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The regional structure of the CAP subsidies and the factor productivity in agriculture in the EU 28

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Abstract: The question of what effect the subsidies have on the productivity of farms in the EU has been studied by many authors, but has not yet been answered. A further research is thus required both in relation to the period since the decoupling reform, and in relation to the new member countries in the EU 28. In the paper, it is suggested that the productivity of resources in agriculture is not affected by the total amounts of subsidies, but by their structure. A three-stage spatial analysis was made of an EUFADN representative sample in the years 2007–2012: in the first stage, clusters of regions with significantly different agricultural support models were identified; in the second, it was determined whether the structure of the political rent, reflecting the different support models in the EU 28, is a significant determinant of the productivity of capital, land and labour on farms when subsidies are excluded and when they are included in the analysis. In the third stage, a robust model has been estimated (employing GLS) to relate the factors productivity to the EUFADN subsidies and to the location variables identified by the cluster analysis. The analysis confirmed that the qualitative predictor, i.e. "a structure of agricultural support", was a significant factor influencing the capital productivity over the whole of the period.

Keywords: model of support, productivity of farms, spatial analysis

At a time when the EU society is striving towards sustainable development, the productive functions of agriculture are coming to be complementary to new utilities provided by that sector. The most important of these include the provision of public goods (in the areas of biodiversity, protection of the natural environment and landscapes, the improvement of water conditions, and food safety). Many authors have pointed out that the valuation of the public goods associated with agriculture, and its sustainable development, represent an opportunity for the new EU 13 member countries, including Poland in particular (Steebling et al. 1998 Slangen 2001; Zegar 2007; Wilkin 2008; Zegar 2012; Czyżewski 2013). The valuation of the new functions of agriculture favours the switching of the agricultural support model in the EU onto a path of sustainable development, through the gradual withdrawal of the support for production, in particular agricultural markets, in favour of payments made on other bases (Czyżewski 2013; Czyżewski and Stępień 2014; Czyżewski and Brelik 2014). On the other hand, the need to ensure food security in the EU makes it necessary to maintain the relatively high productivity of farms as the chief suppliers of food. A dilemma is posed to the modern agricultural economics by the need for a relative reduction in the effectiveness of production offered by the industrial development model (Wojtyna 2008) in favour of the improvement of the quality of life through a new economic paradigm which is sustainable economically, socially and environmentally (Zegar 2012). Agricultural policy should therefore take account of the complementarity of the traditional and "new" goals of agriculture (Czyżewski and Smędzik-Ambroży 2013). In the authors' view, however, the significant differences between regions, which have been noted by many authors (e.g. Matuszczak 2013; Giannakis and Bruggeman 2014), mean that it is not possible to apply a single universal agricultural support model throughout the EU. Various models are reflected in the structure of political rents, namely subsidies and payments under the Pillars I and II of the CAP. It is assumed throughout that the total value of these political rents is the sum of cash transfers (subsidies and payments) to the EU farms under the

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Common Agricultural Policy (Bezat-Jarzębowska and Rembisz 2013).

Although the question of how subsidies affect the productivity (as opposed to production) of farms in the EU has been studied by many authors, it has not yet been definitively answered (Olley and Pakes 1996; Hennessy 1998; Ciaian and Swinnen 2009; Rizov et al. 2013; Banga 2014). These studies show that prior to the decoupling reform (Luxembourg 2003), subsidies had a positive impact on production, but a negative impact on productivity. Conclusions concerning the period since that reform remain ambiguous, although they tend to show that a negative effect is found much less often (in terms of the influence of subsidies on the level of the total factor productivity –TFP) or not at all (in terms of the influence on the rate of growth of TFP) (Rizov et al. 2013). The cited paper of Rizov et al. is the most comprehensive study in this area, and it also reviews the results of other researchers. The problem, however, is that it remains inconclusive as regards the period since the decoupling reform, and that it concerns exclusively the EU 15 countries. Of a particular concern is the fact that the results of the econometrically sophisticated modelling of the TFP of a representative sample of farms after 2003 (Rizov et al. modelled unobserved TFP while directly controlling for the effects of subsidies) were not confirmed by the weakest, non-parametric measures of dependence, namely the Spearman (rank) correlation coefficients. In the cited work, these proved statistically insignificant for 11 of the 15 countries as regards the relationship between TFP growth and subsidies (Rizov et al. 2013).

Banga has made an extensive study of the effect of the "Green Box" (GB) subsidies on the technical efficiency of agriculture in various countries of the world, including the EU 26, concluding that the total factor productivity growth in the EU agriculture is 3.7% per annum without the GB subsidies, but that it increased to 8.3% per annum due to the GB subsidies in 1995–2007 (Banga 2014). We believe, however, that it is unjustified to ascribe this growth in productivity to pro-environmental subsidies and the action taken to further sustainable development, because not all GB tools are of that nature (they also include investment support), and moreover, there are large regional differences in support models, while the average measures of productivity growth in the EU may be heavily affected by the countries and regions which make little use of the GB support (as we shall show later).

Hence a further research into the relationship between subsidies and factor productivity in agriculture is required, taking account of the period since the decoupling reform, the new member countries of the EU 28, and the regional perspective. We believe that this problem requires a slightly different approach to evaluating the effect of subsidies than was applied in the works cited above. Firstly, subsidies for agriculture in the EU are not so much an econometric problem as one of the political economy. Secondly, the productivity of resources in agriculture is affected not by the total amounts of subsidies, but by their structure – in other words by the CAP support model, which is differentiated at the regional rather than national level and is to a strong degree politically determined. In this view, subsidies treated holistically as support models become a qualitative rather than a quantitative predictor, one which is not properly reflected in the production functions computed by the authors of the cited works.

We shall attempt to fill this gap by the means of a three-stage study. In the first stage, the goal is to identify clusters of the EUFADN regions which differ significantly in terms of their agricultural support models.

In the second stage, these models, treated as qualitative predictors, will be used to determine whether the structure of political rent, reflecting the different agricultural support models in the EU 28, is a significant determinant of the productivity of capital, land and labour on farms when subsidies are excluded, and how it affects that productivity. Then subsidies will be included in the analysis, to verify how they influence the differences in the factor productivity between the various support models.

