which introduced the investigated enterprise, and unit costs of these resources to similar products from competitors; the ratio of specific profit from the production and sale of innovative products of the investigated enterprises from the production and sales of similar products from its competitors; the ratio of specific profit from the production and distribution of products, which is made of the investigated enterprise with innovation resource-saving technology, and specific profits from the production and sale of the same products from competitors.

It should be noted that the calculation of the P_{ni} indicator in formula (1) requires the accounting of the following four components in the operating profit of the enterprise: profit due to the production and sale of products that are innovative, however, manufactured using traditional technologies(machinery, materials); profit due to the production and sale of products that are innovative and manufactured using innovative technologies; profit due to the production and sale of products that are not innovative, but manufactured using innovative technologies; additional profit derived from the introduction of other types of innovations by the enterprise (marketing, organizational, etc.). Under such conditions, the value of the P_{ni} indicator in formula (1) will be defined as the difference between the actual operating profit of the enterprise and the sum of the four components of this profit

listed above.

In reference to the P_{ani} in formula (2), during the calculation, one should take into account the possibility of changes in the total capital of the enterprise due to the making of the corresponding investment costs for the development and implementation of innovations. Especially, this applies to investments in the acquisition of new equipment by the enterprise.

It should also be noted that if the investigated enterprise is profitable, the values of indicators (1) and (2) cannot be negative. At the same time, the zero value of these indicators is possible only if the enterprise does not carry out innovative activities and, accordingly, it has a lack of innovativeness. Therefore, the higher the value of indicators (1) and (2), the higher the level of innovativeness of the enterprise.

The use of indicators (1) and (2) also allows assessing the impact of energy-saving technological changes on the level of innovation of enterprises. To this end, these indicators should be calculated twice: respectively, taking into account and without taking into account the use of energy-saving technologies by the enterprise (of course, if such an application actually occurs). In turn, the increase in operating profit of the enterprise as a result of the introduction of energy-saving technological processes can be calculated using this formula:

$$\Delta P_e = \sum_{i=1}^{n} \sum_{j=1}^{m} Q_i \cdot p_{rej} \left(c_{bij} - c_{nij} \right) + \sum_{i=1}^{n} \Delta Q_i \cdot p_{ni} - C \tag{3}$$

where: ΔP_e is the increase in the operating profits of the enterprise as a result of introducing them to energy-saving technological processes, monetary units; n – number of types of products produced by the enterprise; m – number of types of energy resources which the company uses in its operating activities and which the company in the previous periods have been energy-saving technological changes; Q_i is the physical volume of production of enterprise i in product (excluding the increase in these volumes due to the increase of competitiveness of the enterprise, caused, in turn, reducing the unit costs through the production of energy-saving technological change); p_{rej} – average during the reporting period, the purchase unit price of the j-th energy resources, monetary units; c_{bij}, c_{nij} – the physical cost of j-energy resource per unit of the i-product, accordingly before and after the implementation of the enterprise energy-saving technological change; ΔQ_i is the increase in physical volume of production of enterprise i-product caused by the reduction of unit costs through the production of energy-saving technological change; p_{ni} – specific profits from the production and sales of the i-product in the reporting period, monetary units; C – the value of other types of operating costs of the company related to the enterprise energy-saving technological change (in particular, costs associated with the possible substitution of some other energy resources), monetary units.

Taking into account formula (3), indicators for assessing the impact of energy-saving technological changes on the level of innovativeness of enterprises can be formalized in this way:

$$Z_1 = I_1 - I_{1e} \qquad (4)$$
$$Z_2 = I_2 - I_{2e} \qquad (5)$$

where: Z_1 is the impact assessment indicator of energy-saving technological changes on the level of innovativeness of enterprises by size of its operating profit, share of units; I_{1e} – the share of enterprise profit from implementation of innovative activities in the total amount of its operating profit in the reporting period, excluding profit from the implementation of energy-saving technological change, share of units; Z_2 – impact assessment indicator of the energy-saving technological change on the level of innovativeness of the enterprise by the amount of profit of its capital, shares of unit; I_{2e} – a measure of the relative profitability of the capital of the company by its operating profit through the implementation of innovative activities excluding profit and investment costs, due to the implementation of energy-saving technological change, the fraction of a unit.

In particular, the indicator I_{1e} in equation (4) can be calculated by the formula:

$$I_{1e} = 1 - \frac{P_{ni}}{P - \Delta P_e} \qquad (6)$$

. Accordingly, the indicator (4) will be determined by the formula:

$$Z_2 = I_2 - I_{2e} = 1 - \frac{P_{ni}}{P} - \left(1 - \frac{P_{ni}}{P - \Delta P_e}\right) = \frac{P_{ni}}{P - \Delta P_e} - \frac{P_{ni}}{P} \qquad (7)$$

We will test the proposed methodological approach to assessing the impact of energy-saving technological changes on the level of innovativeness of the company on the example of agro-industrial enterprises of Ukraine. To this end, we have collected information on the activities of forty enterprises of such type, which belong to four types of economic activities, namely: horticulture, animal husbandry, processing of crop products and processing of livestock products (Table-I). All of these businesses were profitable in 2018. At the same time, some of them carried out energy-saving technological changes during 2013-2017.

Using formulas (4), (6) and (7), we calculate the indicators of innovativeness of the investigated agro-industrial enterprises by their operating income, as well as assess the impact of energy-saving technological changes on the level of innovativeness of these enterprises (Table-II.).

