REGIONAL DIFFERENTIATION OF FINANCIAL SUPPORT FROM THE EUROPEAN UNION AND ITS IMPACT ON AGRICULTURAL EFFICIENCY IN POLAND

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Abstract. Main objective of this article is to establish whether there is dependence between how intensively EU agriculture-dedicated funds in individual voivodeships are utilized and the pace of efficiency improvement of that agriculture. During the first stage of study the level and dynamics of the EU funds utilized in agriculture across voivodeships were examined for the period between 2005 and 2011. Further, efficiency of agriculture in individual voivodeships was analyzed using traditional indexes (productivity of land and work), as well as multidimensional indexes based on Data Envelopment Analysis and Malmquist Productivity Index. The conducted study indicated lack of dependence between the extent to which financial aid funds from the EU budget were utilized and the pace of agricultural efficiency improvement.

Key words: agriculture, efficiency, Common Agricultural Policy

JEL code: Q10

Introduction

Between 2004 and 2011 Poland received from the EU budget the amount of EUR 76.8 billion (after deducting contributions paid to the budget, which amounted to EUR 22.8 billion, the positive balance of EUR 50.2 billion remained), due to which it was possible to accelerate the expansion and modernization of national technical and social infrastructure. Over 30% of the received EU funding has been allotted to agriculture as part of the Common Agricultural Policy (CAP) (Figure 1) (Czubak, 2012).

The main objectives of the CAP were balanced development of rural areas and improving competitiveness of agricultural food production economy (Golasa et al., 2014). A number of studies indicate that the accession and related changes in economic conditions of farming operations have led to a significant improvement in the income situation of Polish agriculture (Pocztą, 2008; Czyzewski, Matuszczak, 2014). Many studies point to the fact that supporting agricultural investments from the EU budget contributes towards improved economic efficiency of farms. This, in turn, allows for implementation of biological, technical, economic and
organizational progress which furthers the development of production capacity of agriculture, improves productivity of plants and animals, enhances the effectiveness of management and decreases the impact agricultural production has on the environment (Dziemanowicz et al., 2008; Rokicki, 2013).

It should be noted, however, that the impact of integration on the monetary income of agriculture within the country is diverse, due to the fact that agriculture in different regions of the country exhibits higher or lower levels of variation. This stems mainly from the scale of production and the structure of agricultural production, as well as the different levels of marketable agricultural production (Poczta, 2008).

The main purpose of this article is to describe the relation between the intensity of utilizing the EU funds for agriculture, and the pace of agriculture efficiency improvement in the respective Polish voivodeships. To achieve the aim, several research tasks were set: 1) to identify the level and the dynamics of support of agriculture sector with the EU funds in individual voivodeships of Poland; 2) to identify the efficiency of agriculture in Polish voivodeships. For the purpose of this study the following hypothesis was assumed: the voivodeships in which agriculture received the most support from the EU funds per 1 hectare of agricultural area achieved the fastest rate of work, yield and efficiency indicators between 2005 and 2011.

The study used Central Statistical Office of Poland data for the period 2005-2011 on agriculture, in particular, voivodeships published in the Statistical Yearbooks of Agriculture and data from the reports on the activities of the Agency for Restructuring and Modernisation of Agriculture (ARMA) for the period 2005-2011 as source materials. In the article, most valuable variable is expressed in PLN. The exchange rate for converting Polish zloty to Euro is 1 PLN = 0.23926 EUR (23.02.2015).

The Data Envelopment Analysis (DEA), Malmquist Productivity Index (MPI) and the Kruskal-Wallis test were employed in order to verify the research hypothesis on the basis of data for the agricultural sector in individual voivodeships. DEA is the non-parametric approach relied on


Fig. 1. Transfers to Poland from the EU budget between 2004 and 2012

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the linear programming (Baran, Zak, 2014). The DEA model may be presented mathematically in the following manner (Cooper et al., 2007):

$$\max_{\sum_{i=1}^{m} \sum_{r=1}^{s} u_r y_{rj} \over \sum_{i=1}^{m} \sum_{r=1}^{s} v_i x_{ij}}$$

(1)

$$\sum_{r=1}^{m} u_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij}$$

$$u_r, v_i \geq 0$$

where:

$s$ – quantity of outputs;

$m$ – quantity of inputs;

$u_r$ – weights denoting the significance of respective outputs;

$v_i$ – weights denoting the significance of respective outputs;

$y_{rj}$ – amount of output of $r$-th type ($r = 1, ..., R$) in $j$-th object;

$x_{ij}$ – amount of input of $i$-th type ($n = 1, ..., N$) in $j$-th object ($j = 1, ..., J$).

