THE CONVERGENCE OF THE ECONOMIC SIZE OF FARMS IN POLAND – THE ECONOMETRIC ANALYSIS

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Abstract: The research discussed in the article concerned the level of development of agriculture in Poland. The main aim of the study was to verify the hypothesis of convergence of the economic size of farms. The analysis confirmed the existence of β-convergence, however, showed no occurrence of σ-convergence and γ-convergence. Based on the results of the analysis of marginal vertical β-convergence, Poland was divided into two clubs with different paths of development. In one of them the process of convergence was confirmed, but in the second one the phenomenon of divergence was revealed.

Keywords: agricultural development, economic size of the farm, β-convergence, σ-convergence, γ-convergence

INTRODUCTION

The subject of research that has been discussed in the article was the level of development of agriculture in Poland, more precisely, the answer to the question whether private farms are able to reach a similar level of agricultural of development, regardless of their location. In the paper, the economic size of the farm, that describes its potential production capacity, was adopted as a measure of development.

Since the authors' interest had focused on the equalization of the level of agricultural development between regions, the main aim of the study was therefore to verify the hypothesis about the convergence of economic size of farms in Poland. The average in the province, private farm was the research unit.

During the study, different types of convergence were analysed, both the basic – beta, sigma and gamma, as well as less popular – vertical marginal β-convergence and club convergence.

Economic size of farm does not reflect all aspects of the agricultural development. In other paper, the authors [Muszyńska, Müller-Frączek 2013] presented a broader approach to the analysis of the development of agriculture, in which the economic size of a farm was only one component of the synthetic variable.

THE ECONOMIC SIZE OF FARM[1]

FADN (The Farm Accountancy Data Network) is an European system for accountancy data collection from agricultural farms. It is one of the tools used by the EU for creating Common Agricultural Policy. Farms participating in FADN are classified according to Community Typology for Agricultural Holdings. One of the criterion for this classification is the economic size of the farm.

Economic size of a farm is a sum of all Standard Outputs[2] (SO) for all agricultural activities existing in that farm. It describes the potential production capacity of the farm. Farmers – FADN participants[3] – estimate the economic size of their farms, using standard output coefficients, on voluntary basis.

For the purposes of their study on the regional development of agriculture in Poland, the authors have constructed, for each province, a measure as similar as possible to the economic size, defined by FADN for a single farm[4]. Computations were based on the regional coefficients of standard output and the annual data on major crops and acreage of basic animal husbandry. All empirical data were derived from the Local Data Bank of CSO from the period 2004-2012. Due to the lack of data in public statistics, some products were not taken into account, e.g. mushrooms, flowers and ornamental plants. Then, the economic size of the region was divided by the number of farms in the province. Estimated this way the

[1] Detailed information on the topics covered in this chapter can be found in: Goraj L., Bocian M., Cholewa I., Nachtman G., Tarasiuk R. (2012) Współczynniki Standardowej Produkcji "2007" dla celów Wspólnotowej Typologii Gospodarstw Rolnych, Institute of Agricultural and Food Economics, National Research Institute, Warsaw.

[2] Standard Output is defined as the average monetary value of the agricultural output of an agricultural product (crop or livestock) over the reference period of 5 years, per 1 ha or 1 head of livestock per a year, in average production conditions in particular regions. Standard Output coefficients, used for the calculation of economic size, are different for the four Polish regions. In this way local conditions of each region are reflected.

[3] In Poland a group of approx. 12100 farms.

[4] Details of the calculations and the values of the economic size of the average farm in each province can be found in: Müller-Frączek I., Muszyńska J. (2014) Zmiany wielkości ekonomicznej polskich gospodarstw rolnych w latach 2004-2012, The Annals of The Polish Association of Agricultural and Agribusiness Economists, vol. XVI, no.3, pp. 205-210.

economic size of the average farm in the region formed the basis of the further research.

RESEARCH METHODOLOGY

Verification of the hypothesis about assimilation of the regions in terms of the level of agricultural development proceeded on the basis of analysis of the various types of convergence of the economic size of the average farm. There were beta, sigma and gamma convergence, widely discussed in the literature[5]. The study was extended by the analysis of marginal vertical β-convergence. Based on its results, Poland was divided into two clubs with different paths of development. Then the hypothesis regarding club convergence also was verified.

β-type convergence

The phenomenon of β-convergence occurs when there is a constant over time, negative correlation between the level of the analysed process and its growth rate. It means the regions with initially lower level of the investigated process will catch up the better developed provinces. The analysis of this phenomenon was based on the dynamic panel data model in the form:

$$\ln \frac{Y_{it}}{Y_{it-1}} = \alpha_0 - \alpha_1 \ln Y_{it-1} + \eta_i + u_{it}, \tag{1}$$

where:

- Y – the analysed process,
- i – the number of the region, $i = 1, ..., N$,
- t – number of period $t = 1, ..., T$,
- η_i – group effects,
- u_{it} – error term.

