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INVESTMENTS LIMITING NEGATIVE IMPACT OF FARMS ON THE NATURAL ENVIRONMENT AND CLIMATE AND AGRICULTURAL ACTIVITY EFFICIENCY

Key words: environment, farms, technical efficiency, investments reducing environmental pollution

ABSTRACT. The article attempts to evaluate the technical efficiency of farms that in 2015-2016 carried out an investment aimed at reducing pollution of the natural environment with nitrates from agricultural sources. Due to the type of the investment carried out, two groups of farms were distinguished. The first group were farms that carried out adaptive investments for the construction or extension of manure plates or slurry tanks. The second group, on the other hand, were farms investing in the construction of barns and piggeries along with buildings for collecting natural fertilizers. The source of data for the analysis were farms keeping accounting for the Polish FADN in 2014-2019. The results of the analysis showed that the investments carried out in both groups undoubtedly contributed to the significant development of the farms. Income per 1 working person from a farming family (1 FWU) increased in both groups by 95.3% and 78.5%, respectively in 2014-2019. Changes in technical efficiency, measured with the Malmquist index, showed an improvement in efficiency in both groups, but only in the group of farms investing in new buildings the changes were favorable both in terms of efficiency improvement and technological progress. Ultimately, measurement of efficiency showed its increase in the group investing in buildings by 0.7% and in the case of new livestock buildings by 3.4%.

INTRODUCTION

One of the basic goals that the EU sets for agriculture under the Common Agricultural Policy in the new programming period for 2023-2027 is to reduce negative impact on the condition of natural resources (water, soil, and air) and the climate with which the resources are even more closely related than before. According to the European Commission, environmental issues and resource management should play an increasingly important role in agriculture. This is due to the growing awareness of the public about the side effects of agricultural activity on the natural environment and climate.

In 2019, the European Commission announced the European Green Deal Strategy, its roadmap to transform its economy with a net-zero greenhouse gas emissions target of 2050 and its economic growth decoupled from the use of natural resources [EC 2019]. Although the fulfillment of this postulate will apply to all sectors of the economy, regions, and inhabitants of the EU, it should be noted that agriculture will be one of those sectors that will play an important role in its implementation. This is indicated by the "farm to fork" strategy, which is part of the European Green Deal strategy, which sets several goals for agriculture to protect natural resources and the climate even more than before [EC 2020][1].

Proper management of nutrients in agriculture is of great importance for the maintenance of water quality, especially nitrogen, excessive amounts of which pollute them and, consequently, result in eutrophication[2], and often reduce the economic effects of farms resulting from the inappropriateness of doses and dates of its application to the requirements of agricultural crops [Evanylo et al. 2008, Pecio 2017, Rütting et al. 2018]. Moreover, as Mark Sutton et al. [2011] write, losses for the EU's natural environment, including waters, resulting from its pollution with nitrogen from agricultural sources, currently exceed the increase in economic effects resulting from its use [Sutton et al. 2011].

On the other hand, in the last decade, farms in Poland felt the market pressure of increasing the scale of production more and more strongly, mainly due to a faster increase in labor costs and prices of means of production in relation to the purchase prices of agricultural products Wojciech Ziętara and Marcin Adamski [2014]. Relations in recent years have resulted in a significant increase in the share of large and very large-scale farms, and a decrease in the number of smaller farms that cease to operate [GUS 2021]. Owing to the new requirements, farms that are developing have been obliged by new environmental standards to equip new livestock buildings with the necessary infrastructure and to purchase machines that significantly reduce negative impact of their activities on the environment. Therefore, the question arises whether farms making investments in the field of environmental protection (by incurring the costs of such investments and receiving subsidies on this account) are not less effective than those that do not carry out such investments.

1 The current acts of EU law discussed, although they emphasize the need for protecting natural resources and the climate, refer to solutions already adopted at the level of the creation of the Treaty on the Functioning of the EU. Article 191 par. 1 and 2 of this treaty indicates that the EU policy should consider the preservation, protection, and improvement of the quality of the environment and the prudent and rational use of natural resources [Journal of Laws 2004.90.864/2].

2 Europhization is the enrichment of water reservoirs with nutrients, usually caused by sewage and fertilizers, causing excessive production of algae [Great Dictionary of Foreign Words 2008].