In the third stage, a robust model has been estimated (employing GLS) to relate the significant factors (i.e. capital, land or/and labour productivity), identified in the previous stage, to the EUFADN subsidies and to the location variables developed through the cluster analysis.

The hypothesis is proposed that the qualitative predictor determining the productivity of resources on the FADN farms is the structure of the political rent, broken down into production subsidies, payments for public goods, subsidies for indirect consumption and investment subsidies, bearing in mind that the absolute size of the CAP envelopes for countries is limited and is to a strong degree politically determined.

A spatial analysis was carried out based on data from the EUFADN for the 2007–2012 financial per-

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spective; it covered all FADN regions in the EU 28, focusing on the representative farms for the regions (131 units representing 4 919 580 farms in 2012), and considered the average indices of the productivity of working capital (indirect consumption), of fixed assets (buildings, structures, machinery and equipment), and of labour – cf. the methodology.

SUBSIDIES AND PRODUCTIVITY – A POLITICAL OR ECONOMIC ISSUE?

It is an open secret that the decisions on the sizes of the CAP support envelopes for the whole EU and for the individual countries are influenced primarily by the political rather than economic considerations. This is particularly visible in the case of the new EU 13 member countries, where the small, semi-subsistence family farms are dominant.

There is no universally accepted or consistently used definition of either small farms or semi-subsistence farms. If one considers a small farm as a holding which sells less than 50% of its agricultural output and consumes the remainder within the farm household, then there are over 6 million such units in the EU 28 (Steebling et al. 1998; Wiggings et al. 2010; Davidova et al. 2013,). Such a large sector, which provides a livelihood for millions of rural inhabitants, cannot and should not be ignored politically. Almost 90% of these small farms are located in the new member states – over 60% in Romania, about 10% each in Hungary and Poland, 9% in Italy, and over 100 000 in both Bulgaria and Lithuania (Slangen 2001; Wąs and Małażewska 2012).

A basic criterion used in determining the amount and structure of support under the Pillars I and II of the CAP is therefore the need for it to reach the largest possible number of farms, as these represent the potential voters, regardless of the fact that they account for a relatively small total area of agricultural land and only a small percentage of the total output. In research covering the countries considered here (new EU member states), the popular technique of modelling production functions is impressive, but not efficient, as the hierarchy of goals of semi-subsistence farms deviates hugely from the assumptions of neoclassical economics. Moreover, if it is politicians who decide on the level and structure of the CAP support, the arguments and research assumptions of academics must be made comprehensible to policymakers and possible to translate into the language of political debate. The methods applied by the previously cited researchers considering the "effect of subsidies on productivity" (Olley and Pakes 1996; Rizov et al. 2013) fail to fulfil these criteria for several reasons:

(1) The assumptions on which the microeconomic models of farms are based are adopted implicitly, that is, they are not set out and discussed. This applies, for example, to the problem of how the price effects are captured, which is generally encountered by researchers working with the FADN data. The FADN database does not contain data on transaction prices, only the nominal values. Another issue relates to the assumption on which a production function is built, namely that "conditional on staying in production, the farm has to decide about its inputs, labour and materials use and investment" (Olley and Pakes 1996; Rizov et al. 2013) – but what about land? On semi-subsistence farms, land remains in production for own needs regardless of the market conditions, and the purchasing or sale of land is not decided by the criterion of profitability of production.

(2) The assumptions are also not tested to determine whether they hold in reality (few remember about the Popper's principles concerning the falsification of theories, which indicate the need to test auxiliary assumptions (Popper 1959; Gezelter 2009). For example, the condition of the maximisation of the sale value of the farm is unrealistic for a semi-subsistence farm, which rather tends to "optimise" income, i.e. to make it sufficient, while satisfying the household's own food needs. Apart from that, the farm labour – which means own labour in the case of a small farm – is not a function of subsidies or one about which decisions are always made during the current period. Labour resources on small farms remain constant irrespective of the agricultural policy or market conditions, and are determined by the demographic processes.

(3) The efficiency of these models in terms of producing results is low, since the conclusions resulting from the huge amount of research work are ambiguous and hard to implement in practice.

(4) The models do not take account of the political criteria for the allocation of subsidies, which in our view determine the process by which they influence factor productivity in agriculture.

With reference to this last point, our view is as follows: If it is assumed that the criterion for determining the structure of the national CAP envelopes

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is the maximisation of the number of beneficiaries, that structure will initially be matched to the structure and dominant types of production in the given country and its regions. "Initially" means when negotiating the given CAP financial perspective and when determining the structure of the Pillars I and II within the permissible limits of flexibility at national level. With regard to the period covered by this study, this refers to the year 2007, being the start of the 2007–2013 financial perspective. Nonetheless, the determined support structure (amounts allocated to the individual programmes) secondarily shapes the agrarian structures in the given country and region, forcing them to adapt to the criteria presented to the beneficiaries by the various programmes (when the subsidy applications are submitted). In this way, the subsidy structure exerts an influence on the factor productivity. We still believe, however, that it is the support model treated holistically that exerts this influence, and not the amounts of subsidies, because the model of the CAP Pillars I and II has been defined as a whole through a political process. Microeconomic models treat subsidies as taxes with the sign reversed, which in this case is not a completely valid approach. The structure of the CAP Pillars I and II, determined by politicians and being a derivative of the agrarian structures in a particular country, is a qualitative variable which affects the factor productivity in three ways:

(1) Indirectly, through the fulfilment of the criteria of the CAP programmes relating to agricultural practices and the structure of the production (impact on technical and financial productivity). According to (Baumol 1990; Alston and James 2002), this impact is negative, because subsidies distort the production structure of the recipient farms, leading to the allocative inefficiency if the recipients invest in subsidy-seeking activities which are relatively less productive. The recipients may not be eager to seek cost-improving methods.

(2) Indirectly, through the subsidisation of investment and technology (the impact on technical productivity). The impact can be positive due to the investment-induced productivity gains, but also negative while the subsidies give an incentive to change the capital–labour ratio, which can lead to the overinvestment.

(3) Directly, through the influence on the financial productivity and incomes (positive impact). The research carried out in Poland indicates that the dominant target function of the agricultural producer is the maximisation of income in the conditions of substitutability between the economic rent, having its source in the efficiency of production, and the political rent, whose size results from the agricultural policy applied in the region in question. An agricultural producer replaces an income source which is for him/her more costly and demanding, with a cheaper source which does not require so much input. In the light of the concept of rational and adaptive expectations, improving the efficiency of use of production factors subject to the given price relations is always harder than waiting for support (Bezat-Jarzębowska and Rembisz 2013: 36–39).