A positive value of the parameter α_1, in equation (1), proves the existence of β-convergence, a negative value means the occurrence of divergence phenomenon. When the β-convergence occurs, the speed of convergence[6] to equilibrium – the point at which all the regions are at the same level of development – describes the formula:

$$\beta = -\ln(1-\alpha_1). \tag{2}$$

[5] An extensive discussion of these topics can be found, inter alia, in Kusideł E. (2013) Konwergencja gospodarcza w Polsce i jej znaczenie w osiąganiu celów polityki spójności, Wydawnictwo Uniwersytetu Łódzkiego, Łódź, Wolszczak-Derlacz J. (2007) Wspólna Europa, różne ceny – Analiza procesów konwergencji, CeDeWu – Wydawnictwa Fachowe, Warszawa and Łaźniewska E., Górecki T., Chmielewski R. (2011) Konwergencja regionalna, Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, Poznań.

[6] The rate of catching up.

The time required to cover half of the distance to equilibrium point (half-life) can be calculated according to the formula:

$$\tau = -\ln(0{,}5)/\beta. \tag{3}$$

In order to estimate parameters the dynamic panel data model, described by the equation (1), is transformed to the model:

$$y_{it} = \alpha_0 + (1-\alpha_1)y_{it-1} + \eta_i + u_{it}, \tag{4}$$

where $y_{it} = \ln Y_{it}$.

Model parameters can be obtained using the Blundell and Bond System Generalized Method of Moments Estimator (GMM-sys). The quality of the estimated model is verified on the basis of statistical tests[7]. The basic ones are: the Arellano-Bond test for autocorrelation and the Sargan test of over-identifying restrictions. The last one evaluates the correctness of the selection of instrumental variables during estimation stage in the sense of their being uncorrelated with the error terms of the first difference model. The Arellano-Bond test verifies the assumption regarding autocorrelation of the model error term. The model is properly specified if the test provides no grounds for rejecting the null hypothesis about the absence of the second-order autocorrelation of the first difference model error term. Occurrence of the first-order autocorrelation resulting from the model construction is an expected phenomenon.

σ-type convergence

The existence of β-type convergence is not tantamount to the presence of σ-type convergence [Wolszcak-Derlacz 2007]. β-convergence is a necessary but insufficient condition for σ-convergence occurrence. The last one occurs when the diversification of values of analysed variable among regions decreases in time. In practice, this means a significant change in values of measures of dispersion or concentration of variable distribution.

In the study to evaluate changes of the dispersion of economic size distributions the variance equality test was applied [Lichtenberg 1994]. To verify the null hypothesis of the statistical insignificance of changes in the dispersion[8], the Snedecor's F statistic was used. The empirical value of F-statistic was calculated as the ratio of the variance for outermost (2004, 2012) periods of study.

[7] The detailed descriptions of the estimation methods and the statistical tests used to assess the quality of the dynamic panel data models can be found, among others, in: Baltagi B.H. (2005) Econometric Analysis of Panel Data, John Wiley & Sons, Ltd., Chichester and Dańska-Borsiak B. (2011) Dynamiczne modele panelowe w badaniach ekonomicznych, Wydawnictwo Uniwersytetu Łódzkiego, Łódź.

[8] The null hypothesis of equality of variance in the examined periods means lack of σ-convergence / σ-divergence.

Because the σ-convergence analysis using the variance equality test was based only on the first and the last year of the investigated period, the research had been expanded. To evaluate the changes in consecutive units of time the parameters of linear trend models for the variation coefficient (a measure of dispersion) and Gini coefficient (a measure of concentration) were estimated.

γ-type convergence

The subject of the next stage of the study was the analysis of γ-convergence. In order to verify the existence of this type of convergence the rankings of objects were created. Each province in each year of the study was assigned a rank in respect of an examined variable. Gamma convergence occurs when the regions have changed their ranking position.

As before, the analysis covered changes of the rankings for outermost years as well as the whole investigated period. In both cases, compatibility of the rankings was assessed using Kendall's coefficient of concordance.

Marginal vertical β-type convergence

In order to extend the analysis, contribution of individual regions to the process of β-convergence was also examined. The concept of marginal vertical β-type convergence, proposed by Batóg [2010], was used for that purpose. Coefficients of marginal vertical β-convergence (β_i) were calculated according to the formula:

$$\beta_i = \beta - \beta_i^{m-1}, \tag{5}$$

where β is a speed of convergence of all m regions and β_i^{m-1} means a speed of convergence of $m-1$ regions (without i province).

This method allowed to point out the regions that had a positive and negative influence on the process of alignment of the level of agricultural development.