THEORETICAL BACKGROUND

Technical efficiency and technological progress are two of the basic determinants influencing the improvement of economic efficiency and achieving a better competitive position of farms. There are two basic types of technical efficiency measures which are either input or output oriented. In the first approach, differences in effectiveness result from differences in the minimum inputs needed to produce an effect of a given value. Whereas in the second one, differences in productivity are treated as differences in the size of the maximum product for given inputs Tomasz Czekaj et al. [2008] and Anna Ćwiąkała and Wioletta Nowak [2009]. Therefore, its size is influenced by the quantity, quality and proportions of the inputs used, which indicate the degree of use of the technology. It is worth noting, however, that high technical efficiency resulting from the optimal use of inputs to achieve the maximum production with the possessed and often improved production technology is a necessary condition, but more and more often insufficient, to achieve high economic efficiency. It is also the result of technological progress, which, as Lidia Białoń and Tadeusz Obrębski [1989] write, is "... the process of transition to quantitatively and qualitatively higher states in technology and technics, resulting in favorable effects in the economic, social and environmental sphere compared to the initial state". In the light of the research by Paul Samuelson and William Nordhaus [2012], the driving forces of technological progress include human inputs, nat resources, and capital resources, as well as entrepreneurship expressed, inter alia, in knowledge and skills in the field of management (Figure 1).

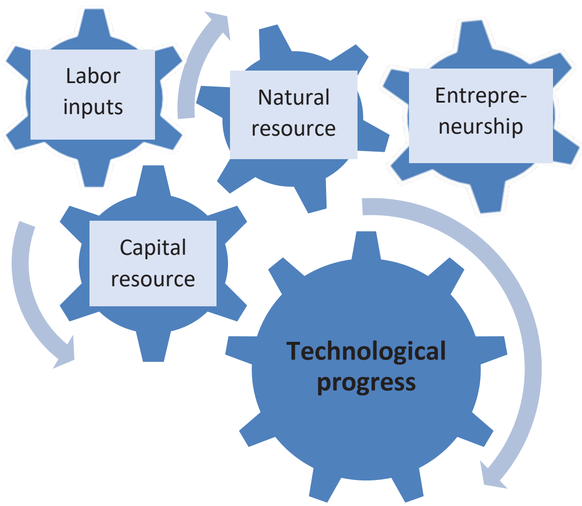

Figure 1. Driving forces of technological progress
Source: own study based on [Samuelson, Nordhaus 2012]

Technological progress is usually expressed by changes in the structure of production factors and the relations between them, in the production structure and in the productivity of production factors, which may concern both one factor of production and the entire set of the factors [Świerczewska 2007]. However, the effect of the changes is the evolution of production processes [Samuelson, Nordhaus 2012]. In this context, it should be added that the concept of technological progress is inextricably linked with the concept of innovation, which Joseph Schumpeter [1960] regarded as one of the main factors, along with entrepreneurship and credit, determining economic development. He distinguished two types of innovation. The first type is fundamental innovation, which creates or extends the world technological frontier in each sector of the economy, and the second type is imitation innovation, which consists in the use by a given sector of existing technologies from more developed sectors [Brzeziński 2016]. On the other hand, William Nordhaus [1976] distinguished two basic trends determining the way in which technological progress arises. The first one is the supply trend, resulting from the assumption that each economy has a certain sphere of activity, the task of which is to create new techniques and technologies. According to this concept, they usually go through a long and costly improvement processes and their implementation is slow. The opposite of this concept is

