LABOUR FORCE DEMAND AND SUPPLY DEVELOPMENTS OF ROMANIA'S AGRICULTURE

ECONOMETRIC MODELS AND METHODS, INDICATORS USED IN STATISTICAL ANALYSIS

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Abstract

As based on available data sets from the World Bank's Yearbook (2008), a statistical analysis was made to highlight some characteristics of Romanian agriculture during 1961-2003. It is presented a series of models (Grabowski and Sivan (1986)) and econometric methods used to analyse supply and demand of the labour force in agriculture. This included an estimated regression model for analyzing the evolution of added value in agriculture during 1980-2003 according to a number of influencing factors. To characterize the concentration of agricultural production by development regions the Herfindahl Index was utilised.

Keywords: *agriculture, statistical analysis, econometric models, econometric methods, Herfindahl Index.*

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One of the determinant factors of social welfare in the case of developing countries is, undoubtedly, the quality of the labour force market in the agricultural sector, and it is significant that, in most of these countries, a high proportion of the active population is working in this sector. **A study of the evolution of the supply and the demand for the labour force in agriculture** shows a particular interest for these countries. For this reason, identification of the social factors and, in particular, economic ones, that influence major changes in the food market, is essential.

This issue has been studied by Grabowski and Sivan (1986), in the case of Japan, during 1885-1920, and for Egypt, between 1950 and1974. In this study, the evolution of supply and demand for the labour force in agriculture is estimated according to the following explanatory variables: wage in agriculture (W_A); labour force employed in agriculture (L_A); invested

capital in agriculture (K_A); time, in years (T); food goods price index (P_F); gross domestic product of a country (Y) ; the country' s total population (Pop); average wage in industry (W_m); the industrial product price index (P_m), and the price index of agricultural products (P_A).

Models used

Labour force demand in agriculture (L_D), we consider that it is a function of effective labour in agriculture (L_A), the capital invested in agriculture (K_A) and the time factor, expressed in years (T). Dependency relationship between variables results from the formula:

$$L_D=f_D(L_A\ ,\ K_A\ ,T)+u_1$$

As the f function is linear, then the equation of the labour force demand in agriculture is expressed by the relationship below:

$$L_D = \frac{W_A}{P_A} = \alpha_0 + \alpha_1 L_A + \alpha_2 K_A + \alpha_3 T + u_1 \quad (1)$$

In case of the **labour force supply in agriculture** (L_S), it is emphasized a linear function dependent upon the following variables: real wage in agriculture (W_A /P_A), and in industry (W_m /P_m), gross domestic product over the period considered (Y), population (Pop) and wage in industry (W_m). The labour force supply is defined by the formula:

$$L_S=f_S(W_A/P_A,\ W_A\ /P_A,\ W_m\ /P_m,\ Y,\ Pop,\ W_m\ )$$

Since the $f_S(\bullet)$ is linear, then this can be rewritten in the following equivalent form:

$$L_S = \beta_0 + \beta_1\left(\frac{W_A}{P_A}\right) + \beta_2\left(\frac{P_F}{P_A}\right) + \beta_3 Y + \beta_4 Pop + \beta_5\left(\frac{W_m}{P_m}\right) + u_2 \quad (2)$$

As authors, we have hypothesized that an increase in the relative prices of food goods, causes a decrease in the labour force supply in agriculture and also an increase in labour force costs in this sector. Through the computed estimations, a validation of some hypotheses in this macroeconomic theory can be tested. Therefore, if it is taken into account the regression model (2), it can be verified utilising the following working hypotheses regarding the labour force supply in this sector:

$$\begin{cases} \dfrac{\partial L_S}{\partial(W_A/P_A)} = \beta_1 > 0, \quad \dfrac{\partial L_S}{\partial(Pop)} = \beta_4 > 0 \\ \dfrac{\partial L_S}{\partial(P_F/P_A)} = \beta_2 < 0, \quad \dfrac{\partial L_S}{\partial(W_m/P_m)} = \beta_5 < 0 \\ \dfrac{\partial L_S}{\partial Y} = \beta_3 < 0 \end{cases} \tag{3}$$

