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The impact of EU enlargement on the agricultural output and income in the member states

Abstract. The paper presents an analysis of the impact of the EU enlargement in 2004 on the agricultural output and incomes of the EU Member States. The main aim of the study is to test the significance of difference of reaction to enlargement in three distinct groups of members, namely the 'old' fifteen Member States, the 'new' ten Member States which accessed the EU on May 1st 2004, and the two 'newest' Member States, i.e. Romania and Bulgaria which accessed the EU on January 1st 2007. For the purpose of description of different countries behaviour a linear mixed model was applied.
Key words: EU enlargement, agricultural output, mixed linear model

Introduction

On May 1st 2004 Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia joined the EU. On that day the ten new Member States joined a single market. As was anticipated, the flow of trade between the 'old' and the 'new' Members States has amplified [Analysis… 2002]. The EU funds became available for farmers in the new Members States which allowed a significant increase of investments in agriculture and a certain economic boom in the rural areas. There is a general consensus that the EU enlargement has a positive effect on the EU agriculture as a whole. Nevertheless, some adjustments of production and consumption had to take place in several countries of the EU-25 and not all of them for the better.

The aim of this paper is to study the impact of the EU enlargement on agriculture in three distinct groups of countries: the 'old' fifteen Member States (EU-15), the 'new' ten Member States (EU-10N) which accessed the EU on May 1st 2004, and the two 'newest' Member States, i.e. Romania and Bulgaria (EU-2N) which accessed the EU on January 1st 2007.

Due to constraints on the size of the paper, the study is limited to investigation of the influence of enlargement on two characteristics of agriculture, namely the *agricultural output* and the *agricultural income indicator A*.

Description of data

The data used in this analysis are available from Eurostat. According to an Eurostat guide [Manual… 2000] the *agricultural output* can be depicted as follows:
- sales (total, excluding trade in animals between agricultural holdings)
- change in stocks

- self-produced fixed capital goods (plantations repeatedly yielding crops, productive animals)
- own final consumption (of agricultural products)
- processed by-products (of agricultural products between separable activities)
- internal consumption in individual activities, i.e. crop products used for animal feed (cereals, oilseeds, fodder crops, marketable or not, etc.)

The agricultural output is valued at basic prices, where the basic price is the price receivable by the producers from the purchaser for a unit of good or service produced as output plus any subsidy receivable on that unit as a consequence of its production or sale, minus any tax payable on that unit as a consequence of its production or sale.

Agricultural income indicator A is an index of the real income of factors in agriculture, per annual work unit[2]. This is one of the most important indicators for measurement of agricultural income and its trends. Indicator A corresponds to the real (deflated) net value added at factor cost in agriculture per total annual work unit. Net value added at factor cost is calculated by subtracting intermediate consumption, depreciation and other production costs from the value of agricultural output at basic prices (i.e. including subsidies on products and excluding taxes on products), and adding the value of other production subsidies. Indicator A is obtained by deflating this net value with the price index of gross domestic product at market prices and dividing by the volume of total labour in agriculture.

The values of agricultural output are expressed in million euro (from 01.01.1999) or million ECU (up to 31.12.1998), at constant prices (2000=100). As to the values of indicator A, year 2000 was chosen as a base year, so the indicator A for all countries in year 2000 is equal 100.

Due to a limited range of available data, this study is based on the data starting in year 1998 and ending in year 2007. For the same reason Cyprus was excluded and data from only twenty six countries were analysed.

Description of statistical model

As it was mentioned in the previous section the analysed data consisted, for each variable, of values applying to ten years and twenty six countries. As a result there are ten observations for each Member State, considering both variables individually. For the analysis of impact of the EU enlargement in year 2004 two explanatory variables were created: *AfterAcces* {0, 1}, a variable describing if an observation comes from a year before 2004 and *Group* {A, B, C}, a variable which takes value A for countries from EU-15, B for countries from EU-10N and C for Romania and Bulgaria. Model which could be applied for such data is presented below (1):

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \upsilon_i + \varepsilon_{ij} \tag{1}$$

where

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[2] In order to take into account part-time and seasonal work, agricultural employment or changes therein are measured in annual work units (AWU's). One AWU corresponds to the input, measured in working time, of one person who is engaged in agricultural activities in an agricultural unit on a full-time basis over an entire year. A distinction is drawn between unpaid and paid AWUs, which together make up total AWUs.