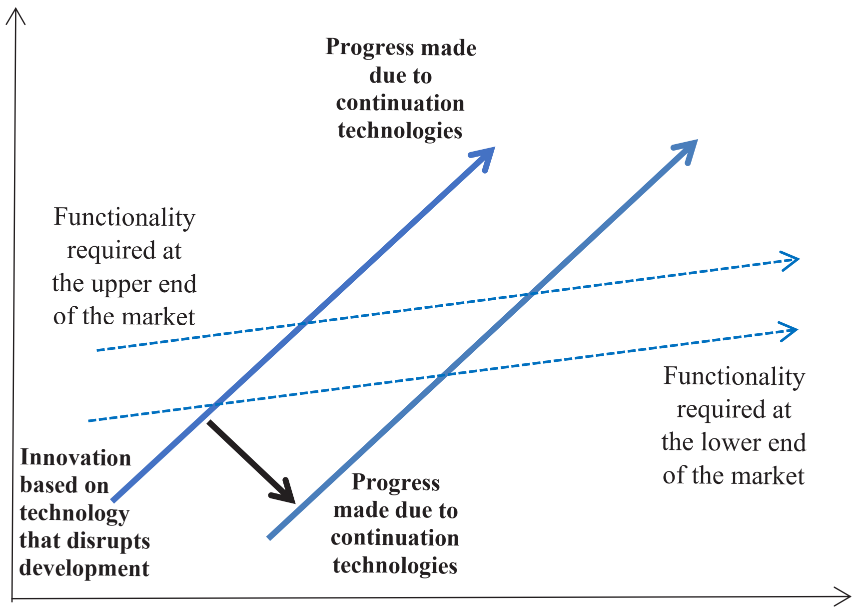

Figure 2. Impact of continuation and interruptive technologies
Source: [Christensen 2010]

the demand trend. It assumes that the driving force behind the creation of new solutions is the demand submitted by potential recipients, and their implementation is relatively quick.

In many sectors of the economy, including agriculture, the pace of technological progress is increasingly ahead of the pace of improvement of currently used technologies. The ongoing changes in the technologies used interrupt the current development of those already in use (technologies interrupting development), becoming the main technology on the market, then subject to the rules of progress based on the continuation technology (Figure 2) [Christensen 2010, Brdulak 2012].

According to Clayton M. Christensen and Michael Raynor [2008], the types of technologies offer new value to their users, usually allowing them to achieve higher efficiency. However, they stipulate that the pace of technological development almost always exceeds the ability to assimilate all the improvements resulting from its application. The weakness may therefore be the not fully optimal use of inputs to obtain the maximum production effects (technical efficiency) under the new technology.

Technological progress is important only when it affects the competitive advantage by changing or influencing factors determining costs, the degree of their differentiation or affecting them [Porter 2006]. By implying technological progress as an additional

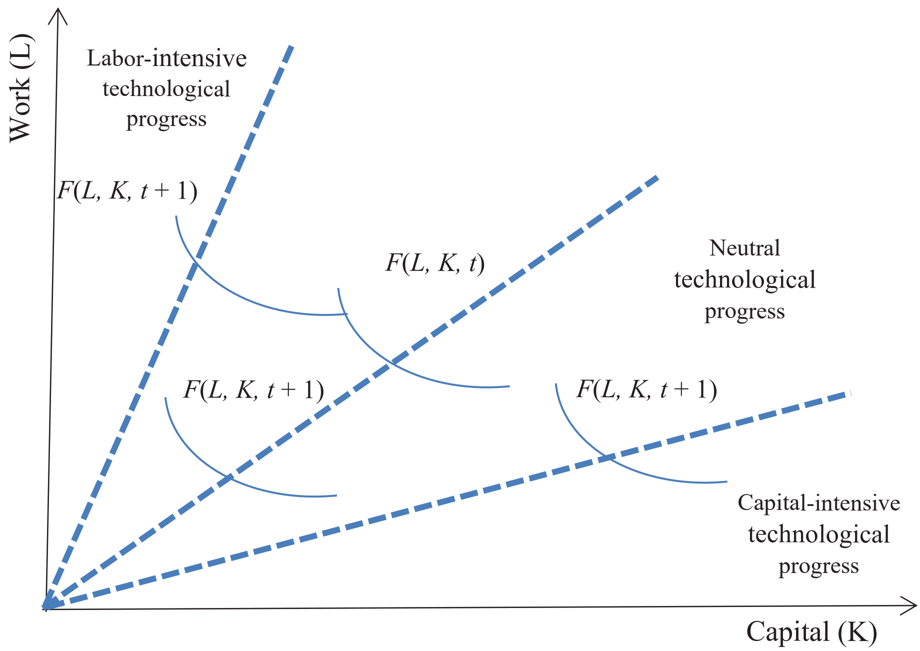

Figure 3. Types of technological progress and the degree of use of production factors
Source: own study based on [Świerczewska 2007]

production factor (next to labor – *L* and capital – *K*) and taking it into account in the production function (*F*) in the form of a time variable *t* and *t* + 1 [*F(L, K, t)* → *F (L, K, t* + *1)*], it can be talked about in the context of an increase in production resulting from increasing efficiency of the labor or capital used, including land, or increasing the effectiveness of both distinguished factors in a given period of time (Figure 3).