In summary, we tend towards the conclusion that the microeconomic models of farms developed for the EU 15 are not accurate for the new member states, where small farms are dominant. This does not mean, however, that new models need to be developed for farms in those countries. We believe, in fact, that the creation of a microeconomic model that precisely captures the behaviour of small farms is impossible and unnecessary, in view of the wide variety of irrational behaviours and target functions, which are indeed continuously evolving.

METHODOLOGY

Having the above considerations in mind, we propose a relatively simple statistical procedure based on assumptions which will not give rise to doubts of the kind discussed above.

In the first stage, the goal was to identify areas in the EU 28 having similar agricultural support models. For this purpose, an agglomerative cluster analysis was carried out (using the Ward's method) covering 131 representative farms for all EUFADN regions[1] (representing 4 919 580 farms in 2012), according to the criterion of percentage contributions to the political rent, for the following grouping variables:

X1 – value of payments for public goods (the sum of set-aside and agri-environmental payments, sup-

[1]Sampling was performed by the EUFADN National Liaison Agencies, according to the classification rules defined and formally established by the Commission Regulation (EC) No 1242/2008 of 8 December 2008 (Official Journal of the European Union, L 335, p. 3, 13 December 2008), French overseas territories were excluded from the analysis.

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port for less favoured areas, and other subsidies under rural support programmes);

X2 – value of crop and animal production subsidies (the sum of other subsidies for crop and livestock production plus the balance of subsidies and penalties for milk production, subsidies for other cattle production and subsidies for sheep and goat production);

X3 – value of single farm payments and area payments;

X4 – value of subsidies for indirect consumption;

X5 – values of investment subsidies.

Cluster analysis is a multivariate statistical technique that entails the division of a large group of observations into smaller and more homogeneous groups. He Ward's method, an agglomerative hierarchical clustering procedure, is based on the least-squares criteria and minimises the within-cluster sum of squares, thus maximising the within-cluster homogeneity (Everitt et al. 2011). In general, this method is regarded as very efficient. The variables X1–X5 were taken as the average values across a six-year reference period (2007–2012), as well as for each year separately. The estimated cluster sets were quite similar in each year, because the national structures of subsidies are mostly defined at the beginning of the programming period when the programmes of the CAP Pillars I and II begin. However, we chose the clustering result from the last year of the analysis, because it reflects adjustments of agrarian structures over the entire programming period and gave the best results of disjointness tests. The disjointness of clusters is the most important criterion from the point of view of the hypothesis put forward at the outset. It was tested by evaluating the significance of the differences between the average contributions of the types of subsidy to the political rent in the obtained clusters. The assumption of homogeneity of variance of variables between the groups of regions was evaluated using the Levene's test and the Brown-Forsythe test. The hypothesis of the homogeneity of variance in comparable groups was rejected for the individual variables (X1–X4) with the exception of the variable expressing the contribution of subsidies for indirect consumption. Hence the significance of the differences between the means of samples (clusters) was evaluated using the non-parametric Mann-Withney U test (Stanisz 2006: 247). It was confirmed that the clusters (isolated at a level of approximately 50% of the maximum distance) differ significantly in terms of the structure of budgetary subsidies for agriculture. The calculations were performed using the *Statistica* 10 program.

In the second stage, the single-factor and six-dimensional analysis of variance (multi-factor ANOVA) was performed for the years 2007–2012 (each year separately), where the qualitative predictor was the structure of the CAP subsidies (the support models identified in the cluster analysis in the first stage), and the dependent variables were the average indices of productivity of working capital (indirect consumption), land, productive assets and the labour – the construction of these indices is shown in Table 1.

In the multi-factor ANOVA, the variance is computed as the sum of squared deviations from the overall mean, divided by $n - 1$ (sample size minus one). Thus, given a certain n, the variance is a function of the sums of (deviation) squares, or SS for short. For the evaluation of the significance of differences in the vector of dependent variables Y1–Y4, the multidimensional tests of Wilks, Pillai, Hotelling and Roy were used, in addition to the F-test for evaluating the single-dimensional dependences. The assumptions of the homogeneity of covariance and variance were checked using the Box's M-test for the multidimensional space. Because this test did not confirm the assumption of the homogeneity of covariance for the multidimensional space, the assumption of the homogeneity of variance for each dependent variable was checked using the Levene's test, and the normality of the distribution was tested in each of the clusters.

A very restrictive statistical procedure was applied, since only the variables fulfilling the assumption of the homogeneity of variance were included in the further analysis. For these variables, the post hoc multiple comparison tests (LSD, Bonferoni, Scheffe, HSD for unequal N) were performed to determine which support models have a significant effect on the factor productivity. Next, a contrast analysis was carried out: the contrasts were computed for predictor classes identified in the post hoc analysis, to determine to what degree the contrast coefficients enable the prediction of the group means. In other words, it was assessed what proportion of the variability (of the total variation in the means of a given variable in all classes) can be ascribed to a given contrast. The sum of squares (SS), namely the variation for which a contrast is responsible, was calculated using the formula below, and was divided by the SS for a given dependent variable in all predictor classes:

$$SS_L = \frac{\overline{L}^2}{\frac{1}{n}\sum_{i=1}^{k} c_i^2} \quad (1)$$

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Table 1. Construction of indices of the average productivity on representative farms

Variable	Description
1. Productivity of indirect consumption (i.e. of working capital)	The ratio of the total production to indirect consumption. This index indicates any differences in flows through sale prices and prices of the means of production.
2. Productivity of land	The ratio of production to the area of agricultural land in use. An increasing value can be interpreted as the intensification of production, particularly in conditions of increasing capital-intensity.
3. Productivity of assets	The ratio of the total production to fixed assets (i.e. productive assets – buildings, structures, machinery and equipment). It is an indicator of the absorption of fixed assets per unit produced, and reflects the farm's ability to allocate those assets effectively. A fall in the value can also be interpreted as the development through the capital-driven intensification of production, particularly if the index of labour-intensity falls at the same time.
4. Productivity of labour	The ratio of the total production to inputs of family and outside labour on a farm. Higher values indicate more effective absorption of the labour factor in agricultural production, and consequently a higher residual income per unit of agricultural labour. As in the case of productivity of land, a change in the productivity of labour should be compared with the index of productivity of assets in order to draw conclusions about a farm's development model.