In the DEA model $m$ of inputs and $s$ of diverse outputs come down to single figures of “synthetic” input and “synthetic” output, which are subsequently used for calculating the object efficiency index (Rusielik, Switlyk, 1999). The quotient of synthetic output and synthetic input is an objective function, which is solved in linear programming. Optimized variables include $\mu_r$ and $v_i$ coefficients which represent weights of input and output amounts, and the output and input amounts are empirical data (Cooper et al., 2007).

By solving the objective function using linear programming it is possible to determine the efficiency curve called also the production frontier, which covers all most efficient units of the focus group. Objects are believed to be technically efficient if they are located on the efficiency curve (their efficiency index equals 1, which means that in the model focused on input minimization there is no any other more favourable combination of inputs allowing a company to achieve the same outputs). However, if they are beyond the efficiency curve, they are technically inefficient (their efficiency index is below 1). The efficiency of the object is measured against other objects from the focus group and is assigned values from the range $(0, 1)$ (Charnes et al., 1978).

Malmquist Productivity Index is the most frequently used approach to quantification of changes in total factor productivity. MPI first introduced by Malmquist has further been studied and developed in Färe (Malmquist, 1953; Färe et al., 1992; Färe et al., 1994). Färe constructed the DEA-based MPI as the geometric mean of the two Malmquist productivity
indices - one measures the change in technical efficiency and the other measures the shift in the frontier technology. Färe developed it into the output-based Malmquist productivity change index (Färe et al., 1994). The input-oriented Malmquist productivity index of a DMU can be expressed as

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \left[ \frac{D'(y_{t+1}, x_{t+1})}{D'(y_t, x_t)} \cdot \frac{D^{+1}(y_{t+1}, x_{t+1})}{D^{+1}(y_t, x_t)} \right]^{1/2}$$

(2)

where \(x_t\) and \(x_{t+1}\) are input vectors of dimension \(l\) at time \(t\) and \(t+1\), respectively. \(y_t\) and \(y_{t+1}\) are the corresponding \(k\)-output vectors. \(D'\) and \(D^{+1}\) denote an input – oriented distance function with respect to production technology at \(t\) or \(t+1\), which is defined as:

$$D(x, y) = \max \{\rho : (s / \rho) \in L(y)\}$$

(3)

where \(L(y)\) represents the number of all input vectors with which a certain output vector \(y\) can be produced, that is, \(L(y) = \{x : y \text{ can be produced with } x\}\). \(\rho\) in eq. (3) can be understood as a reciprocal value of the factor by the total inputs could be maximally reduced without reducing output.

\(M\) measures the productivity change between periods \(t\) and \(t + 1\), productivity declines if \(M < 1\), remains unchanged if \(M = 1\) and improves if \(M > 1\). The frontier technology determined by the efficient frontier is estimated using DEA for a set of DMUs. However, the frontier technology for a particular DMU under evaluation is only represented by a section of the DEA frontier or a facet.

The DEA method and MPI were used to evaluate and create efficiency rankings of various entities, such as hospitals, educational bodies (schools, universities), banks, farms, agribusiness companies, industrial enterprises (Rusielik, Switlyk, 1999; Lenort et al., 2014; Wysokinski et al., 2014).

**Research results and discussion**

During the first stage of study, the level and dynamics of the EU funds utilized in agriculture across voivodeships was examined. The study took into account the following categories of expenditures as part of financing the CAP activities: direct payments and tasks performed within the Rural Development Programme (RDP) in the periods from 2004 to 2006 and from 2007 to 2011.
Between 2004 and 2011 total expenditures for the CAP in all voivodeships of Poland amounted to PLN 70090 million. It is notable that over 50% of all expenditures were made in the period between 2010 and 2011. Average annual spending for the CAP per voivodeship in the analyzed period increased from PLN 232.7 million to PLN 1214.5 million, which is a fivefold increase (Figure 2). It is also visible in the studied period that agriculture support varies greatly from one voivodeship to another, which is shown in large differences between minimal and maximal values in Figure 2.