The effect of technological progress is a change in production capacity, structure and organization of production, technical equipment of work and work efficiency, but not exclusively. Technological progress is inextricably linked with the process of transition to qualitatively higher states, not only in the production sphere, but also in the sphere of knowledge, awareness, skills, and human qualifications [Świerczewska 2007]. In the current conditions, technological progress deserves special attention, as it allows for an increase in management efficiency and at the same time is focused on the protection of natural resources and the climate.

In the agricultural sector, in the first place, technological progress is adopted and implemented on farms with greater economic strength. The ability of farms to undertake it largely depends on the production potential, the scale of production, and thus – the obtained income [Ziętara 1997, Woś 1999]. Moreover, as Michele Marra and Gerald Carlson [2002] write, farms with greater economic power may also have access to better sources of information on new technologies. What is more, a larger farm size may indicate less credit or capital constraints on the implementation of them [Feder 1980].

Technological progress creates opportunities to increase efficiency and scale of production, often through increased concentration and specialization of production. In the conditions of ever-increasing requirements that the EU imposes on agriculture to take additional measures to protect natural resources and the climate, meeting the requirements should also be an advantage. Hence, the importance of technological progress in farms should be emphasized, as it copes with the increasing competitive pressure of other domestic and foreign farms, while limiting interference with the natural environment and climate. In farms with livestock production, it is first reported by their investments in new barns and pigsties equipped with structures for storing natural fertilizers, as well as manure plates and tanks for storing liquid natural fertilizers. This is because they usually force them to change in e.g., livestock maintenance system. For example, it is forecast that further specialization and concentration of livestock production in the country will strengthen the importance of litterless systems in many farms. In 2040, for dairy cattle and pigs, the share of this maintenance system may amount to 70 and 75%, respectively. Changes will also be made in the methods of storing natural fertilizers without losing natural resources and the climate [KOBiZE 2009].

MATERIALS AND METHODS

In this study, an assessment of farms was undertaken, which in 2015-2016 carried out an investment aimed at reducing pollution of the natural environment with nitrates from agricultural sources and kept continuous accounting for the Polish FADN in 2014-2019. The premise for the division of the analyzed farms according to the period of implementation of this type of investment was to convince the authors of the need for performing this type of analysis in the longest possible period, which limited impact of random factors on the production and economic effects achieved by farms, and at the same time the intention to use the most up-to-date data.

The data of the Polish FADN from 2014-2019 made it possible to select two groups of farms with investments aimed at reducing water pollution with nitrates from agricultural sources. The first were farms investing in the construction of manure plates and tanks for liquid natural fertilizers, hereinafter referred to as farms with investments in buildings, and the second – in the construction of barns and piggeries together with buildings for the collection of natural fertilizers, hereinafter referred to as farms with investments in livestock buildings. In each of the separated groups of farms, their characteristics were carried out on average in the period before the investment, in the year of the investment and on average in the period after its implementation. For farms that implemented the investment on average in 2015-2016, their characteristics were therefore made during the investment implementation period and in the year before and on average in the 3 years after the investment (Figure 4).

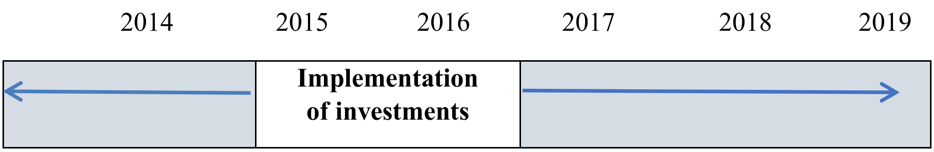

Figure 4. Scheme of the analysis of farms conducting investments aimed at reducing the pollution of the natural environment with nitrates from agricultural sources

Source: own study

The Malmquist index (M) was used to determine the causes of changes in the productivity of the analyzed farms. This index is based on the productivity change index, understood as the relation of a given unit's productivity over time t and $t + 1$ [Coelli, Prasada Rao 2003]. Within this index, productivity is defined as the relation of production expressed in the value of a given effect (y) to all inputs (x_i) used [Coelli et al. 1998]. The index measures the change in productivity over the period t and $t + 1$. Productivity decreases if M <1, does not change when $M = 1$, and increases when $M > 1$. This index is calculated according to the following equation:

$$M = \frac{y^{t+1}/x^{t+1}}{y^t/x^t} \tag{1}$$

where:
y^t/x^t – the average productivity of a unit at time t,
y^{t+1}/x^{t+1} – the average productivity of a unit at time $t + 1$.