y_{ij} is the value of the response variable[3] for the jth of n_i observations in the ith country,

x_{1ij} is the value of the explanatory variable *AfterAcces* for the jth observation in the ith country,

x_{2ij} is equal 1 if the value of the explanatory variable *Group* for the jth observation in the ith country is B and 0 otherwise ,

x_{3ij} is equal 1 if the value of the explanatory variable *Group* for the jth observation in the ith country is C and 0 otherwise,

$\beta_0, \beta_1, \beta_2, \beta_3$ are the regression coefficients, which are identical for all groups.

The parameter β_0 represents so called reference level which in this case applies to a situation when a country belongs to EU-15 and the observation comes from a year before 2004. There are two random variables in the model (1). First of them is υ_i and represents the random effect in ith country, the second one is ε_{ij} which represents the random error of jth observation from ith country. It assumed that both variables follow normal distribution, with expected value equal to 0 and variances σ_υ^2 and σ_ε^2 respectively. It is also assumed that υ_i for different values of i are independent, the same apply to ε_{ij} which are also independent for different values of i and j.

Hence if one of the regressors has a random character the model (1) belongs to the linear mixed models family [Demidenko 2004].

As it was mentioned in the introduction the aim of this paper is to study the impact of EU enlargement on agriculture in three groups of countries. In order to assess that three models were compared. Model (1), already presented, assumes that effect of the enlargement is the same in all three groups and that group effect is the same before and after the enlargement.

$$y_{ij} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{1ij} x_{2ij} + \beta_5 x_{1ij} x_{3ij} + \upsilon_i + \varepsilon_{ij} \qquad (2)$$

Model (2) allows differences in reaction by including interaction terms.

$$y_{ij} = \beta_0 + \upsilon_i + \varepsilon_{ij} \qquad (3)$$

Model (3) contains only constant β_0 besides random variables and is equivalent to a lack of impact of the EU enlargement and also to a lack of differences between groups.

Model (1) can be treated as a special case of model (2) with restrictions on two parameters ($\beta_4 = \beta_5 = 0$), also model (3) can be treated as a special case of model (1) with restrictions on three parameters ($\beta_1 = \beta_2 = \beta_3 = 0$). This allows application of likelihood-ratio test for testing if the additional parameters are equal 0.

$$LRT = 2(LLF_1 - LLF_0) \qquad (4)$$

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[3] The agricultural output or the agricultural income indicator A.

where: LRT is a value of the test statistic, LLF_1 and LLF_0 are values of likelihood function logarithms calculated for appropriate models.

If the hypothesis is true the LRT statistics follows asymptotically the chi-square distribution with $p_1 - p_0$ degrees of freedom (DF), where p_1 and p_0 are numbers of parameters for respective models. The difference $p_1 - p_0$ is equal to the number of restrictions on parameters.

The likelihood-ratio test can be used for testing hypotheses about whole group of parameters at once and can be considered as a substitute for an analysis of variance test, when its assumptions are not fulfilled.

In the further part of the paper model (3) will be denoted as M_{A0}, model (1) as M_{A1} and model (2) as M_{A2}.

The calculations for all models were performed in R, an environment for statistical computing [R; A language… 2008] with help of the lme4 package [Bates 2007].

Results

For the assessment of changes in agricultural output three models were compared: M_{A0} containing only constant, M_{A1} containing main effects of factors and M_{A2} containing main effects and interaction of factors. To test the significance of added variables influence, likelihood-ratio test was used. p-values presented in Table 1 correspond with two hypotheses:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = 0 \tag{5}$$

$$H_0 : \beta_4 = \beta_5 = 0 \tag{6}$$

While the hypothesis (5) says that both the effect of the enlargement and the effect of group membership are nonexistent the hypothesis (6) says only that effect of the enlargement is the same in all three groups and that group effect is the same before and after the enlargement.

Table 1. Results of testing influence of factors on agricultural output

model	Number of parameters	LLF	LRT	Chi^2 DF	p-value
M_{A0}	3	-2246.5			
M_{A1}	6	-2242.9	7.0929	3	0.0690.
M_{A2}	8	-2242.2	1.4690	2	0.4797

Source: own calculations.