![Fig. 2. General expenditure financed within the CAP (minimal, average and maximal value per voivodeship between 2005 and 2011)](image)

**Source:** author’s calculations based on the reports of the ARMA, 2005-2012

The distribution of total expenditures (sum from 2005 to 2011) as part of the CAP across voivodeships is shown in Figure 3. The amounts of general EU agricultural support vary greatly – from PLN 9790 million in Mazovia voivodeship to PLN 1681 million in Silesia voivodeship and PLN1902 million in Lubuskie voivodeship. The CAP expenditures in Mazovia voivodeship were almost six times higher than in Silesia voivodeship and over five times higher than in Lubuskie.

![Fig. 3. Total expenditures financed as part of the CAP across the voivodeships](image)

**Source:** author’s calculations based on the reports of the ARMA, 2005-2012
voivodeship. It can be observed that out of PLN 70 billion which has been spent as part of the CAP in Poland since 2004, over 30% was used in three voivodeships: Mazovia, Silesia and Lubelskie. Accounting for the difference between individual voivodeships with respect to agricultural area, number of workers, structure of the economy, urbanization level and many other aspects that are of vital importance for division of public funds for agriculture it seems more justified to analyze the distribution of expenditures financed with the EU funds when we consider not the global expenditure sums per voivodeship, but the amounts per 1 hectare of agricultural area or per agricultural worker. Having carefully considered the above, the CAP expenditures per 1 hectare of agricultural area were analyzed.

**Source:** author’s calculations based on the reports of the ARMA, 2005-2012

**Fig. 4.** CAP expenditures per 1 hectare of agricultural (minimal, average and maximal value per voivodeship between 2005 and 2011)

Despite the decreasing role of land as a production factor, it is still the essence of agriculture and it is the decisive element in terms of production potential and economic strength of farming (Wysokinski, Dziwulski, 2013). In the period between 2004 and 2011 the
level of annual EU expenditures in agriculture made in voivodeships per 1 hectare of agricultural area, increased fivefold. On average in the studied period the CAP expenditures amounted to PLN 507 per hectare, whereas Podlasie, Wielkopolska and Kujawy-Pomerania voivodeships dominate with relation to the average value, while Silesia, Małopolska and Podkarpacie voivodeships close the list with the lowest values. In direct payments, values of average amount for a voivodeship per 1 hectare change from 69 to 128 percent of national average; in case of RDP the distribution of voivodeship averages is somewhat higher – from 72 for Opole voivodeship to 135% for Podlasie voivodeship (Figure 5).

In the subsequent stage of study a question was posed: did the voivodeships which in the period between 2005 and 2011 benefited the most from the EU agricultural support also improve their agricultural efficiency the most? In order to answer that question, single and multi-dimensional agricultural efficiency indexes were calculated. Further analysis was based on the following indexes:

- productivity of work in agriculture calculated as the value of sold agricultural goods per 1 agricultural worker (in PLN per person) and the dynamics of this index between 2005 and 2011 (in percent);
- productivity of the land calculated as value of final product per 1 hectare of agricultural area (in PLN per hectare) and the dynamics of this index between 2005 and 2011 (in percent);
- Data Envelopment Analysis index illustrating efficiency of individual voivodeship’s agriculture in comparison with efficiency of other voivodeships’ agricultures;
- Malmquist Productivity Index, comprehensively illustrating the change of agricultural productivity in the period between 2005 and 2011 in individual voivodeships.
### Table 1