Source: own analysis based on the EUFADN data

where:
$\overline{L}$ = the value obtained for the contrast;
n = the number of replications (of measurements in the group);
c_i = the weights describing the contrast.

The values of the contrasts were determined by the formula:

$$\overline{L} = \sum_{i=1}^{k} c_i \overline{x}_i, \text{ where } \overline{x}_1,\ldots\overline{x}_k \text{ are means of samples}$$

Then the variables Y1–Y4 were modified, by increasing the numerator of the indices described in Table 1 by the sum of subsidies, and the multi-factor ANOVA procedure described above was repeated with the inclusion of subsidies.

In the third stage, we have estimated the parameters of the following model, considering the results of the cluster analysis and the multi-factor ANOVA:

$$FP_i = \alpha_0 + \sum_{k=1}^{K} \alpha_k \times S_{ik} + \sum_{m=1}^{M} \beta_1 \times L_{im} + \varepsilon_i$$

where i = 1, ...131 EU region; FP_i = factor productivity variable that has passed the ANOVA procedure; S_k = the K "subsidy variables" (acc. the EUFADN all codes of subsidies: SE406, SE407, SE612, SE613, SE616, SE617, SE618, SE619, SE621, SE622, SE623, SE699, SE625, SE626, SE631, SE632, SE640, SE650); L_m = the M "dummy location variables" according to the cluster analysis. The EU regions are heterogeneous in nature. This heterogeneity can create heteroscedasticity in the residuals of the estimation of the FP function. Indeed we detect heteroscedasticity in our model. Therefore, we estimate the robust model, employing the GLS (backward stepwise method) and addressing the unobserved heterogeneity to the location variables L_m that have been identified by the cluster analysis. We have also reduced the problem of the time influence using the means for the dependent and independent variables over the period 2007–2012. Due to the high number of independent variables available (all EUFADN subsidies codes), multicollinearity may be a serious concern. Recall that multicollinearity leads to unstable coefficients and inflated standard errors. The VIF values do not exceed 3.66 (and the mean VIFs do not exceed 2.18, c.f. Table 9) in our model, which is in line with the most conservative rules of thumb that advocates the mean of VIFs should not be considerably larger than 1, and never exceed 10 (Chatterjee and Hadi 2006).

The above procedure made it possible to achieve the goals of the study and to verify the research hypothesis put forward at the outset.

RESULTS AND DISCUSSION

Regional variation in the EU 28 according to the subsidy structure

Table 2 contains data relating to the statistical significance of the differences between clusters as regards the mean contributions of the listed types

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Table 2. Results for the statistical significance of differences in mean contributions of the types of subsidies to the political rent, between clusters of the EU 28 regions in 2012 (*p*-value in the Mann-Withney U test – differences are significant with $p < 0.05$)

Clusters of EU 28 regions		B					C				
	*	X1	X2	X3	X4	X5	X1	X2	X3	X4	X5
A	X1	0.0000					0.0000				
	X2		0.0006					0.0047			
	X3			0.0000					0.0000		
	X4				0.8932					0.0289	
	X5					0.0134					0.0017
B	X1						0.0000				
	X2							0.0000			
	X3								0.0000		
	X4									0.0271	
	X5										0.0000

*X1 to X5 denote the contributions of particular types of subsidies to the political rent: X1 for payments for public goods, X2 for crop and animal production subsidies, X3 for single farm and area payments, X4 for subsidies for indirect consumption, and X5 for investment subsidies (see research methodology).

Source: own analysis based on the EUFADN data

of agricultural subsidies to the political rent. The information in the table demonstrates what was stated above – that the identified clusters differ significantly in terms of the mean contributions of the particular types of subsidies to the political rent of a region's representative farm. The only difference not found to be significant was the difference between clusters A and B in the mean contributions of subsidies for indirect consumption.

The analysis identified three clusters of regions with different agricultural support models (cf. Table 3). In the most numerous group of regions (cluster A), a moderately sustainable model operated, in which the support for agriculture was provided primarily through the single farm and area payments (these contributed to more than 59% of the political rent). At the same time, farms in those regions derived significant economic benefits from the supply of public goods – the contribution of agri-environmental payments, set-aside payments, support for less favoured areas and other subsidies under the rural support programmes to the political rent of representative farms in those regions was close to 17%.

In the regions in the next largest cluster (B), the contribution of the single farm and area payments to the political rent was markedly higher than in the other clusters, at close to 80%. The contributions from other types of budgetary support, including payments for public goods, were relatively small. Cluster B reflected to the clearly greatest degree a model in which the support for production has been almost entirely replaced by the direct support for farms, and which can be described as weakly sustainable.

The third, and the least numerous, group of regions (cluster C) contained parts of the EU 28 having a model that combines different mechanisms for the

Table 3. Mean contributions of various types of subsidies to the political rent in 2012, by cluster (%)

CLUSTER	Number of regions	X1*	X2	X3	X4	X5
A	57	**16.78**	8.82	**59.48**	1.55	3.92
B	50	8.75	3.22	**79.77**	2.08	1.73
C	24	**32.88**	**17.18**	**27.26**	2.30	**9.89**
Total	131	16.66	8.21	61.32	1.89	4.18

*X1 to X5 denote the contributions of particular types of subsidies to the political rent: X1 for payments for public goods, X2 for crop and animal production subsidies, X3 for single farm and area payments, X4 for subsidies for indirect consumption, and X5 for investment subsidies (see research methodology)

Source: own analysis based on the EUFADN data

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support of farms. Payments for crop and animal production, as well as the single farm and area payments, made contributions of no more than 30% to the political rent (Table 3). Cluster C also had the highest contributions of the payments for public goods (approx. 33%) and investment subsidies (almost 10%) compared with the other groups of regions. It is therefore seen that over most of the area of the EU in 2012, there functioned a model (A or C) in which the support for agricultural production was being replaced by direct payments (area and single farm payments) and payments for public goods (Figure 1). This is in accordance with the desired direction of the evolution of the European agricultural model