As follows from the data that is provided in table 2, the average level of innovativeness of the investigated agro-industrial enterprises by their operating income ranges from 0.246 for horticulture to 0.527 for processing of livestock products. Thus for all types of economic activity which are considered, the level of innovativeness of the enterprises that carried out energy-saving technological changes considerably (on average more than twice) exceeds the level of innovativeness of the enterprises which did not conduct energy-saving technological changes. It should also be pointed out that there is a strong influence of energy-saving technological changes on the level of innovativeness of the investigated enterprises in terms of their operating profit. In particular, the average level of innovativeness of the investigated enterprises that have implemented energy-saving technologies is 0.484. At the same time, the average value of the indicator for these enterprises' assessment of the impact of energy-saving technological changes on the level of innovation of enterprises is 0.331. Thus, approximately 68% of the level of innovativeness of the investigated agro-industrial enterprises, which carried out energy-saving technological changes, is conditioned by this production.

Regarding the investigated agro-industrial enterprises, which did not carry out energy-saving technological changes, we conducted a survey on the presence of obstacles during the implementation of this kind of realization. The results of this survey are presented in Table-III. At the same time, respondents were able to specify several types of obstacles at the same time.

1. From the data provided in table 3, it follows that, according to the managers of the investigated agro-industrial enterprises, the main obstacle to the realization of energy-saving technological changes is the lack of necessary information (this obstacle was noted by 61.9% of respondents). One of the means of overcoming this obstacle should be the digitalization of the agro-industrial business in Ukraine. In particular, it concerns the creation of databases on manufacturers and consumers of energy-saving equipment, as well as indicators on the basis of which the economic efficiency of investment projects for the purchase of such equipment is estimated.

Table - I: Initial information on individual indicators of agro-industrial enterprises activity in Ukraine

Indicators	Values of indicators by types of economic activity				
	Horticulture	Animal husbandry	Processing of crop products	Processing of livestock products	Total
1. Number of enterprises under investigation	14	8	11	7	40
2. Number of enterprises that implemented energy-saving technological changes during 2013-2017	5	3	8	3	19
3. Total operating profit in 2018, thousand US dollars	635	381	560	279	1855
Including:					
3.1. Enterprises that implemented energy-saving technological changes	406	257	486	182	1331
3.2. Enterprises that have not carried out energy-saving technological changes	229	124	74	97	524

4. The amount of operating profit due to innovative activities, thousands of US dollars.	188	146	237	193	764
Including:					
4.1. Enterprises that implemented energy-saving technological changes	156	123	218	147	644
4.2. Enterprises that have not carried out energy-saving technological changes	32	23	19	46	120
5. The amount of operating profit due to energy-saving technological changes, thousands of US dollars.	134	101	166	119	520

Table- II: Indicators of innovativeness of agro-industrial enterprises and the results of assessing the impact of energy-saving technological changes on the level of innovativeness of these enterprises

Indicators	Values of indicators by types of economic activity				
	Horticulture	Animal husbandry	Processing of crop products	Processing of livestock products	Total
1. Average level of innovativeness of enterprises by their operating income, share of unit	0,246	0,323	0,389	0,527	0,347
Including:					
1.1. Enterprises that implemented energy-saving technological changes	0,384	0,479	0,449	0,808	0,484
1.2. Enterprises that have not carried out energy-saving technological changes	0,140	0,185	0,257	0,474	0,229
2. Indicator for assessing the impact of energy-saving technological changes on the level of innovation of the enterprise in terms of its operating profit, unit share	0,303	0,338	0,286	0,363	0,331

Table- III: The results of the survey of managers of the investigated agro-industrial enterprises, which did not carry out energy-saving technological changes, regarding the obstacles for this kind of realization

Indicators	Values of indicators by types of economic activity				
	Horticulture	Animal husbandry	Processing of crop products	Processing of livestock products	Total
1. Number of enterprises that have not carried out energy-saving technological changes	9	5	3	4	21
2. The number of enterprises whose managers among the obstacles to the implementation of energy-saving technological changes denominated:					
2.1. Lack of necessary information for the realization of energy-saving technological changes	6	3	2	2	13
2.2. The lack of financial resources for the realization of energy-saving technological change	4	2	1	2	9
2.3. Other obstacles (especially, insufficient efficiency of energy-saving technological change projects from the point of view of managers)	3	1	1	1	6
3. The share of enterprises, whose managers called the lack of information one of the obstacles to the realization of energy-saving technological changes, in percentage	66,67	60,00	66,67	50,00	61,90

V. CONCLUSION

It is reasonable to emphasise five groups of indicators which assess the level of innovativeness of the enterprise, namely: indicators of the volume of innovative activity of the enterprise for a certain period of time; indicators of the amount and quality of innovation resources of the enterprise; indicators of the level of novelty of developed and implemented at the enterprise innovations; indicators of the impact of innovative activity on its economic performance; indicators of the impact of innovative activity of enterprise on its competitive advantages. Among these groups of indicators to assess the impact of energy-saving technological changes on the level of innovativeness of enterprises, first of all, the indicators of the fourth group of them all should be implemented. To this end, these indicators should be calculated twice: respectively, taking into account and without taking into account the use of energy-saving technologies by the enterprise. At the same time, as shown by

Retrieval Number: C10341183C19/19©BEIESP
DOI:10.35940/ijrte.C1034.1183C19

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Blue Eyes Intelligence Engineering
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the study of the totality of agro-industrial enterprises of Ukraine, which introduced energy-saving technologies, about 68% of the level of innovativeness of these enterprises are conditioned by this realization. It was also revealed that, according to the managers of the investigated agro-industrial enterprises, the main obstacle to the realization of energy-saving technological changes is the lack of necessary information. One of the means of overcoming this obstacle is the digitalization of agricultural business in Ukraine.

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