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Specialization and diversification of agricultural production in the light of sustainable development

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Abstract. The study evaluated the importance of agricultural production structures for economic efficiency and environmental sustainability of farms. For this purpose, multivariate methods were used: ordering and data envelopment analysis (DEA). The study is based on accounting data from the farms of intensive agriculture in Wielkopolska Province, collected by the Institute of Agricultural and Food Economics in Warsaw in 2004-2009. It was demonstrated that diversified farms achieve similar economic efficiency indicators as specialized farms. At the same time it was proven that the farms with production specializing in breeding cattle, implement their function of "guardians of the countryside" in the same degree or even better. Thus, the main hypothesis of the study formulated on the basis of studying literature was rejected. It said that: specialized farms achieve higher economic efficiency with lower environmental sustainability of the production than diversified farms. In the diversified farms there is higher environmental sustainability of production at lower economic efficiency than in specialized farms.

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INTRODUCTION

One of the most important factors determining the economic performance of the agricultural farm is carried out in the production lines. They determine whether the farm is specialized or diversified (or omnidirectional or multidirectional). It is noted that the increase in production specialization leads most often to an increase in its profitability, which, as in the sphere of companies, is related to the growing advantages of scale (Juszczyk 2004, p.101, Stępień 2007, pp. 209-230, Zieliński 1985, pp. 11, 12). Obtaining them is possible

due to an increase in the intensity of the use of resources, which accompanies specialized production. This causes, on the one hand, an increase in the efficiency of production, on the other hand, it can adversely affect the quality of agricultural production, space and the natural environment of the village (Woś, Zegar 2002, p. 23). Thus, the question arises whether in addition to the economic benefits resulting from specialization there is a correlation between the structure of agricultural production and the impact of agriculture on the quality of natural resources. Currently, the answer to this question is of particular significance, which ensures the growing importance of agriculture as a provider of public goods.

The most important non-market functions of agriculture include preventing the degradation of agricultural land, protection of biodiversity in rural areas, improvement of water relations in agricultural areas and prevention of soil erosion (Wilkin 2008, p. 16, Chmielewska 2010). The impact of agriculture on the environment is particularly important in areas for intensive agricultural production. Agriculture is one of the areas of the economy, which mainly by the intensification of production, significantly influences the natural environment (Kopiński, Madej 2006, Pomianek 2014, Karwat-Woźniak 2011, Czyżewski A., Smędzik-Ambroży 2013, Hayami, Ruttan 1985, Grethe 2006). Already in the 70s intensive agriculture met a real environmental barrier, preventing further exclusion of the agricultural production from natural conditions, by the excessive use of the means of production of industrial origin, a significant concentration of production and increasing scale (Czyżewski 2013, Henning 2008), hence the return of the EU's common agricultural policy in the direction of sustainable agriculture, i.e. ensuring parity income of the farming population but also producing in accordance with the laws of nature (Steebling, Maier, Legg 1998, Potter 2004).

This implies the need to find a way of combining the economic viability of farms with their preferred and ultimately neutral impact on the environment. Therefore, in the context of aiming at a growth of environmental sustainability of agriculture and maintaining its high efficiency in areas of intensive agriculture, it is particularly important to assess the impact of agricultural production structures on the economic efficiency of farms and their environmental sustainability. It is important to determine whether the changes in the structure of farm production in these areas can lead to an increase in their environmental sustainability while at the same time maintaining their high economic efficiency. Therefore, the aim of this article is to determine whether the farms located in an area of intensive agriculture with the specialized production achieve higher economic performance than farms with diversified production, as well as the answer to the question whether the type of specialization affects the environmental sustainability of these farms. Considering these issues will indicate the way in which farms may, by shaping their production structures, affect the growth of environmental sustainability of the areas where they occur. This is especially important for the agricultural economics as a scientific discipline, and also practice of the agricultural sector, forced by EU regulations to focus on environmental sustainability. Converting the development of agriculture from the industrial model to the sustainable model is, in the long term, inevitable, and the imposition of the mechanism of the development of agriculture industrial brakes and social ethics becomes the current necessity especially in areas with intensive agricultural production (Czyżewski A. 2013).