Because the appropriate p-value is equal to 0.069 then hypothesis (5) that both main factors had no impact on agricultural output cannot be rejected on *0.05* significance level. The same applies to the hypothesis (6) where p-value is equal to 0.4797.

Such results are not really surprising. The reason for that is a very large variability of agricultural output between Members States, due, at least in some part, to differences in

size of the analysed countries. To overcome that problem, recalculation of the absolute values of agricultural output to indexes was applied. As a base year 2000 was chosen.

Table 2. Results of testing influence of factors on agricultural output indexes

model	Number of parameters	LLF	LRT	Chi^2 DF	p-value[4]
M_{A0}	3	-941.67			
M_{A1}	6	-921.05	41.224	3	5.86E-09
M_{A2}	8	-905.56	30.985	2	1.87E-07

Source: own calculations.

In Table 2 results of testing the same hypothesis as in Table 1 are presented, but this time instead of absolute values indexes are used as dependent variables and it is no longer a comparison of agricultural outputs but a comparison of changes in agricultural outputs.

In that case the results indicate that the effects of both factors are significant as well as is their interaction. This suggests that reaction of countries from different groups to the EU enlargement in 2004 differ.
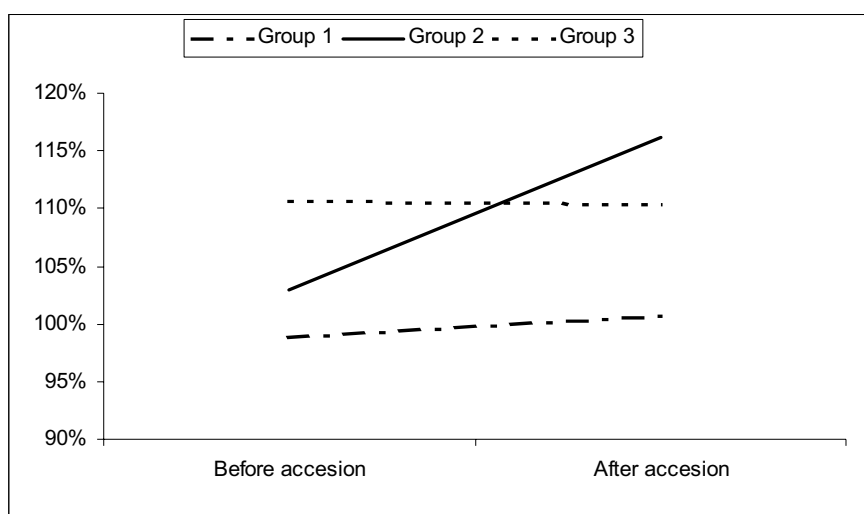

Fig. 1. Interactions between factors *Group* and *AfterAcces* for agricultural output indexes

Source: own calculations.

Fig. 1 illustrates the mentioned differences in the reactions of three distinct groups to the EU enlargement. It may be clearly seen that group 2 demonstrates a big leap in agricultural output while group 1 a very moderate increase and group 3 even a decrease.

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[4] The p-value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed, providing the null hypothesis is true; one rejects the null hypothesis if the p-value is smaller than or equal to the significance level.

The lines drawn on the picture can be understood as an indication of a relative direction only, this is a typical way for the presentation of interactions between categorical factors

Fitted estimates of model (2) coefficients and t-statistic values for the hypotheses of equality of an appropriate parameter to 0 are presented in Table 3. Due to big number of observations (260) as critical value for the t-statistic 0.95 quantile of the standard normal distribution is used i.e. 1.96.

Table 3. Results of testing influence of factors on agricultural output indexes

Factor	Parameter	Estimate	Std. Error	t-value
Intercept (reference level)	β_0	98.794	1.588	62.2
Group B	β_2	4.193	2.608	1.61
Group C	β_3	11.806	4.631	2.55
AfterAcces 1	β_1	1.816	1.265	1.44
Group B: AfterAcces 1	β_4	11.367	2.084	5.46
Group C: AfterAcces 1	β_5	-2.084	3.690	-0.56

Source: own calculations

The value of intercept shown in Table 3 and depicted as reference level is an average for countries from Group A (EU-15) before year 2004. The value of estimate for Group B is the difference between averages for EU-10N and EU-15. The same logic can be applied for the rest of factor levels.