**Productivity and efficiency indexes across voivodeships**

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>Lower Silesia</td>
<td>2157</td>
<td>3691</td>
<td>9</td>
<td>2627</td>
<td>171</td>
<td>125</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Lesser Poland</td>
<td>4406</td>
<td>3850</td>
<td>9</td>
<td>3243</td>
<td>87</td>
<td>128</td>
<td>0.75</td>
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<td></td>
<td>Subcarpathia</td>
<td>3973</td>
<td>3326</td>
<td>9</td>
<td>2102</td>
<td>84</td>
<td>108</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>Silesia</td>
<td>1076</td>
<td>1323</td>
<td>9</td>
<td>3209</td>
<td>123</td>
<td>137</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>101</strong></td>
<td><strong>143</strong></td>
<td><strong>34</strong></td>
<td><strong>2795</strong></td>
<td><strong>352</strong></td>
<td><strong>116</strong></td>
<td><strong>125</strong></td>
</tr>
<tr>
<td>Group 2</td>
<td>Lublin</td>
<td>8419</td>
<td>1383</td>
<td>5</td>
<td>2564</td>
<td>164</td>
<td>157</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Lubusz</td>
<td>3056</td>
<td>3726</td>
<td>9</td>
<td>2270</td>
<td>122</td>
<td>137</td>
<td>0.98</td>
</tr>
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<td></td>
<td>Lodzkie</td>
<td>1341</td>
<td>2150</td>
<td>0</td>
<td>3716</td>
<td>160</td>
<td>142</td>
<td>0.86</td>
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<tr>
<td></td>
<td>Opole</td>
<td>2194</td>
<td>4358</td>
<td>4</td>
<td>2989</td>
<td>199</td>
<td>149</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Pomerania</td>
<td>1843</td>
<td>4832</td>
<td>7</td>
<td>2316</td>
<td>262</td>
<td>171</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Swietokrzyskie</td>
<td>4767</td>
<td>7971</td>
<td>0</td>
<td>3155</td>
<td>167</td>
<td>147</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>Warmia-Masuria</td>
<td>3147</td>
<td>5946</td>
<td>0</td>
<td>2473</td>
<td>189</td>
<td>131</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>West Pomerania</td>
<td>3592</td>
<td>6169</td>
<td>0</td>
<td>1920</td>
<td>172</td>
<td>142</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>206</strong></td>
<td><strong>367</strong></td>
<td><strong>18</strong></td>
<td><strong>2675</strong></td>
<td><strong>393</strong></td>
<td><strong>179</strong></td>
<td><strong>147</strong></td>
</tr>
<tr>
<td>Group 3</td>
<td>Kuyavia-Pomerania</td>
<td>2419</td>
<td>4467</td>
<td>7</td>
<td>3509</td>
<td>185</td>
<td>118</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Masovia</td>
<td>1380</td>
<td>2992</td>
<td>5</td>
<td>3490</td>
<td>217</td>
<td>154</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Podlaskie</td>
<td>1818</td>
<td>3068</td>
<td>3</td>
<td>2603</td>
<td>169</td>
<td>143</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Greater Poland</td>
<td>2838</td>
<td>4639</td>
<td>9</td>
<td>5153</td>
<td>163</td>
<td>105</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>211</strong></td>
<td><strong>379</strong></td>
<td><strong>28</strong></td>
<td><strong>3689</strong></td>
<td><strong>466</strong></td>
<td><strong>184</strong></td>
<td><strong>130</strong></td>
</tr>
</tbody>
</table>

Source: author’s calculations based on Statistical Yearbooks of Agriculture, 2005-2012

In order to analyze the differentiation of efficiency of agriculture depending on the amount of the EU support used, the voivodeships were divided into three groups with the use of quartiles. The following divisions were formed: Group 1 (25% of the data set) characterized by the lowest level of utilized EU support per 1 hectare of agricultural area, Group 2 (50% of the data set) characterized by the average level of utilized EU support per 1 hectare of agricultural area, and Group 3 (25% of the data set) characterized by the highest level of utilized EU support per 1 hectare of agricultural area (Table 1).

Conducted analysis showed that agriculture characterized by the highest level of EU support per 1 hectare of agricultural area indeed noted the highest work productivity and land productivity as well as a faster change of land productivity.

In order to determine efficiency and changes in total productivity of agricultural production in individual voivodeships, the input-oriented DEA model and Malmquist
Productivity Index were used. The models have been oriented to input minimisation, since in the light of current EU legislation on environmental policies and the disseminated principles of sustainable development, it is assumed that currently the only option for the development of European and Polish agriculture is to increase agricultural production through innovation and investment deintensification. The calculated models use the following variables: output $y_1$ – value of sold agricultural goods (million PLN), input: $x_1$- agricultural land area (ha), $x_2$ - number of people employed in agriculture (people), $x_3$ - NPK and CaO fertilization (t), $x_4$ - number of tractors (pcs), $x_5$ – livestock (thousands).