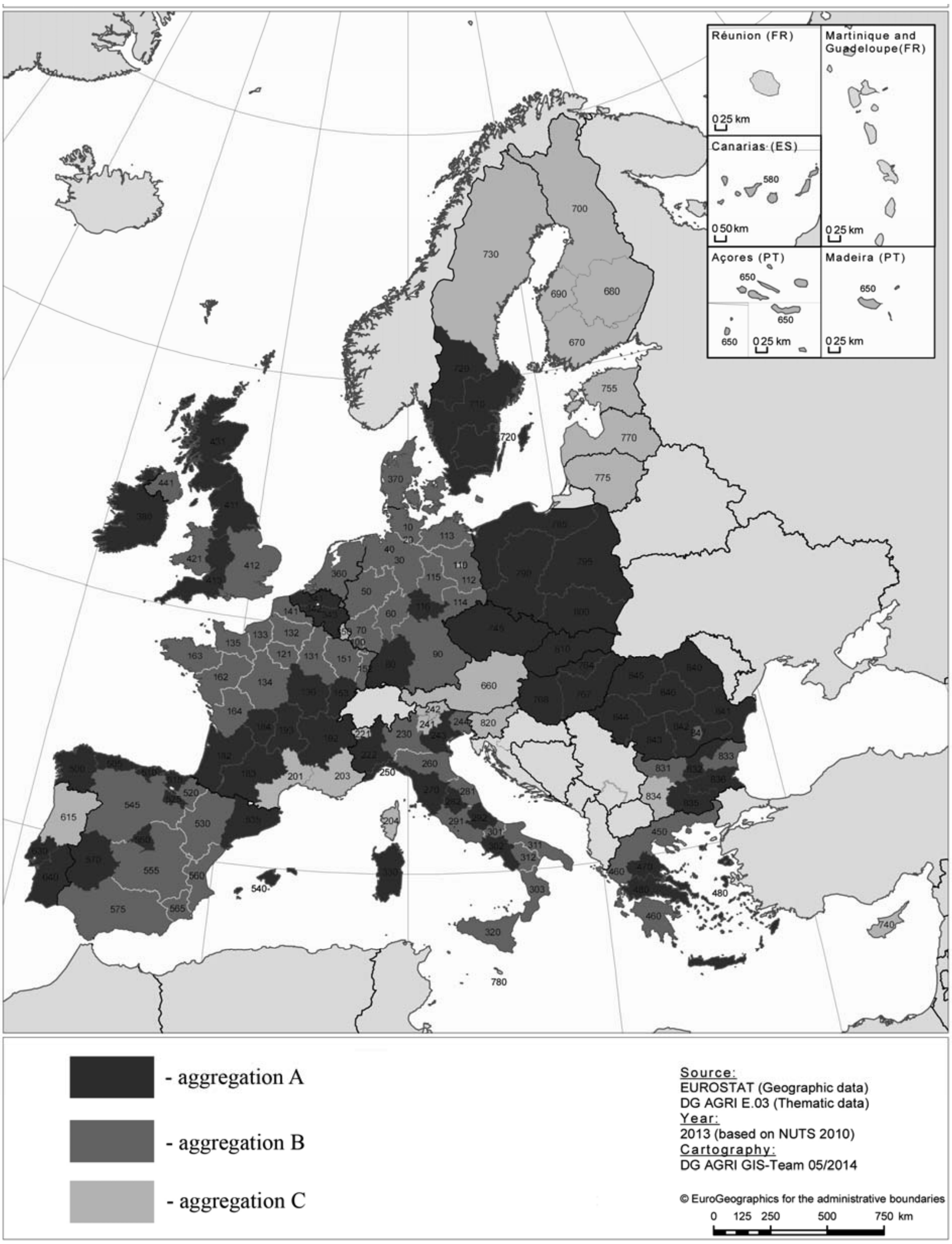

Figure 1. Clusters of EU 28 regions in 2012 according to structure of political rent

Source: own analysis based on EUFADN data

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towards sustainable agriculture, most strongly supported in model C (where the contribution from payments for public goods is the highest). In most regions of the "old" EU member countries, however, the model B operates, oriented exclusively towards direct payments, which are treated as a substitute for production support and produce a relatively weak stimulus for sustainable development, whereas in the countries of the Central and Eastern Europe, the model A applies, providing an opportunity for the valuation of the public goods produced by agriculture. This is confirmed by the spatial analysis of Giannakis and Kutkowska, in which it was observed, among other things, that the direct support primarily reaches farms in the intensive farming areas (Giannakis and Bruggeman 2014). It was also noted that the degression, resulting from modulation, in area payments for farms with larger areas in the new member countries will cause changes in production in favour of the methods that are more friendly to the environment and assist sustainable development (Kutkowska and Berbeka 2012: 266–267). This is no doubt determined by the fears of a fall in the factor productivity in agriculture in case of a possible change in the support structure. The question of whether these fears are justified will be addressed in the following section. A mention should be made here, however, of the results of the research by Grochowska and Mańko, which show that the Polish commercial farms observed by the FADN have a similar total factor productivity (TFP) to those in the EU 15 countries (Grochowska and Mańko 2014: 30). It is also notable that in many countries, particularly those of the EU 15, the rate of growth in the productivity of land was negative in the years 2004–2009, whereas Poland recorded a positive growth (by 117%), outperformed only by Cyprus (152%) and Slovenia (194%). Some believe that the transformations taking place in agriculture in those countries have put them on a development path similar to that on which the EU 15 countries found themselves formerly (Nowak 2013; Poczta 2014). It should nonetheless be remembered that these changes are taking place in conditions where the structure of the political rent in those countries is different from that in the EU 15 (Figure 1). In Poland, Cyprus and Slovenia in 2012, there functioned agricultural support models in which the payments for public goods made a significant contribution to the political rent, in contrast to the situation found in most of the EU 15 countries.

In a small group of regions, there was found to be a strongly sustainable support model combining various forms of assistance to farms (cluster C). Subsidisation for the supply of public goods was accompanied there by high subsidies for agricultural production and a significant direct support (single farm payments). This group included most of the island regions of the EU, the Northern part of Europe consisting of the Finnish regions and the Län i Norra region in Sweden, and the regions of Lithuania, Latvia and Estonia. This cluster also contained a few regions in Southern and Central Europe, mainly mountainous (Figure 1). In summary, it was found that the groups of the EU 28 regions generated by the cluster analysis differed significantly in terms of the structure of budgetary subsidies to agriculture, and that only models A and C were to a greater or lesser extent aligned with the development priorities of the European agricultural model emphasised in the new financial perspective of 2014–2020.