Club convergence

The final step of the study was an attempt to divide Polish provinces into two groups (clubs) of a different nature from the point of view of convergence in the level of agriculture. The results of the analysis of the marginal vertical β-convergence were used for that purpose.

Depending on the sign of βi coefficient, calculated in accordance with equation (5), the clubs of negative and positive impact on the convergence process were distinguished. Then, for each club separately, beta, sigma and γ-type convergences were examined.

THE EMPIRICAL RESULTS

β-convergence analysis

The analysis of β-convergence was the first stage in the process of verification of the main hypothesis of work about assimilation of Polish provinces in terms of agricultural development. The model of β-convergence, described by equation (4), was estimated. It took the following empirical form[9]:

$$\hat{y}_{it} = 0{,}557 + \underset{(\pm 0{,}107)}{0{,}949}\ y_{it-1}. \tag{6}$$

The correctness of the estimated model was verified using statistical tests. The results are compiled in table no 1.

Table 1. The test results for model described by equations (6)*

test	value of the test statistics	p-value
AR(1)	-2,527	0,0115
AR(2)	-1,412	0,1578
Sargan	14,677	0,9984
Wald	77,984	0,0000

*-verification was conducted at 5% level of significance

Source: own computations

All the tests confirmed the proper specification of the model. The Arellano-Bond test gave no arguments for rejecting the null hypothesis about the lack of the second-order autocorrelation of model error terms. Also the Sargan test provided no grounds for rejecting the null hypothesis. The instruments applied during the estimation process were not correlated with the error terms of the model. Significance of the parameter estimates was proved using the Wald test.

The characteristics of β-convergence, calculated in accordance with formulas (2) and (3) are shown in table 2. A positive value of the coefficient α_1 confirmed the hypothesis of the occurrence of β-convergence. The speed of convergence was estimated at 5,25% per year and the half-life was assessed at 13 years.

Table 2. The characteristics of β-type convergence

α_1- model parameter	β – speed of convergence (%)	τ – half-life (in years)
0,051	5,25	13

Source: own computations

[9] All computations, presented in the paper, were performed in GRETL.

σ-convergence analysis

Since the presence of β-convergence is a necessary condition for the existence of σ-type convergence, a positive verification of the hypothesis of the occurrence of that first phenomenon gave grounds to the next stage of study – analysis of σ-convergence.

In the analysis based on the variance equality test, covering the first and the last year of the study, there was no significant decrease in variance, and hence the hypothesis of σ-convergence has not been confirmed[10].

To assess the changes in consecutive units of time, the parameters of linear trend models of the variation coefficient and Gini coefficient were estimated. Table no 3 presents the results.

Table 3. The parameters of linear trend models of the variation coefficient (V) and Gini coefficient (G)

measure	trend slope	p-value
variation coefficient (V)	0,0078	0,0003
Gini coefficient (G)	0,0042	0,0004

Source: own computations

Since the parameters of empirical models did not indicate a downward tendency (the slopes of the trends were statistically significant, but positive) it was concluded that there was no σ-convergence. Positive values of the parameter estimates of the time variable showed a slight increase in the dispersion of the examined phenomenon, i.e. the existence of σ-type divergence.

γ-convergence analysis

In order to determine the occurrence of γ-type convergence, Kendall's concordance coefficient was used. The analysis covered changes of the rankings for outermost years as well as the whole investigated period. In all cases, concordance between the rankings of regions was high and statistically significant[11]. That meant the lack of changes in the arrangements of regions – i.e. the lack of γ-type convergence[12].

[10] The empirical value of F-statistic amounted to 1,86 and provided no arguments for rejecting the null hypothesis about the lack of the sigma-type convergence.

[11] Since in case of small samples (e.g. the sample of 16 Polish provinces), χ^2-statistic, due to the adopted values, can lead to errors of I and II type, to test the significance of Kendall's concordance coefficients t-statistics also were used (see: Kusideł (2013) Konwergencja gospodarcza w Polsce i jej znaczenie w osiąganiu celów polityki spójności, Wydawnictwo Uniwersytetu Łódzkiego, Łódź).

[12] In all cases, the null hypothesis of the presence of γ-type convergence has been rejected.

The values of Kendall's concordance coefficients, describing the compatibility of the arrangements of regions, and the values of test statistics are compiled in table no 4.

Table 4. The values of Kendall's concordance coefficients and the test statistics

rankings	Kendall's concordance coefficients	χ^2-statistic	t-statistic
2004 and 2012	0,974	29,206	15,937
all	0,975	131,559	16,253

Source: own computations

Analysis of the marginal vertical β-convergence

Since the results of estimation of the model (4) have confirmed the occurrence of β-convergence of economic size of the average farms the next step of the study was to assess individual province contribution to this phenomenon. According to equation (5), coefficients of marginal vertical β-convergence were calculated. They were used to define a positive or negative impact of the region on the speed of convergence. The values of the coefficients are shown in table no 5.