The first part of the paper discusses the significance of the processes of specialization and diversification of production as a determinant of economic efficiency and environmental sustainability of farms. The next one, with the use of multivariate methods: rang, linear ordering and data envelope (DEA) presents an analysis of the impact of production structures on the economic efficiency and environmental sustainability of farms in the area of intensive agriculture in Poland (Gostyń County).

REVIEW OF THE LITERATURE

Specialization and diversification of production as determinants of the effectiveness of farms

Specialization of agricultural production means reducing the assortment of diversity, or increasing the production of the selected product, which is accompanied by maintaining the production of the remaining products at the unchanged level. Repeating after R. Manteuffel: "a specialized farm is the one which produces for sale and for the needs of the farmer and his family one or two products, or products in which even at the multilateral final production, one or two articles have such a large share that they set the tone for the whole farm, i.e. they make up more than two-thirds in the structure of the final production, and therefore are intended for sale and consumption of their own farmer ". The fewer products the farm produces the more specialized it is. Full specialization is the production of a single product (Wojtaszek 1980, pp. 16-18). The opposite of specialization of production is its diversification, which is to increase the number of courses conducted on the farm or to eliminate the dominating course and to introduce a few others in its place. It leads to the creation of a multi-directional farm. The process of moving from a farm of multilateral forms to the specialized form is most frequently a long-term process, because it means the need to invest, associated with the modernization understood as technical modernization, technological or organizational (Chyłek 2005, p. 10). In Poland, the percentage of multidirectional is very large and stands at about 63%. For comparison, in Germany it is only 17%. A higher level of economic development of the country favours specialization of the farms (Józwiak, Juźwiak 2007, p. 10). The most frequently mentioned positive effects of specialization processes that determine the effectiveness of the farms are:

- the possibility of reducing unit costs through an increase in the scale of production and, consequently, increase of the value added from agricultural activities (Juszczyk 2004, p. 101).
- economization of effort leading to an increase in productivity and production levels, by performing repetitive tasks, increasing accuracy, improving the practical and theoretical knowledge about the direction that is the subject of specialization, resulting in a reduction of production costs (Zieliński 1985, pp. 11, 12).
- disclosure of comparative advantages and increase of the competitiveness of specialized farms (Stępień 2007, pp. 209-230).
- a change in the structure of expenditures by limiting their versatility and simplifying the organization.
- increase in the effectiveness of marketing of agricultural products, by reducing the transaction costs associated with trade.
- lower material consumption resulting from better control of technological processes (Grabowski 1975, pp. 21-33).

Thus, in the traditional approach simplifying agricultural production leads to an increase in the efficiency of specialized farms as compared with the multidirectional ones. You cannot, however, forget about the main advantage of the diversified production, mentioned in the literature. It is the dispersion of risk arising from fluctuations in prices on different agricultural markets. It ensures that in times of economic downturn the diversified farm efficiency may be greater than that of specialized ones (Czyżewski B., Czternasty 2007, p. 60). In modern farming conditions resulting from the increase of its importance as a provider of public goods and aspirations of the common agricultural policy of the EU to sustainable agriculture, one should, however enrich the traditional perception of the processes of specialization and diversification of production as a determinant of the efficiency of farms with their impact on the quality of the natural resources in rural areas. Such an approach was used in this study, assessing the significance of specialization processes and diversification of production in shaping the effectiveness of farms and rural environmental sustainability.

Specialization and diversification of production as determinants of environmental sustainability of farms

The concept of environmentally sustainable agriculture stems from the philosophy of sustainable development, which was created as a response to global environmental problems of international nature, appearing in the late 70s and 80s of the 20th century. Then the industrialization of agriculture gradually violated its previous harmony with the natural environment. As a result, more and more efficient technologies and manufacturing structures replaced the existing ones, leaving, however, a more and more pronounced ecological footprint in the form of: the loss of food, soil, water and air pollution and biodiversity of ecosystems. A danger to the environment appeared resulting from the abuse of synthetic and other growth chemicals (Zegar 2012). As a result, the European Union has developed a number of instruments to encourage agricultural activity in accordance with the laws of nature (Czyżewski A., Stępień 2009, pp. 231-239). They allow you to indirectly assess the environmental sustainability of production on the farm and are used for this purpose by many authors (see. Table 1).