In case of labour force demand were used appropriate data sets, considering the following assumptions:

$$\begin{cases} \dfrac{\partial L_D}{\partial L_A} = \alpha_1 < 0, \quad \dfrac{\partial L_D}{\partial K_A} = \alpha_2 < 0, \\ \dfrac{\partial L_D}{\partial T} = \alpha_3 > 0 \end{cases} \tag{4}$$

In order to estimate the parameters of the above-mentioned models for the labour force demand and supply in agriculture, the following three methods can be utilised:

- ordinary least squares method;
- recursive method of least squares and recursive residues method;
- generalized least squares method.

It is related a number of issues related to using these methods. These methods can be applied by using Gauss and Eviews software packages.

Table 1. Presentation of the applied methods

Methods	ORDINARY LEAST SQUARES METHOD (M_1)	RECURSIVE METHOD OF LEAST SQUARES AND RECURSIVE RESIDUES METHOD (M_2)	GENERALIZED LEAST SQUARES METHOD (M_3)
Model's definition	$\mathbf{y = \beta X + u}$ and the hypotheses $\mathbf{H_1}$. $E(\mathbf{u}) = \mathbf{0}$ $\mathbf{H_2}$. $E(\mathbf{u u'}) = \sigma^2 \mathbf{I}$. $\mathbf{H_3}$. $E(\mathbf{u} \mid \mathbf{X}) = \mathbf{0}$. $\mathbf{H_4}$. X is a k x T non-stochastic matrix, its range been equal to k $\mathbf{H_5}$. $\mathbf{u} \rightarrow N[\mathbf{0}, \sigma\, \mathbf{I}]$	$y_t = x_t \beta + \eta_t, \quad t = 1, \ldots, T$ where η_t are independent and normally distributed $N(0, \sigma^2)$.	$y_t = x_t \beta + u_t, \quad t = 1, \ldots, T$ $M(\mathbf{uu'}) = \sigma^2 \mathbf{\Omega}$ where matrix $\mathbf{\Omega}$ is positively defined
Parameter's estimator	$\hat{\beta} = (X'X)^{-1} X'Y$	$\hat{\beta}_t = \hat{\beta}_{t-1} + \frac{x_t' (y_t - x_t \hat{\beta}_{t-1})}{\sum_{i=1}^{t} x_i' x_i}$	$\hat{\beta} = (X \Omega^{-1} X)^{-1} X' \Omega^{-1} y$
Observations	For example, for L_S: $\mathbf{X'} = (L_A, K_A, T)$ $\beta = (\beta_1, \beta_2, \beta_3, \beta_4, \beta_5)$.	The use of this method is based on the assumption that the initial value β_0 is known. Two cases are taken into consideration: ▪ $\beta_0 = 0$; ▪ $\beta_0 = \hat{\beta}_0$, where β_0 estimation has been obtained from the OLS method	We assume that the residues follows an autoregressive process of order one: $u_t = \rho u_{t-1} + \varepsilon_t \quad \lvert\rho\rvert < 1$ with : $M(\boldsymbol{\varepsilon}) = \mathbf{0}$ and $M(\boldsymbol{\varepsilon\varepsilon'}) = \sigma_\varepsilon^2 \mathbf{I}$ In this way, we get the ρ's estimation : $\hat{\rho} = \frac{\sum_t \varepsilon_t \varepsilon_{t-1}}{\sum_t \varepsilon_{t-1}^2}$

We present below a number of models used to identify specific features of Romanian agriculture: some aspects of the data series used, descriptive statistics used to depict specific features of Romanian agriculture; long-term trend analysis of data sets used by the application of econometric methods ; identifying inside the period considered of subperiods with different characteristics.