Considering the agricultural efficiency indexes average for the group, determined with the use of DEA method, it is visible that efficiency was enhancing along with the increase of EU agricultural support. In turn, when analyzing the improvement of agricultural efficiency in the period between 2005 and 2011, it is visible that the groups which received the smallest and medium support from the EU funds in the studied period have achieved the biggest improvement in agricultural efficiency.

Subsequently, in order to verify the statistical relevance of differences, variance analysis was carried out on the variables illustrating efficiency, productivity and agricultural efficiency as dependent variables with level of EU expenditures per 1 hectare of agricultural area as the grouping variable. In the first stage of the analysis, the premises regarding normal distribution were verified, while the second stage involved the verification the premise of homogeneousness of dependent variable variance in groups. Due to formal imperfections of the variance analysis (not fulfilling the conditions regarding homogeneousness of the variance), an alternative, non-parametric method was agreed upon - the Kruskal-Wallis test. It was used to verify the zeroth hypothesis stating that all groups were extracted from a population with the same distribution or distributions with the same median.

The Kruskal-Wallis test result is the following: for all studied indexes, that is, land productivity, work productivity, efficiency measured with the use of DEA method and change of agricultural productivity measured according to MPI, there are no grounds for dismissal of the zeroth hypothesis on relevance level of 0.05, which means that the level of EU support per 1 hectare of agricultural area does not substantially differentiate individual voivodeships’ agricultures based on efficiency (Table 2). The conducted analysis did not confirm the assumed hypothesis that the voivodeships in which agriculture received the most support from the EU funds per 1 hectare of agricultural area achieved a better growth rate than the agriculture of remaining voivodeships.
Table 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>H</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity of work</td>
<td>4.25</td>
<td>0.12</td>
</tr>
<tr>
<td>Land productivity</td>
<td>4.34</td>
<td>0.11</td>
</tr>
<tr>
<td>Dynamics of work productivity</td>
<td>4.34</td>
<td>0.11</td>
</tr>
<tr>
<td>Dynamics of land productivity 2005=100</td>
<td>4.96</td>
<td>0.08</td>
</tr>
<tr>
<td>Efficiency according to DEA</td>
<td>2.02</td>
<td>0.36</td>
</tr>
<tr>
<td>The change of agricultural productivity based on Malmquist Productivity Index</td>
<td>2.13</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Source: author's calculations

The analysis may lead to the conclusion that the EU funds were not the substantially decisive factor of agricultural efficiency improvement in the individual voivodeships and that the voivodeships developed “at their own pace”, regardless of the size of the EU help.

Conclusions, proposals, recommendations

The analyses conducted in this article can be used to draw the following conclusions:

1. In the period between 2004 and 2012, Polish agriculture received from the EU budget PLN 70090 million, of which over 1/3 was used in three voivodeships: Mazovia, Lubelskie and Wielkopolska. Considering the above, it should be stated that in the period between 2004 and 2011 the goal of increasing social and territorial cohesion was not reached because more support was directed to the voivodeships which at the point of Poland’s accession to the EU already were in possession of better infrastructure and greater potential for agricultural development.

2. The conducted analyses point to lack of relation between the size of financial aid from the EU budget used by the agricultural sector, and the pace of land productivity, work productivity or agricultural efficiency measured with the DEA method and the Malmquist index. Therefore, it can be assumed that in the period between 2004 and 2011 the EU funds were not the substantially decisive factor of agricultural efficiency improvement. The present study is supported by analyses of other authors (Misiag et al., 2013; Kuszewski, Sielska, 2012). This phenomenon requires further and more detailed analysis aimed at explaining its causes.

3. One of the manners of explaining the above situation can be the fact, that the use of EU funds in agriculture is only one of the factors influencing the pace at which agricultural efficiency improves. Other external factors also influence agricultural efficiency. Assumption can be made that in the studied period, agricultural efficiency was negatively influenced by ongoing global economic crisis. Explanation can also be sought in the EU funds distribution mechanisms among individual voivodeships as well as in procedures of establishing the directions for using those funds.

4. It seems fit to recommend a proposition of changes regarding the rules of funds distribution, leading to, for example, a decrease in differentiation of fund flow values as per 1 hectare of agricultural area across the voivodeships.
Bibliography