Table 1

Variables used by different authors in the study of environmental sustainability of agricultural production

Author	Objective of the analysis	Variables (diagnostic features)
A. Kagan	Assess the impact of agricultural enterprises on the natural environment, creating the synthetic indicator of environmental performance	biodiversity, the balance of organic matter in the soil, the share of permanent grassland in the structure of crops, nitrogen balance
W. Wrzaszcz	Comparison of the results of sustainable farms against the total number of individual FADN farms	the share of cereals in crop structure, the number of groups of crops, the coverage ratio of arable land vegetation in winter, stocking density per hectare of arable land
E. Majewski	Estimation and comparison of farm sustainability indicators in the economic, social and environmental aspects	organic matter in the soil, soil microorganisms, biodiversity, energy consumption, nitrogen balance, ecological infrastructure
S. Krasowicz, J. Kuś, J. Jankowiak	Determine the influence of economic and organizational conditions on the functioning of agricultural farms	balance of nutrients (nitrogen, phosphorus, potassium) on the surface of the field, the balance of soil organic matter (SD stocking per hectare of arable land), the index of the soil vegetation cover during the winter, the consumption of plant protection products per hectare of crops
J. Bieńkowski, J. Jankowiak, J. Marcinkowski, A. Sadowski	Determination of technical and environmental efficiency of commercial agricultural farms in Wielkopolska	nitrogen balance, the volume of pesticide use

Source: own results based on (Kagan 2009, Wrzaszcz 2008, Majewski 2008, p. 82, Krasowicz Kuś, Jankowiak 2007, Bieńkowski, Jankowiak, Marcinkowski, Sadowski 2005).

The criteria for the support from the EU funds create difficulties for the operation of specialized farms. This is due to the fact that they support the farms which: limit the use of fertilizers and pesticides, reduce livestock density to 2 livestock units per hectare, respect the principle of succession of plants and the use of intercropping, reduce the share of cereals in crop structure and increase the number of groups of crops on the farm. These criteria are thoroughly described in the methodological part and used in the empirical part of the study to assess the environmental sustainability of the analysed farms. More easily it

fits the multidirectional farms than the specialized ones. It was found that farms specializing in commercial milk production and the multidirectional (mixed) ones contribute to the objectives of sustainable agriculture (Krasowicz 2005, p. 36). In the multidirectional farms, also due to the *mutual benefit* of each activity, in a natural way the ecological character of internal links is ensured, and consequently the biological balance of agricultural production. The introduction of specialization disrupts the natural regulatory mechanisms operating in nature (Runowski 1994, p. 29). Therefore, this study sets a hypothesis that the specialized farms achieve higher economic efficiency of environmental sustainability at a lower production than the diversified farms. However, in the diversified farms there is higher environmental sustainability of production at lower economic efficiency than in the specialized farms. The adoption of this hypothesis would allow to state that the farms, through the development of their production structures and their adaptation to the circumstances of the concept of sustainable development, can favourably influence the quality of the natural resources in rural areas.

COMPARATIVE STUDY OF THE STRUCTURES OF PRODUCTION IN FARMS

Methodology of research

As already mentioned, the impact of agriculture on the environment is particularly important in areas of intensive agricultural production. Therefore, the analyses referred to the farms in the area (county) of the most intensive agriculture in Wielkopolska. It is a region in Poland with the highest average value of agricultural commodity production on 1 hectare of arable land. Commodity production means production for sale and not for consumption in farm (Kulikowski 2013, pp. 108-115). For the selection purposes, comparisons were made between the different counties in Wielkopolska using the following criteria:

– population making their living in agriculture, based on 100 farms in the particular county (GUS 2003),
– the number of fixed assets (machinery, equipment and farm buildings), based on 100 farms in the particular county (GUS 2003).