Data sets available for Romania
(as published in the World Bank's Yearbook of 2008):

Simbol	Variable name	Time period
NT	Number of tractors in agriculture (number)	1960-2003
NTH	Number of tractors per 100 hectars of arable land (number)	1960-2003
VAA _2000	Value added per worker in agriculture in 2000 prices (USD)	1980-2003
CCH	chemical fertilizers consumption per hectar (100 grams/ arable hectar)	1961-2005
CC	Chemical fertilizers total consumption (tons)	1961-2005
AGP	Share of employed population in agriculture in the total employment (%)	1980-2005
PAG	Employed population in agriculture (persons)	1980-2005
PCH	Average production of grains per hectare (Kg/ha)	1961-2005
STC	Total agricultural area cultivated with cereals (ha)	1961-2005

These data sets allow us to higlight some of the characteristic of Romanian agriculture during 1961-2003. There were utilised a range of econometric methods, which allowed integration and co-integration analyses on these data series, as well as for estimating parameters of some regression models. The econometric techniques used are attempting to answer a series of issues related to: the evolution on a long period of time of labour productivity in agriculture (computed as a valued added per worker during an entire year) ; the contribution of some factors such as: technical endowment of labour in agriculture, expressed as the average number of tractors per 100 ha and the use of chemical fertilizers, labour productivity dynamics in the analysed period and in some sub-periods; the developments in employments share in agriculture in the total labour force of Romania; identification of some important sub-periods in agriculture's evolution.

After analyzing the data series corresponding to the above variables, the following remarks can be made:

Remark 1. In the period 1961-1987 we were witnessing a growing number of tractors in agriculture and, consequently, an increase of the number of tractors per hectar of arable land. In contrast, for the period 1988-1991,

there is a massive reduction in the number of tractors in agriculture. Thus, only in the year 1988, as compared to the previous year, it shows a decrease of 10.2%. It is is important to point out that a significant decrease in the number of tractors was registered in 1990 (12.4% comparative) with year 1989. The largest number of tractors were bought in 1992. The growth from this year compared with the previous year was of 10.6%.

Remark 2. The total fertilizers consumption and the consumption per hectar increased between 1962 and 1984. In the next six years, a decrease was registered in these indicators, but not a sharp one. However, they rapidly decreased in 1991. In the transition period, the fertilizers consumption decreased with an yearly average of 8%. The average fertilizers consumption per hectar in 2003 was equal to the consumption registered in the 1960s.

Remark 3. Until 1991, cereals production per hectare had registred an increasing trend. In the next period that followed, the grains production had an oscillatory evolution. In 2000, the lowest cereals output per hectar was registered for the last thirty years.

Remark 4. Population and employed population share in agriculture remained relatively constant between 1980 and 1989. After 1990, the two indicators registred very large values.

Remark 5. The values of the indexes for some sub-periods, as well as the increase/decrease rate and yearly average rate for some important indicators in the field of agriculture, are presented:

Variable		1961-2005	1961-1989	1990-2005
NT[a]	$R_{t/0}$	225.6	192.0	11.5
	Rma	2.7	3.9	0.6
NTH[a]	$R_{t/0}$	239.6	201.9	12.5
	Rma	2.8	4.0	0.7
VAA_2000[b]	$R_{t/0}$	22.0	3.3	18.1
	Rma	0.8	0.4	1.0
CCH[a]	$R_{t/0}$	15.2	334.9	-73.5
	Rma	0.3	5.4	-8.0
CC[a]	$R_{t/0}$	9.7	327.3	-73.7
	Rma	0.2	5.2	-8.1
PAG[b]	$R_{t/0}$	15.4	-4.2	20.5
	Rma	0.3	0.5	1.17
PCH	$R_{t/0}$	105.4	101.9	-5.8
	Rma	1.61	2.54	-0.34
STC	$R_{t/0}$	-27.7	-14.8	-15.8
	Rma	-0.7	-1.5	-1.0

a. Calculus made for the 1961-2003 period;

b. Calculus made for the 1980-2005 period.