Effect of the political rent structure on the factor productivity in agriculture

Assumptions of the multi-factor ANOVA

In the ANOVA analysis, a certain difficulty may be posed by the fairly restrictive assumptions. These were satisfied, except as noted below:

(1) the assumption of measurability of dependent variables – satisfied without reservation;

(2) the assumption of randomness of the sample and independence of measurements – satisfied without reservation;

(3) the assumption of randomness of selection within the support models A, B, C – satisfied without reservation (membership of a group was decided by the support structure, which is a qualitative factor independent of the authors' decision; the EU states have a high degree of autonomy in determining that structure, particularly in relation to the CAP Pillar II);

(4) the assumption of normality of distribution of the analysed dependent variables in each of the subgroups for the qualitative predictor – not satisfied, the distributions have skewness and kurtosis greater than zero. The skewness of the distribution usually does not have a sizable effect on the *F* statistic, used in the ANOVA. The F test is also remarkably robust to deviations from normality (Lindman 1974). However, if the kurtosis is greater

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than 0 (as it was over the whole period), then *F* tends to be too small and we cannot reject the null hypothesis even though it is incorrect. This means, in fact, that the results confirming the significance of the differences in productivity between classes A, B and C become even more reliable;

(5) the assumption of homogeneity of variance and covariance – only variables that unconditionally satisfied that assumption were included in the analysis. The assumption of homogeneity of covariance in multidimensional space was not satisfied, because the Box's M test failed to confirm that assumption in any of the years studied. Nonetheless, the Levene's test for single-dimensional analysis confirmed the assumption of homogeneity of variance for the productivity of indirect consumption and productivity of capital in both variants (with and without subsidies) in all years for $\alpha = 0.05$ (cf. Table 4). Hence the single-dimensional ANOVA was continued with respect to those variables.

Testing of significance of differences in the average productivity

As was noted above, the assumptions of the analysis of variance were satisfied only in the case of two measures of productivity – those describing the productivity of working capital and of fixed assets. We therefore performed F-tests for the significance of the differences in productivity for those variables in all of the studied support models, and post hoc tests for the years 2007–2012, to show which of the classes A, B, C differed significantly from each other. A general conclusion drawn for the whole of the period of analysis is that the regional structure of subsidies causes significant differences only in the productivity of fixed assets in support models B and C – cf. Table 5. (Other comparisons of the models proved to be statistically insignificant throughout the period of the analysis, as was the case for the variable "productivity of working capital".) It should be noted that the probability of H0 increases when account is taken of the subsidies, which means that models B and C are more competitive in the conditions where support is applied than when it is absent. The analysis of contrasts reinforced the above conclusion, because the variation for which the contrast B vs. C is responsible ("0; 1; –1" computed from the formula 1) represents up to 70–80% of the changes in the productivity of fixed assets in the qualitative predictor classes, over the whole period of analysis.

In investigating how the various support models affect the productivity of fixed assets, we noted that the highest productivity, when the subsidies are excluded from the analysis, occurred in cluster B, consisting of areas where the support for agriculture is provided chiefly in the form of the single farm and area payments. This is not a surprise, although it is clear that this takes place to a certain extent at the cost of public goods in rural areas. The lowest indices of the productivity of fixed assets were found in cluster C, where the agricultural support model included payments of various types and was the most sustainable (Table 6). The values given in Table 6 thus show that the highest productivity of assets is obtained by typically agricultural regions, with the smallest percentage of the fallow land, less

Table 4. Probability of the incorrect rejection of H0 on the homogeneity of variance of productivity indices in models A, B, C in favour of H1 stating that the variances are not homogeneous – the Levene's test analysis withouth and with subsiedis

Variable	2007	2008	2009	2010	2011	2012
			analysis without subsidies			
Productivity of indirect consumption	**0.146745**	**0.402215**	**0.983745**	**0.995099**	**0.496301**	**0.729122**
Productivity of land	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001
Productivity of fixed assets	**0.383681**	**0.507052**	**0.797211**	**0.767922**	**0.946481**	**0.747999**
Productivity of labour	0.001980	0.000483	0.002930	0.000282	0.000268	0.000705
			analysis with subsidies			
Productivity of indirect consumption	**0.293847**	**0.215233**	**0.890749**	**0.892965**	**0.162959**	**0.308151**
Productivity of land	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001
Productivity of fixed assets	**0.344712**	**0.457975**	**0.909330**	**0.988364**	**0.992357**	**0.907025**
Productivity of labour	0.009750	0.002736	0.012231	0.002204	0.002829	0.006263

Source: own analysis based on the EUFADN data

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Table 5. Results for the statistical significance of differences in the average measures of productivity of indirect consumption and of fixed assets in support models B and C – post hoc analysis without and with subsidies

Variable	Test	2007	2008	2009	2010	2011	2012
		p – probability of incorrect rejection of H0 on absence of differences in favour of H1 stating that there are significant differences					
		analysis without subsidies					
Productivity of fixed assets	LSD[1]	–	**0.014174**	**0.009138**	–	–	–
	Bonferoni	–	**0.042523**	**0.027415**	–	–	–
	Scheffe	–	**0.048824**	**0.033020**	–	–	–
	HSD (unequal N)	**0.039515**	0.082243	0.059199	**0.009529**	**0.012270**	**0.002926**
		analysis with subsidies					
	LSD[1]	**0.009405**	**0.031267**	**0.023014**	–	–	–
	Bonferoni	**0.028214**	0.093802	0.069041	–	–	–
	Scheffe	**0.033884**	0.097502	0.074757	–	–	
	HSD (unequal N)	0.060534	0.146662	0.117504	**0.033201**	**0.047113**	**0.013061**

[1]Where the strongest test (HSD for unequal N) was satisfied at $p < 0.05$, the remaining weaker tests were not computed

Source: own analysis based on the EUFADN data

favoured areas and areas with the high nature value (cluster B). This results from the higher revenue earned from agricultural activity (by 91% compared with farms in cluster A, and by as much as 153% compared with the farms in cluster C), even in a situation where the value of fixed assets is higher. The demand for fixed assets is greater on farms in cluster B than on those in clusters A and C – by 29% and 19% respectively, in relation to buildings, and 74% and 91% in relation to machinery. It should be added that farms in clusters A and B did not differ significantly in terms of the structure of revenue from crop and animal production. In the case of cluster C farms, however, the contribution of cereals to the crop production revenue was only half as great, the contribution of sugar beet was less than half as great, the contribution of revenue from the industrial crop production was twice as large, and the contribution from the vegetable and flower production was also 2.5 to 3.5 times larger than in clusters A and B. The structure of revenue from the animal production was similar among clusters. The structure of the revenue from the crop production can be explained by the markedly higher productivity of land on farms in cluster C than in the other two clusters (although this was not statistically significant).