Table 5. The values of coefficients of marginal, vertical β-convergence (%)

province	β_i	significance	province o	β_i	significance
dolnośląskie	-4,21	+	podkarpackie	-1,12	no
kujawsko-pomorskie	0,01	no	podlaskie	0,14	no
lubelskie	1,28	no	pomorskie	1,56	no
lubuskie	6,94	+	śląskie	0,45	no
łódzkie	-0,55	no	świętokrzyskie	-1,99	no
małopolskie	-2,34	no	warmińsko-mazurskie	-1,21	no
mazowieckie	1,57	no	wielkopolskie	-0,01	no
opolskie	-0,25	no	zachodniopomorskie	2,62	+

Source: own computations

The analysis of the coefficients' significance[13] revealed that lubuskie and zachodniopomorskie have contributed to the convergence of agricultural level of development whereas dolnośląskie province has had a negative impact on the speed of that process.

Analysis of the club convergence

The analysis of vertical β-convergence allowed to identify groups of regions that differed in the influence on the convergence process. The first one consisted of

[13] The statistical significance of the coefficients was assessed by comparing the coefficients values and their standard deviation. The coefficients with absolute value greater than the standard deviation were considered to be statistically significant.

provinces with the negative impact[14]. There were the following regions: dolnośląskie, łódzkie, małopolskie, opolskie, podkarpackie, świętokrzyskie, warmińsko-mazurskie and wielkopolskie. The second group included regions that positively influenced the speed of convergence[15]. The "positive impact club" consisted of provinces: kujawsko-pomorskie, lubelskie, lubuskie, mazowieckie, podlaskie, pomorskie, śląskie and zachodniopomorskie.

It seemed natural to use these results in order to find the different path of development for each group, i.e. to apply the results of vertical convergence analysis as the basis for the analysis of club convergence.

The final step of the study was to analyse the convergence process in each of the suggested clubs. In the "positive impact club" the phenomenon of β-convergence with the rate of 17,6%, was confirmed. Nevertheless, in this club, as for the whole country, sigma or γ-convergence were not demonstrated. In the "negative influence club" the occurrence of β-divergence phenomenon with rate of 0,06% was revealed.

SUMMARY AND CONCLUSIONS:

The results of the study, described in the paper, confirmed the occurrence of the phenomenon of β-convergence of the economic size of the average private farm in the regions. It means that farms in Poland, regardless of their location, are able to reach the same level of agricultural development over 13 years. The analysis did not demonstrate the existence of σ-convergence or γ-convergence. Therefore the main hypothesis of the work regarding the assimilation process of economic size of farms between regions in Poland has not been unambiguously confirmed. However, the actual results of β-convergence seem to indicate that the processes of equalization of level of agriculture in Poland occur, but maybe due to a short period of the study it was impossible to verify them based on other types of convergence.

In addition, during the analysis of vertical marginal β-convergence, the regions, that have a significant positive impact on the process of aligning the level of agriculture in Poland, were indicated. These were the provinces: lubuskie and zachodniopomorskie. It was also pointed to dolnośląskie as the region that inhibits this process. Furthermore, based on the results of the analysis of the vertical marginal β-convergence, Poland was divided into two clubs with different paths of development. The results for one of the clubs were similar as for the whole country, i.e. the existence of β-convergence was confirmed, the occurrence of σ-convergence and γ-convergence were not demonstrated, whereas in the second club the phenomenon of β-divergence was revealed.

[14] β_i coefficient was negative.
[15] Positive value of β_i coefficient.

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KONWERGENCJA WIELKOŚCI EKONOMICZNEJ GOSPODARSTW ROLNYCH W POLSCE - ANALIZA EKONOMETRYCZNA

Streszczenie: Badanie opisane w artykule dotyczyło upodabniania się poziomu rozwoju rolnictwa w Polsce, którego miernikiem była wielkość ekonomiczna przeciętnego w województwie gospodarstwa rolnego. Głównym jego celem była weryfikacja hipotezy o zachodzeniu konwergencji wielkości ekonomicznej gospodarstw. Przeprowadzona analiza potwierdziła zjawisko konwergencji typu β, jednak nie wykazano zachodzenia konwergencji typu σ ani γ. Na podstawie wyników analizy krańcowej konwergencji typu β, podzielono Polskę na dwa kluby o odmiennych ścieżkach rozwoju. W jednym stwierdzono zjawisko konwergencji, w drugim dywergencji.

Słowa kluczowe: rozwój rolnictwa, wielkość ekonomiczna gospodarstwa rolnego, β-konwergencja, σ-konwergencja, γ-konwergencja