In the analyzes, a formula for interpreting the Malmquist index was used, as based on decomposition of the causes of changes in farm productivity into two components [Tone 2004, Coelli et al. 2005, Cooper et al. 2007]. The first of them measures technological progress related to the change of *the technical change – tc*, i.e., a shift of the production possibilities boundary of the researched farm, and therefore also answers the question which technology is more (or less) effective [Maudos et al. 1999]. The second one concerns the change of technical efficiency (*efficiency change – ec*) measured with the relation of the obtained effects at a given level of inputs to possible boundary (maximum) effects, i.e., farm deviations from the efficiency boundary within the existing technological possibilities [Kudła, Gadowska 2005, Floriańczyk 2008, Adamski 2018]. Determination for each of the analyzed farms not only to change the relationship between inputs and effects in the analyzed period with given technological possibilities, but also technological progress are therefore advantages of this approach [Weber 2015]. Farms can change their efficiency because they use their inputs better (worse) to obtain an effect within the existing technology, or because they change production possibilities (technology). The product of the two changes gives the total efficiency change, i.e., the value of the Malmquist index (equation 2, 3 and 4).

$$M(y^t; x^t; y^{t+1}; x^{t+1}) = tc \times ec \tag{2}$$

$$tc = \sqrt{\frac{d^t(y^{t+1}, x^{t+1}) \times d^t(y^t, x^t)}{d^{t+1}(y^{t+1}, x^{t+1}) \times d^{t+1}(y^t, x^t)}} \tag{3}$$

$$ec = \frac{d^{t+1}(y^{t+1}, x^{t+1})}{d^t(y^t, x^t)} \tag{4}$$

where:
$d^t(y^{t+1}, x^{t+1})$ – efficiency with year one manufacturing technology for year two data,
$d^{t+1}(y^t, x^t)$ – efficiency using year two technology for year one data,
$d^t(y^t, x^t)$, – efficiency year one within the available technology,
$d^{t+1}(y^{t+1}, x^{t+1})$ – efficiency for year two within the available technology.

For the purposes of calculating the Malmquist index, the total production value was assumed as the effect. On the input side, on the other hand, total labor costs were considered[3] the outlays of fixed assets expressed by depreciation and total operating costs, less payroll and depreciation costs. The index was calculated with the use of DEAP version 2.1 [Coelli 1996].

RESULTS

Tables 1 and 2 aggregate data characterizing farms reporting for the Polish FADN in 2014-2019 which simultaneously implemented investments in 2015-2016 in the field of improving the storage conditions of natural fertilizers (construction of manure plates and tanks for storing liquid natural fertilizers, hereinafter referred to as buildings) or comprehensive investments in the form of new barns or pigsties (hereinafter referred to as livestock buildings) meeting the requirements concerning animal welfare and their positive impact on the environment. The obtained panel of farms for comparison in the case of investments in buildings included 34 farms, and in livestock buildings – 30 farms. Investments carried out in both groups undoubtedly contributed to the significant development of the farms. This is evidenced by the dynamic growth of the economic size in 2017-2019, just after the completion of the investment. It should therefore be noted that, as in the case of the construction of livestock buildings, investment in buildings for the storage of natural fertilizers was due to increase in livestock production.

It should be emphasized that both analyzed groups of farms were characterized by a significantly higher SO (Standard Output – standard output), as compared to the average farms in the country[4]. What is more, in the analyzed period, their economic size increased additionally by 47.3% and 45.1%, respectively.

Scale of the increase was to the greatest extent caused by the increase in the number of the kept herd of animals and the area of agricultural land in the farms. It is worth paying attention to the fact that the number of animals in the group with investments in buildings had a higher growth dynamic than the area of agricultural land, which resulted in an increase in the density of animals per ha of UAA by 42.3%, while in the group with investments in livestock buildings density increased by 17.9%. In the case of the owned acreage of agricultural land, the dynamics of their growth amounted to 15.0% and 20.7%, respectively. It should be noted that in both analyzed groups of farms – as for the average national conditions – high stocking density of animals per ha of UAA was maintained.

[3] Costs of own and external labor were expressed as the product of working hours and the rate paid for contract work in the analyzed farms.

[4] In Poland, the average economic size of an individual farm in 2016 was 16.1 thousand euro [GUS 2017].