These criteria indicated the differences in the levels of labour- and capital-consumption intensification between the compared counties. The higher the number of agricultural population and the number of assets based on 100 farms in the county, the higher degree of labour- and capital-consumption intensification respectively. In the assessment of the environmental intensity of agriculture in the individual counties selected indicators applied and they resulted from the principles of good agricultural practice (Code of Good Agricultural Practice 2011) and agricultural and environmental programmes (Sustainable Agriculture 2011), adapting them to the comparisons of environmental intensity of farming at the local scale, taking into consideration the division into counties. These included:

density of livestock (pigs and cattle) per 100 ha of the farmland of the individual county. The effect of intensive livestock farming is the production of significant quantities of organic fertilizers used in fertilizing fields. Excessive use of fertilizers contributes both to pollution and eutrophication due to excessive nutrient loading, on the other hand, leads to acidification and global warming due to greenhouse gases (Directive 2013). Thus, the higher the livestock density per 100 ha of farmland in the county, the higher the degree of its environmental intensity in relation to other counties.

participation of grain crops in the structure per 100 ha of the farmland of the county. In accordance with the principles of good agricultural practice, the share of cereal crops in the structure of crops should not exceed 66%. Otherwise, this is a monoculture. Considering this, it was assumed that a larger share of grain crops in the structure of crops per 100 ha of farmland, reflects the higher intensity of crop production in the county than in areas where it is lower.

the share of winter crops (winter wheat, rye, barley, triticale, canola and rape seeds) in the structure of crops per 100 ha of farmland of the individual county. A favourable effect on the environmental balance is thanks to an increased share of winter crops in the crop structure. Therefore, it was assumed that a higher proportion of these plants in the crop structure per 100 ha of arable land provides for a lower intensity of crop production in the region in relation to the areas where it is smaller.

The above-mentioned measures made it possible to rank the counties in the Wielkopolska according to the degree of intensity of agricultural production. The evaluations used data from the Agricultural Census of 2002, as the period immediately preceding the Polish accessions to the EU, which started from the analysis of economic efficiency and environmental sustainability of farms. In the end, using the method of ordering a map was drawn presenting the intensity of agricultural production in Wielkopolska by counties (cf. Figure 1). It was found that the highest intensity of agricultural production occurred in the south-western part of Wielkopolska. In this respect definitely Gostyń and Krotoszyn Counties stand out. However, due to a much higher number of pigs per 100 ha of arable land, Gostyń County was considered the area with a higher intensity of production. On the area the density of pigs per 100 ha of arable land amounted to 466 640 units as compared with Krotoszyn County (Użytkowanie 2003, p. 78). The other measures for the two counties were at a similar level. Therefore, the spatial extent of the research included Gostyń County.

Figure 1. Differentiation of the intensity of agricultural production in Wielkopolska by counties in 2002
Source: own results based on: GUS 2003, Użytkowanie, pp. 55, 78, 122, 124.

After the delimitation of the area of the most intensive agriculture in Wielkopolska (Gostyń County) an analysis was made about the differences in terms of economic efficiency and environmental sustainability of farms specialized and diversified (multidirectional) having agricultural accounting FADN (Farm Accountancy Data Network) from Gostyń County. They were 48 farms whose accounting data are collected by the Institute of Agricultural and Food Economics - National Research Institute in Warsaw. These data were used by the authors to conduct their own analyses, the results of which are presented in this article. The proposals concern thus the FADN farms and cannot be extended to the entire population of farms from the Gostyń County. In carrying out the study based on FADN data there are problems of small numbers of samples of research. In accordance with the requirements of the FADN, accounting data of individual farms may be made public only in a processed form or as averaged results on at least 15 farms. Therefore, the comparative analysis of the efficiency, the DEA model was used for the evaluation of the effectiveness of individual entities against the total number of tests - effectiveness measures obtained using this method are relative, taking the values from zero to one. The higher the ratio, the greater the effectiveness of the entity in relation to the others. Farms with the highest efficiency, according to this method, gain ratio equal to one. DEA method is based on linear mathematical programming and is used for estimation of relative efficiency of the tested object, in a situation where there are also a lot of costs and benefits. They are imported to the synthetic values, which allows the calculation of the efficiency ratio as a function of the purpose of linear programming. The size of the "synthetic" ratio of the particular object and the "synthetic" effort are optimized (Ziółkowska 2008, pp. 161-163, Prasada, Coelli 1998, Casch, Balmann, Odening 1998, Thiele, Brodersen 2008). The analyses on the side of expenditures showed: consumption of the labour factor measured by the number of labour hours per year, the amount of land expressed in hectares of owned or leased land, and the total costs, which included the direct costs, general economic and depreciation costs. The costs of external factors were eliminated from the value of the general costs. This made it possible to avoid double entry into the model of wage labour and the leased land. The effects side showed the value of income from agricultural production in PLN.