Source: World Bank, 2008

Further, there is estimated the regression model used to analyze the value added in agriculture during 1980-2003 depending on the number of tractors per 100 hectares of arable land, the share of agricultural employment in total employment and consumption of fertilizers per hectare. In the dynamic of some indicators of the Romanian agriculture, there is introduced in the model a qualitative variable:

$$VD1 = \begin{cases} 1, & t = 1980,...,1989,1992,...,2003 \\ 0, & t = 1990,1991 \end{cases} \quad (5)$$

The regression model becomes:

$$\log(VAA\_2000_t) = \alpha_0 + \alpha_1 \log(NTH_t) + \alpha_2 \log(AGP_t) + \alpha_3 \log(CCH_t) + \alpha_4 VD1_t + \varepsilon_t \quad (6)$$

	M_1
C	9.100* (0.180)
$\log(CCH_t)$	-0.067* (0.026)
$VD1_t$	0.176* (0.062)
R^2	0.405
DW	1.63
AIC	-1.993

Significance level: * $\alpha = 0.00$ ** $\alpha \leq 5$
Source: World Bank, 2008

Based on the results obtained, the negative role that the fertilizers consumption per hectar had in the post-revolutionary period on labour productivity in agriculture is clearly highlighted. The estimations of the other two variables were not significant. The positive value corresponding to the qualitative variable means a productivity of agriculture reduction in the second sub-period, which began with 1990.

For regional trends, there is shown the structure of agricultural production by development region for 2001 and 2006. In order to depict the output's concentrations on these regions, a number of indicators can be calculated, such as: Herfindahl, Krugman or Gini. We present the calculations made for the first indicator, in the case of the yearly agricultural output on regions which is represented by a structural vector $y_t = [y_{1t}, y_{2t}, ..., y_{8t}]$.

The Herfindahl index is defined as the weighted arithmetic mean of the structural vector's elements, having as weights the entries themselves, based on the relationship:

$$H_t = y_t \cdot y'_t = \sum_{i=1}^{8} (y_i)^2$$

Having a maximum value equal with 1, it is positive. Usually, in economic calculations, the indicator's values range from 0,1 to 0,7.

Taking into account the two years's data, the following two numerical are obtained:

- 0.14326 (for 2001);
- 0.14349 (for 2006).

The structure of the agricultural branch production by development region for the years 2001 and 2006

Development Region	2001 (lei thou current prices)	Weight in total (%)	2006 (lei thou current prices)	Weight in total (%)	Weight change in 2006 compared with 2001
North-East	4788239	17.2	9169393	18.1	0.9
South-East	3607391	13.0	7344727	14.5	1.5
South Muntenia	5049594	18.1	8485410	16.8	-1.3
South-West	3690793	13.3	5418925	10.7	-2.6
West	3168261	11.4	5292202	10.4	-1.0
North-West	3938583	14.1	7555850	14.9	0.8
Centre	3208740	11.5	6550880	12.9	1.4
Bucharest-Ilfov	391235	1.4	832215	1.6	0.2

Source: Territorial Statistics, NIS, Bucharest, 2009

The data presented highlight the fact that the North-East region has the most important weight in agricultural output, followed by the South Muntenia region. Except for the Bucharest-Ilfov region, the other five regions have relatively equal weights in agricultural output. Values obtained in case of Herfindahl index reveal a weak concentration of agricultural output per Region. Throughout the five analyzed years, the index's value varied from 0.14326 to 0.14349.

Conclusions

By using certain quantitative methods, significant characteristics of the dynamics of some important indicators used in depicting agriculture's situation are highlighted. To this end, we emphasize the following major aspects related to the evolution of some specific indicators:

- during 1961-1987, the dynamics of **tractor numbers** shows a significant increase, while in 1988-1991 there is a massive reduction;

- **the fertilizer consumption, both as a whole and per hectar**, had an ascending trend in 1962-1984, followed by a slight decrease in 1985-1990. Starting from 1991, there is a significant decrease;

- until 1991, **cereals output per hectar** had an ascending evolution; after that, it had an oscillatory evolution;

- **labour productivity in agriculture** has declined substantially after 1990.

Also worth mentioning, is the existence of a different agricultural profile for each development of the eight regions from our country. The Herfindahl index value that was obtained in this study shows a weak concentration of the agricultural output in the development regions.

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