Table 1. Selected characteristics for farms investing in buildings in 2015-2016

Specification	Units	2014	2015	2016	2017	2018	2019	Change % 2019/2014
Number of farms	-	34						-
Economic size	thous. Euro SO	100.5	105.2	116.5	142.1	135.9	148.0	47.3
UAA	ha	64.2	64.6	66.5	67.9	69.3	73.9	15.0
Labor inputs per 1 ha of UAA	hour/ha of UAA	73.5	70.6	70.7	69.5	67.0	61.8	-15.9
Average capital value	PLN thous.	1,450	1,553	1,699	1,899	2,056	2,150	48.2
Soil valuation index	point	0.74						-
Index of agricultural production space valorization in communes	point	62.90						-
Stocking density of animals per 1 ha of UAA	LU/ha of UAA	1.26	1.33	1.49	1.90	1.75	1.79	42.3
Total costs per 1 ha of UAA	PLN thous./ ha of UAA	7.8	7.7	8.5	9.6	10.0	10.6	36.9
Direct costs per 1 ha of UAA	PLN thous./ ha of UAA	4.9	4.9	5.4	6.4	6.5	7.1	44.3
Direct costs of livestock production per 1 ha of UAA	PLN thous./ ha of UAA	3.6	3.5	3.9	5.0	5.1	5.6	57.0
Share of own feed costs in total feed	%	31.0	29.0	28.1	22.0	22.7	22.5	-8.5*
Work productivity	PLN thous./ AWU	266.3	259.4	292.1	376.9	365.2	478.4	79.6
Land productivity	PLN thous./ ha of UAA	9.2	8.6	9.7	12.4	11.5	13.9	51.0
Farm income per 1 ha of UAA	PLN thous./ ha of UAA	2.8	2.1	2.5	4.0	2.9	4.7	72.4
Farm income per 1 FWU	PLN thous./ FWU	97.2	74.3	91.0	147.1	109.0	189.9	95.3
Net investment rate**	%	275.9	340.9	280.1	337.1	193.7	195.5	-80.4*

* Difference in percentage points

** Relation of value of net investments and depreciation costs

Source: own study based on the Polish FADN data

Table 2. Selected characteristics for farms investing in livestock buildings in 2015-2016

Specification	Units	2014	2015	2016	2017	2018	2019	Change % 2019/2014
Number of farms	-	30						-
Economic size	thous. Euro SO	137.9	146.6	169.7	182.9	200.7	200.2	45.1
UAA	ha	78.1	74.6	82.5	81.6	88.5	94.2	20.7
Labor inputs per 1 ha of UAA	hour/ha of UAA	74.0	36.3	36.2	39.3	35.3	33.9	-54.2
Average capital value	PLN thous.	1,797	1,921	2,342	2,803	2,969	3,079	71
Soil valuation index	point	0.71						-
Index of agricultural production space valorization in communes	point	64.10						-
Stocking density of animals per 1 ha of UAA	LU/ha of UAA	1.57	1.80	1.79	2.02	2.00	1.85	17.9
Total costs per 1 ha of UAA	PLN thous. /ha of UAA	8.1	8.4	8.5	10.3	10.3	10.4	28.7
Direct costs per 1 ha of UAA	PLN thous./ ha of UAA	5.3	5.4	5.4	6.4	6.4	6.5	22.7
Direct costs of livestock production per 1 ha of UAA	PLN thous./ ha of UAA	4.2	4.2	4.2	5.2	5.3	5.3	27.6
Share of own feed costs in total feed	%	27.8	26.4	24.8	24.8	22.2	20.7	-7.1*
Work productivity	PLN thous./ AWU	282.8	285.0	319.1	387.6	422.7	444.2	57.1
Land productivity	PLN thous./ ha of UAA	9.9	9.2	10.3	13.6	13.3	13.4	36.2
Farm income per 1 ha of UAA	PLN thous./ ha of UAA	3.0	2.3	3.1	4.7	4.5	4.6	53.9
Farm income per 1 FWU	PLN thous./ FWU	121.8	88.2	135.6	197.3	202.5	217.4	78.5
Net investment rate**	%	178.8	411.5	700.5	322.8	245.6	112.4	-66.4*

* Difference in percentage points

** Relation of value of net investments and depreciation costs

Source: own study based on the Polish FADN data

In 2019, it was 1.79 LU/ha of UAA and 1.85 LU/ha of UAA, respectively. In farms investing in livestock buildings, the fact that in 2017-2018 the stocking density exceeded 2 LU/ha of UAA was a disturbing phenomenon from the point of view of the proper management of natural fertilizers, which forced farmers to find recipients for the surplus of this fertilizer on the market. In the last year of observation, however, the situation improved due to the increase in agricultural land, but it should be borne in mind that the dynamic development of farms with livestock production in regions with a low supply of agricultural land may increase such problems in the future.