In order to determine the environmental sustainability of the analysed farms the criteria used were those of the beneficiaries of agri-environmental programmes and the principles of good agricultural practice (ZDPR). They included:

- the share of cereals in the structure of arable crops (for the sustainable production it should not exceed 66%),
- the number of groups of crops on the farm (in a sustainable production it should be at least 3)
- all animals kept on the farm (in the sustainable production should not exceed 2 pieces of large units (SD) on 1 hectare of arable land).

Based on these criteria using the multivariate linear ordering method a synthetic indicator of environmental sustainability of production was constructed. The environmentally sustainable production stimulant was assumed to be the number of groups of crops on the farm and its destimulant was: the share of cereals in the crop structure. In addition, it is assumed that the number of animals amounting to 2 SD per ha is the limit beyond which the number becomes a destimulant of the sustainable production, thus that factor was given the nature a naminant. Due to the different titres of indicators and trends of the impact on the phenomenon, they were subjected to a process of normalization in the way of unitarisation. For this purpose the following transformations were used:

- for the stimulant:

$$z_j = \frac{x_j - \min\{x_j\}}{\max\{x_j\} - \min\{x_j\}} \quad (1)$$

– for the destimulant:

$$z_j = \frac{\max\{x_j\} - x_j}{\max\{x_j\} - \min\{x_j\}} \quad (2)$$

– for the nominant:

$$z_j = \frac{x_j - \min\{x_j\}}{nom\{x_j\} - \min\{x_j\}}, \quad x_j \leq nom\{x_j\}$$

$$z_j = \frac{\max\{x_j\} - x_j}{\max\{x_j\} - nom\{x_j\}}, \quad x_j \geq nom\{x_j\} \quad (3)$$

Where

max $\{x_j\}$ – maximum value of the j character
min $\{x_j\}$ – minimum value of the j character
nom $\{x_j\}$ – value of the j character considered optimu

Source: Poczta-Wajda 2010, pp. 74-77.

Calculated in this way, the synthetic indicator of environmental sustainability of production in individual farms accepted the values ranging from 0-1, with its higher value corresponding to higher environmental sustainability of production. Thus, the linear ordering method made it possible to rank the FADN farms in Gostyń County according to the degree of environmental sustainability of their production. The list of indicators of economic efficiency and environmental sustainability of the farms analysed, allowed the identification of the best subjects in terms of these two aspects. The time scope of the analysis included the years 2004-2009. The analyses used average economic efficiency indicators and environmental sustainability of farms being the arithmetic average of the indicators of each year of the research period.

THE RESULTS OF THE RESEARCH

On the basis of economic efficiency and environmental sustainability of the production of each of the FADN farm of Gostyń County in the years 2004-2009 Figure 2 was drawn up. One can distinguish three systems on the farms. The first includes the farms specialized in breeding cattle that produced, in a relatively least environmentally sustainable way, achieving varied economic efficiency indicators. It can be even said that a negative correlation between the degree of efficiency and environmental sustainability of the production revealed on these farms. It clearly indicates the farm which was the only one in the group to reach the average rate of economic efficiency for the entire study period of 1, with bay - far the lowest environmental sustainability of production in relation to the other analysed farms. In the group with the lowest low economic efficiency and environmental sustainability of production also were two multidirectional farms. They were, however, exceptions to this type. A high scale of pig farming, and the share of cereals in the sown area brought the structures of production of these farms closer to the specialized ones in pig breeding. The vast majority of multidirectional farms belonged to the next sequence of points, which was characteristic of the farms reaching much higher degree of sustainability and higher or similar performance indicators, such as *pig* farms. In this group were actually 90% of farms specializing in cattle breeding and multi-type ones and

most of those dealing with field crops. It can be argued that the economic efficiency and environmental sustainability of these types of farms were similar, although the farms specializing in cattle breeding showed slightly higher average levels of sustainability than the farms with diversified production (multidirectional).