Why is the productivity of fixed assets significantly lower in the new member states (EU 13)? The authors propose the following explanations:

(1) The simplest explanation is that the productive assets are technologically obsolete and their technical productivity simply falls behind the EU 15 countries;

(2) An additional factor is the irrational use of assets, namely the mismatch between new assets (machinery, technological equipment) purchased

Table 6. Average values of the productivity of fixed assets in models A, B and C in 2007–2012 – analysis with and without subsidies (in euro per €1 of capital resources)

Cluster	2007	2008	2009	2010	2011	2012
	analysis excluding subsidies					
A	1.146235	1.111792	0.962591	1.034933	1.109203	1.032066
B	1.413225	1.247893	1.119162	1.255188	1.283792	1.294553
C	0.890954	0.877200	0.798177	0.810419	0.857356	0.853121
	analysis including subsidies					
A	1.362371	1.325735	1.183906	1.269056	1.340157	1.240776
B	1.625670	1.453683	1.331432	1.477536	1.496709	1.484282
C	1.081235	1.088273	1.015498	1.039178	1.083274	1.064871

Source: own analysis based on the EUFADN data

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out of the CAP funds and the agrarian structure. Farms often purchase expensive modern machinery whose potential cannot be fully exploited in the small growing areas or smaller breeding herds. There is also the problem of the insufficient horizontal integration among farmers and the lack of joint investment carried out by producer groups;

(3) The costs of capital (interest rates) are higher in the EU 13 than in the old member states. Consequently, the assets purchased on credit carry a high alternative cost and significantly restrict the farms' liquidity;

(4) Benefits of the scale of production are much smaller or do not occur at all.

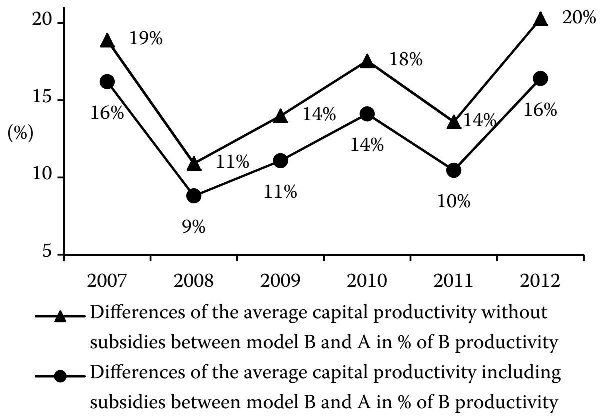

Figure 2. The effect of CAP subsidies on productivity differences between clusters A and B

Source: based on Table 8 (for Figure 2–4)

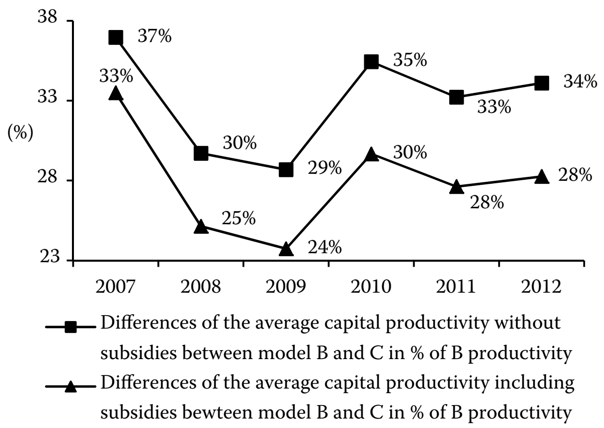

Figure 3. The effect of CAP subsidies on productivity differences between clusters B and C

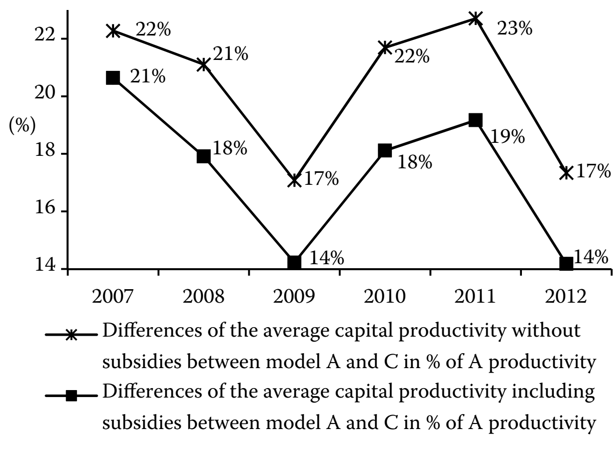

Figure 4. The effect of CAP subsidies on productivity differences between clusters A and C

Do subsidies reduce the differences in productivity between different agricultural models?

If the CAP sets the goal of stimulating the sustainable development of agriculture in the EU, it ought to create for that purpose economic stimuli which would mitigate the losses on account of the reduction in intensity of agricultural production. This problem is taking on the ever greater significance, and attempts have been made to achieve such an effect in creating the new CAP financial perspective for 2014–2020, with a still greater flexibility in the structure of the pillars and the emphasis on the "greening" of agriculture (Stępień and Mironescu 2013; Czyżewski and Stępień 2014). The degree to which this was successful in the period 2007–2012 is shown by Figures 2–4, which present the differences in productivity between models A, B, C with and without consideration of subsidies. The conclusion is unambiguous: subsidies and payments from the CAP in 2007–2012 did not, in the authors' opinion, create sufficient stimuli for a change towards more sustainable management models in agriculture. Admittedly, when the subsidies are included, the differences in productivity between the models are smaller, but they are constant over time, and their absolute size exposes farmers to significant losses in the productivity of assets, in particular when moving from model B to the sustainable model C. Without subsidies, this difference ranges from 29% to 37%, and with subsidies from 24% do 33%, depending on the economic situation in the agricultural sector. Interestingly, during the period of worsening economic conditions in the years 2008–2009, the difference was smaller.