Apart from area of agricultural land, quality of agricultural land is no less important, which translates into yield stability. As it turned out, in both groups of farms, farms had land of a slightly worse quality than the national average (0.8) [GUS 2012]. This unfavorable situation in this respect is also confirmed by their location in communes with the Index for the Valorization of Agricultural Production Area (WRPP) amounting to an average of 62.9 and 64.1 points, respectively, with 120 points achievable.

Improvement of production potential of the analyzed groups was also possible thanks to the limitation of the incurred labor inputs by substituting them with capital. In the analyzed period, the number of working hours per 1 ha of UAA on farms investing in buildings and livestock buildings decreased by 15.9% and 54.2%, respectively. This clearly proves that such investment, in addition to improving animal welfare and having a positive impact on the environment, also contributed to the reduction of labor intensity of the production to a greater extent. At the same time, the average capital value increased by 48.2% and 71.3%, respectively. Therefore, on the farms, technical development of work equipment was progressing. The analyzed groups, being better and better equipped with agricultural machinery and equipment as well as modern livestock buildings, had the possibility of limiting the incurred labor inputs.

Level of costs incurred per ha of UAA was also analyzed. It was established that in 2014-2019, total costs per ha of UAA in both groups of farms increased by 36.9% and 28.7%, respectively. On the other hand, in the case of direct costs per ha of UAA, this increase amounted to 44.3% and 22.7%, respectively.

In the years 2014-2019, an increase in labor efficiency and land productivity was observed in both groups of farms. This dependence was conditioned by increasing the scale of production. Increased production scale of the farms was also very clearly visible in the generated income. In the case of farms investing in buildings, the increase in farm income per ha of UAA was 72.4%, and in livestock buildings 53.9%. In turn, income per 1 working person from a farming family (1 FWU) increased by 95.3% and 78.5%, respectively. Therefore, it can be concluded that investment consisting in meeting the environmental requirements in the case of the analyzed entities did not contradict the achievement of decent income on a farm.

Table 3. Average Malmquist indexes in 2014-2019 for farms investing in buildings and livestock buildings in 2015-2016 to reduce water pollution with nitrates from agricultural sources

Years	Change in technical efficiency	Change in technological progress	Malmquist index
Farms with investments in buildings			
2014-2015	0.813	1.041	0.846
2015-2016	1.247	0.911	1.136
2016-2017	0.874	1.309	1.144
2017-2018	1.087	0.853	0.927
2018-2019	0.872	1.161	1.012
2014-2019	0.966	1.042	1.007
Farms with investments in livestock buildings			
2014-2015	1.134	0.805	0.913
2015-2016	1.203	0.877	1.055
2016-2017	0.974	1.246	1.214
2017-2018	0.69	1.484	1.024
2018-2019	1.121	0.879	0.986
2014-2019	1.005	1.028	1.034

Source: own study based on the Polish FADN data

To better illustrate reasons for differences in the achieved effects and the inputs incurred, the Malmquist productivity index was used, which quantifies the dependencies over time axis (Table 3). Results of the index based on the determination of changes in technical efficiency and technological progress in 2014-2019 are presented in Table 3. In the case of farms investing in buildings, it was found that in 2014-2019 the farms increased their technological progress by 4.2%, the highest increase took place in the years after the investment completion, 2016-2017, and amounted to 30.9%. However, on the farms it was not possible to improve technical efficiency of the inputs involved. In the analyzed period, their technical efficiency decreased by 0.3%. As a result, the Malmquist index only increased by 0.7%. The group with investments in livestock buildings fared significantly better in terms of the assessment of technical efficiency and technical progress. In 2014-2019, the index for this group increased by 3.4%. This result was positively influenced by technological progress increased by 2.8%, and almost 0.5% improvement in technical efficiency. When discussing results of the index, it should also be noted that, similarly to the group investing in buildings, significant changes in technological progress were recorded in 2016-2018, i.e., immediately after investment completion.

It should be noted that in 2017-2019, both groups of farms were characterized by improvement in technological progress. This favorable situation was largely influenced by investments in fixed assets carried out in 2015-2016, including those in structures and buildings limiting water pollution with nitrates from agricultural sources. It should be noted, however, that results of technical efficiency indicate possible improvement in this respect in most farms, especially in the group with investments in buildings.