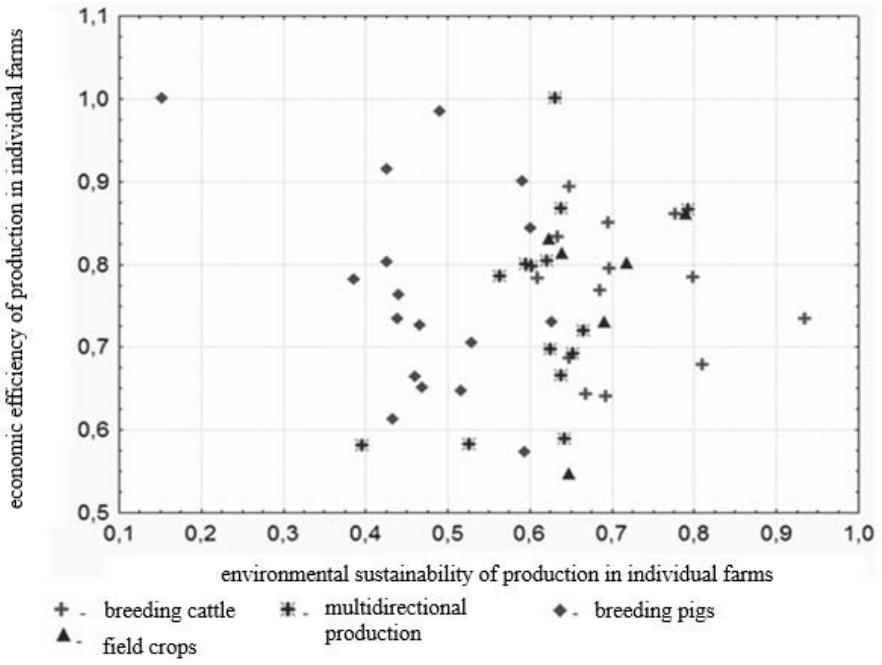

Figure 2. Diversification of economic efficiency and environmental sustainability of production in the FADN farms in Gostyń County according to the production types in the years 2004-2009 (average values)
Source: own results based on the accountancy data from the FADN farms from Gostyń County

The analyses of a unitary type carried out, do not support the main hypothesis of the study stating that specialized farms achieve higher economic efficiency at lower environmental sustainability of production than the diversified farms. However, the diversified farms have higher environmental sustainability of production at its lower economic efficiency than specialized farms. They are denied by experience of the farms specializing in breeding and raising cattle.

CONCLUSIONS

The configuration of production structures in agricultural farms is one of the most important determinants of their economic situation. The issue of specialization and diversification of production as factors shaping the economic efficiency of farms has been widely discussed in the literature in the field of agricultural economics. It is noted that the specialization of production leads to higher economic performance than its diversification. This study revealed however, that diversified farms in the area of intensive agriculture can

achieve similar economic efficiency indicators as specialized farms. In the light of the concept of sustainable development also an important thing is to answer the question of how the structure of agricultural production affects the quality of the natural resources in rural areas. In the light of the concept of sustainable development it is important to answer the question of how the structure of agricultural production affects the quality of the natural resources in rural areas. In view of this paradigm it is expected that farmers, through their practices, will serve additional functions of "guardians of the rural landscape". Through the formation of good agricultural practice and criteria of agricultural and environmental programmes, this function is assigned particularly to multidirectional farms. Meanwhile, the results of the analyses carried out in this paper have shown that the implementation of this function in areas of intensive agriculture in the same or greater extent than multidirectional farms, is well carried out by farms specializing in breeding and raising cattle.

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