The opinions of other researchers concerning the effect of the CAP support on the factor productivity are divided, although the impact of the structure of support has rarely been investigated. S. Mary showed that in France several subsidies had a negative impact on productivity during the period 1996–2003 (Mary

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2003). Kazukauskas carried out a study of the EU 15 countries after 2003, showing that the probability of a farm disinvesting decreased due to the policy change for most farms (Kazukauskas et al. 2013). In turn, T. Yanwen showed that outside the EU, there exists a negative relation between the subsidy and the TFP, if subsidies are associated with the acreage in low per capita income countries (Yanwen et al. 2013). The closest approach is that presented by Manevska-Tasevska, who states, however, that the Pillar II support appears to stimulate the farm technical efficiency, and to a large extent has compensated for the losses originating from the agri-environmental and regional potential (but in Sweden, where model C dominates) (Manevska-Tasevska and Rabinowitz 2013).

Results of the GLS modelling

The estimated model is well fitted since it explains over 90% of the capital productivity variations. In general, it confirms the previous conclusions. Marginal effects for the model are presented in Table 9. They are the most considerable for the location variables, i.e. A, B or C clusters. It means that clustering is appropriate since it captures almost the entire unobserved heterogeneity for the productivity of capital. We observe a strong negative agricultural policy incidence for the most sustainable support in cluster C. Farms located in this cluster lose 0.35 € per 1 € of assets which means almost 27% of the average capital productivity. The loss is three times lower in the cluster A (which represents a moderately sustainable structure of support) – 0.12 € per 1 € of assets. However, farms located in the cluster B (with weakly sustainable support) gain 0.12 € per 1 € of assets, i.e. 9% of the average capital productivity. There are two interesting conclusions in terms of the specific subsidies: firstly, the coupled subsidies (i.e. on investment, on external factors, art. 68 cereal specific aid) exert a negative influence on the capital productivity, while the decoupled payments have a positive impact, with the exception of special types of farming. A possible explanation is that the single farm payment and the single area payment are not a capital-intensive stimulus of the farm revenues and

Table 7. Regression results

Variables	Dependent variable: **CP capital productivity** (total output/value of buildings and machinery in € per 1 € of assets); average values over 2007–2012			
	coefficients α, β	standard errors	*p*-value	VIF[1]
Const	1.35767	0.0767968	< 0.0001***	–
Subsidies on investment SE406	−3.74251e-05	8.14882e-06	< 0.0001***	2.098
Set aside premiums SE612	0.00350631	0.00145959	0.0178**	1.506
Other crops subsidies SE613	6.27892e-05	3.46897e-05	0.0728*	1.308
Subsidies sheep & goats SE618	0.000599791	0.0002277	0.0095***	1.526
Subsidies on external factors SE626	−0.00016207	5.85478e-05	0.0065***	3.062
Single Farm payment SE631	5.92285e-06	1.54587e-06	0.0002***	3.661
Single Area payment SE632	1.44261e-05	5.82888e-06	0.0147**	2.791
Support_Art68 SE650	−0.000535941	0.000151458	0.0006***	2.297
A cluster (moderately sustainable support), or	−0.115173	0.0814645	0.1600	1.537
B cluster (weakly sustainable support)[2]	*0.115173*	*0.0814645*	*0.1600*	*1.537*
C cluster (most sustainable support)	−0.34982	0.121874	0.0048***	2.073
Observations	131			
R-squared	0.911691			
Adj *R*-squared	**0.904332**			
Mean for dependent variable	1.313743			
Standard dev. For dependent variable	0.592724			
ViF mean	2.1859			

[1]Variance Inflation Factors; $VIF(j) = 1/(1 - R(j)^2)$; it should not exceed 10

[2]Only $n - 1$ of dummy variables can be modelled since 'the last one' is collinear with the other

Source: own estimations based on the EUFADN data and on the Tables 3–5

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the subsidies on investment or on external factors quite the contrary. Since we are considering six years period (which should encompass lags), the marginal productivity of assets must be decreasing in those farms which have obtained the coupled subsidies. It is possible, since only the farms of a substantive economic strength, usually with the capital-intensive production, apply for investment subsidies both in the Western and Eastern Europe. In the new member countries of the EU 12, there is also a problem of the overinvestment or poor wealth management. Hence we come to the general thesis that the capital-intensive path of farming development is ending.

CONCLUSIONS

An evaluation has been made of the effect of the structure of subsidies from the CAP, on representative farms from all regions of the EU (besides French overseas territories), on the factor productivity in the years 2007–2012. Three clusters of regions in the EU 28 countries were identified, differing significantly in terms of the structure of budgetary subsidies (agricultural support models). In the most numerous group of the EU 28 regions, the moderately sustainable model A operated, primarily combining the direct support with payments for public goods. The second most numerously represented was the weakly sustainable model B, in which the support consisted chiefly of the single farm and area payments (direct support). The smallest group of regions featured a highly sustainable model, combining various forms of support for farms at similar levels (both through the direct and production subsidies, and through the payments for the supply of public goods and to a lesser degree the subsidisation of investment). The analysis confirmed that the agricultural support model is a significant factor determining the productivity of fixed assets over the whole of the studied period, in accordance with the hypothesis proposed at the outset. The conclusion is drawn that the CAP subsidies in the 2007–2012 financial perspective led to the petrification of the productive structures in the EU agriculture, to some extent preventing them from evolving in the pro-environmental direction. In such conditions, the weakly sustainable support model B was not able to evolve towards the sustainable model C, because the CAP failed to provide an adequate compensation for the economic effects of such a transformation. This therefore leads to a general conclusion that agriculture in the EU 28 is set on a dual development course for a long period of time. Farms will probably evolve from the support model A in the direction of the sustainable model C as the CAP becomes more "green", provided the natural conditions allow it. This applies particularly to the new member countries of the Central and Eastern Europe. There will, however, remain a large group of regions for which under the present CAP there is no alternative solution (model B) in the sense of a more sustainable support structure.

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