SUMMARY AND CONCLUSIONS

The conducted analysis showed that both groups of farms implementing investments limiting water pollution with nitrates from agricultural sources were characterized by a significant – considering the average conditions in the country – economic size exceeding 100 thousand SO. In the analyzed period from 2014 to 2019, it further increased, in the case of the group investing in buildings, economic value increased by 47.3%. Changes also took place in the basic factors of production. Their UAA and average capital value increased, while the amount of labor inputs per ha of UAA decreased. The effect of the changes was an increase in the technical equipment of work. The farms, being increasingly better equipped with agricultural machinery and equipment and livestock buildings, including those aimed at limiting water pollution with nitrates, had the possibility of limiting their incurred labor inputs. On the farms there was an increase in total and direct costs per 1 ha of UAA. It should be added that the increase in direct costs was usually related to increased direct costs related to livestock production, the important reason for which was increased livestock density per 1 ha of UAA. Increased intensity of conducted production was one of the important reasons for increased their labor efficiency and land productivity. As a result, their increases were also visible in the improvement of their income per 1 ha of UAA and 1 FWU. In the case of income per 1 FWU, it was even greater than the parity income in the national economy. This means that the farms were capable of further development, including through the implementation of investments limiting water pollution with nitrates from agricultural sources, as evidenced by their high net investment rate. It should be emphasized, however, that their technological progress was the source of efficiency improvement. At the same time, however, they often did not fully efficiently use the incurred outlays to achieve the effects of their technology. Perhaps the reason for this situation - especially in the period after the application of new technologies - was too short time for farms to fully absorb them.

It is worth emphasizing that the Polish FADN collects accounting data from economically stronger farms compared to average farms in Poland. This means that the development possibilities of farms implementing investments limiting water pollution with nitrates from agricultural sources presented in this analysis probably do not fully reflect the development possibilities of all farms implementing this type of investment. It should be emphasized, however, that the adoption and implementation of the latest technologies, including those relating to the reduction of water pollution with nitrates from agricultural sources, usually concerns economically stronger farms in the first place. Hence, one of the advantages of the conducted analyzes was the indication of the changes taking place in their production potential, costs, economic situation, and development opportunities, as a result of the investments carried out in them, including those limiting water pollution with nitrates from agricultural sources.

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INWESTYCJE OGRANICZAJĄCE NEGATYWNY WPŁYW GOSPODARSTW ROLNYCH NA ŚRODOWISKO PRZYRODNICZE I KLIMAT A EFEKTYWNOŚĆ DZIAŁALNOŚCI ROLNICZEJ

Słowa kluczowe: środowisko, gospodarstwa rolne, efektywność techniczna, inwestycje ograniczające zanieczyszczenie środowiska

ABSTRAKT

W artykule podjęto próbę oceny efektywności technicznej gospodarstw rolnych, które w latach 2015-2016 przeprowadziły inwestycję, mającą na celu ograniczenie zanieczyszczeń środowiska przyrodniczego azotanami pochodzącymi ze źródeł rolniczych. Ze względu na rodzaj przeprowadzonej inwestycji wydzielono dwie grupy gospodarstw. Pierwszą grupę stanowiły gospodarstwa, które przeprowadziły inwestycje dostosowawcze dotyczące budowy bądź rozbudowy płyt obornikowych lub zbiorników na gnojowice. Drugą grupa to gospodarstwa inwestujące w budowę obór i chlewni wraz z budowlami do gromadzenia nawozów naturalnych. Źródłem danych do analizy były gospodarstwa prowadzące rachunkowość dla Polskiego FADN w latach 2014-2019. Wyniki analizy wykazały, że przeprowadzone inwestycje w obu grupach przyczyniły się do znacznego rozwoju tych gospodarstw. Dochód w przeliczeniu na 1 osobę pracującą z rodziny rolniczej (1 FWU) wzrósł w obu grupach odpowiednio o 95,3 i 78,5%. Zmiany efektywności technicznej mierzone indeksem Malmquista wykazały poprawę efektywności w obu grupach, jednak jedynie w grupie gospodarstw inwestujących w nowe budynki zmiany było korzystne zarówno pod względem poprawy efektywności, jak i postępu technologicznego. Ostatecznie pomiar efektywności wykazał jej wzrost w grupie inwestującej w budowle o 0,7%, a w przypadku nowych budynków inwentarskich o 3,4%.

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