What is worth mentioning is the fact that there is no evidence of significant changes in agricultural output (measured in indexes) after accession for any group but EU-10N. So one must conclude that the only countries which experienced effect of the EU enlargement in the year 2004 where the countries which actually accessed the EU in that year. On average, it was an increase of 14%, which is a sum of 1.816% due to the main effect of the EU enlargement common to all groups and 11.367% due to the specific effect of the EU enlargement in group B, comparing to the years before accession.

To test whether the impact of enlargement was significant to agricultural income expressed in values of indicator A, similar analyses were performed.

Table 4. Results of testing influence of factors on indicator A

model	Number of parameters	LLF	LRT	Chi^2 DF	p-value
M_{A0}	3	-1269.0			
M_{A1}	6	-1232.7	72.606	3	1.18E-15
M_{A2}	8	-1180.5	104.478	2	<2.20E-16

Source: own calculations.

As it is shown in Table 4 the effects of both factors and their interaction are significant. What is interesting, this time the effects are much stronger, which can be seen when comparing p-values from Table 4 with p-values from Table 2.
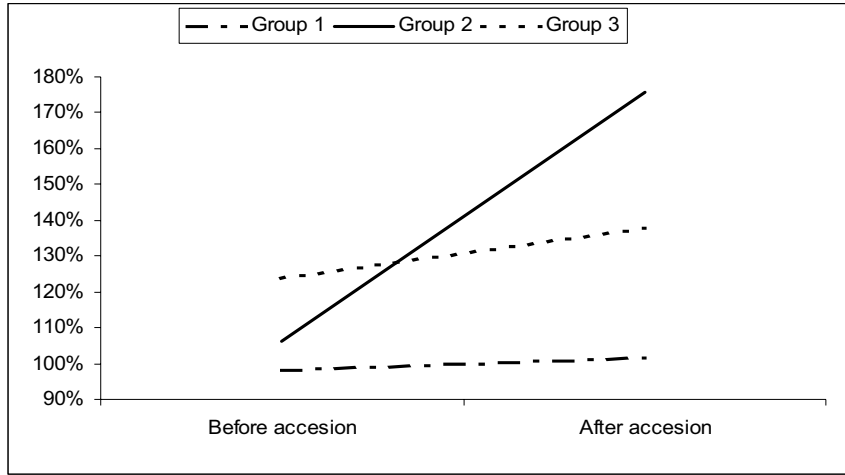
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Fig. 2. Interactions between factors *Group* and *AfterAcces* for agricultural indicator A

Source: own calculations.

Fig. 2 shows, once again, that from the three groups only one, i.e. EU-10N displays a strong reaction. Such facts confirms that the increase of agricultural income, in terms of indicator A, cannot be explained by time variable and that the accession is the key factor.

Fitted estimates of model coefficients and t-statistic values are presented in Table 5.

Table 5. Results of testing influence of factors on indicator A

Factor	Parameter	Estimate	Std. Error	t-value
Intercept (reference level)	β_0	98.314	4.940	19.901
Group 2	β_2	7.792	8.067	0.966
Group 3	β_3	25.253	14.699	1.718
AfterAcces 1	β_1	3.088	3.587	0.861
Group 2: AfterAcces 1	β_4	66.361	5.857	11.330
Group 3: AfterAcces 1	β_5	10.981	10.861	1.011

Source: Own calculations.

The results presented in Table 5 agree with those in Table 3; again, there is no evidence of significant changes after accession for any group but EU-10N. However, this time the average for EU-10N is increased by almost seventy percent (3.088+66.361), comparing to the years before accession.

Conclusions

The impact of the EU enlargement on agricultural output and income measured by indicator A is similar as to direction but differ in strength. In both cases in the three groups of countries the only group which significantly profited from the enlargement are the new Member States which accessed the EU in the year 2004.

The difference between the gains in agricultural output and in indicator A, 14% and 70% accordingly, indicates that number of people working in agriculture is decreasing in EU-10N without loss to size of production.

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