

COMPARATIVE STUDY ON THE EVOLUTION OF AVERAGE CEREALS PRODUCTION IN THE EUROPEAN UNION

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Abstract: *The study describes the trends of evolution of the average production of the cereals on hectare, for the European Union countries, the period subject to analysis being of 2000-2015. For grouping the statistic data, there were analyzed the values of the angular coefficient of the regression straight-line, respectively the coefficient of variation of the statistic series. Repartition on groups thus obtained, coincides to a great extent with the details known concerning the peculiarities of the agricultural and food economy of the states to which reference was made, delimiting in an obvious way the states characterized by different economic models.*

Key words: *average production at hectare, cereals, comparative study, analytical geometric application*

INTRODUCTION

The vegetal production for hectare may describe on one hand the agricultural results at local level, but more, the observations may be extended at zonal, regional or national level, indicating the state of the agriculture of this country. This fact is due mainly to correlations that appear between the basic vegetal production, and performance of the agricultural systems through the agricultural technologies in their aggregate – performance of the biological material, degree of mechanization, fertilization and chemical agents use as a whole [13, 15, 16, 17, 20], level of services downstream and upstream of agriculture and other agricultural branches on the agricultural and food chain [3, 6]. Moreover, as the cereals culture occupies a significant weight in the agriculture of the majority of European countries [22], the results obtained in this segment of the agriculture may become many times a real image of the entire agricultural process in the reference area, or in other areas from the globe compared to other references [7, 9]. Following the results presented in the international databases [21], the average production of cereal at hectares increased from a value of approximately 1421 kg/ha in the year 1961 to 2870 kg/ha in 1990 so that in the year 2014 will become approximately 3886 kg/ha. The evolution trend is increasing, save some low and normal fluctuations that take place for short periods of time [14].

The comparative studies between the EU states may lead to multiple information concerning performances from various branches of the economy, agriculture, tourism, politics and other, by indicating more the current position but also the possible trends to follow [2, 12, 18].

The purpose of the study was to analyze the trends of evolution of the cereals production on hectare between 2000 and -2015 and to make certain correlations between the obtained values and certain particular aspects related to the state of the economy of the cereal-producing countries from the European Union.

MATERIALS AND METHODS

Statistic data were obtained from the Eurostat database (November 2016) and represents "Cereals for the production of grain (including seed) – Harvested production" expressed in thousand tones respectively "Area (cultivation/harvested/production)" expressed in thousand hectares. The analyzed states are those from the European Union (EU-28) excepting Malta. In order to determine the evolution of the cereals production on

hectare, it was calculated the ratio of the two indicators specified above for each state individually, and the evolution trend was analyzed by means of the angular coefficient of the regression straight line, describing actually the slope of the line (production increase in relation with a time period). Thus, if the regression function [8, 10] given by the values of the production of cereals on hectare of a state namely is $f(x)=ax + b$, $a, b \in \mathbf{R}$, the coefficients a and b are determined statistically by means of the ratios:

$$a \sum_{i=1}^n x_i^2 + b \sum_{i=1}^n x_i = \sum_{i=1}^n x_i y_i, \quad a \sum_{i=1}^n x_i + b n = \sum_{i=1}^n y_i$$

Coefficient a , which is actually representing the angular coefficient of the straight-line is determined by means of the ratio: $a = \frac{\Delta_a}{\Delta}$, where:

$$\Delta_a = \begin{vmatrix} \sum_{i=1}^n x_i y_i & \sum_{i=1}^n x_i \\ \sum_{i=1}^n y_i & n \end{vmatrix}, \quad \Delta = \begin{vmatrix} \sum_{i=1}^n x_i^2 & \sum_{i=1}^n x_i \\ \sum_{i=1}^n x_i & n \end{vmatrix}.$$

The calculations were made by using the positions Microsoft Excel, and the series of the years, described by the variable x was renumbered so that $x = 1, \dots, n$. As the angular coefficient represents the tangency of the angle in which the regression straight-line makes with axis Ox , we deemed more suggestive the transformation of the tangent line (in trigonometric direction), in degrees and radians, by using the Excel function, $ATAN(x)$.

Data grouping was made according to quartile by using the Tukey' Hinges method, respectively analyzing Boxplot chart, determined by using the SPSS, Explore procedure. Also, a classification of the statistic data was made, depending on the value of the coefficient of variation, by using the Excel STDEV respectively AVERAGE functions, the coefficient of variation being calculated with the formula $STDEV/AVERAGE$.

RESEARCH RESULTS

The results concerning the calculation of the angular coefficients of the regression straight-line, respectively transformations leading to the measurements of the angles in degrees respectively in radians are rendered in Table 1.

A quartile of the series of "degree" are $Q_1=2.05$, $Q_2=3.96$, $Q_3=5.34$, and the Boxplot chart is given in the Figure 1. Outlier values were not observed.

The data represented in the Table 1 were grouped in quarters, thus resulting thus Table 2. In the first quarter we find Belgium, Cyprus, Spain, Luxembourg, Finland, UK, France, respectively, in the third quarter, Denmark, Italy, Sweden, Netherlands, Austria, Ireland, Hungary. Most of them found in the first half of the series are the state located in the Western part respectively the central part of Europe, being characterized through a well-developed or at least consolidated economy until the year 2000, the period of start of the series of data analyzed in this study. Here, the high values of the agricultural productions are quite close to the physiological maximum values, which the current cultures may reach at present, being in a natural threshold stage. This stage of the successor of a period of real technical and economic transformations, as we can characterize the period between 1960 and 1990, when very important increases of the agricultural productions were noticed. Concretely, if in France of the '60s the production of cereals was of approximately 2200 kg/ha, in 1990 it may reach to approximately 6000 kg/ha; in UK, from 3100 kg/ha in 1960 it reaches to 6400 kg/ha in 1990. In Netherland in 1960 the cereals production was of approximately 3600 kg/ha and reaches to approximately 6900 kg/ha in 1990 and in Hungary from 1850 kg/ha in 1960 it becomes approximately 5500 kg/ha in 1990 [21].

Table 1
Angular coefficients of the regression straight-line (m) describing the evolution of the production of cereals (2000-2015), respectively the transformation that lead to angular measures in degrees (degree) respectively in radians (rad)

State	m	rad	Grad	State	m	rad	degree
Belgium	-0.023	-0.023	-1.335	Germany	0.069	0.069	3.977
Cyprus	0.000	0.000	0.022	Slovenia	0.071	0.071	4.091
Spain	0.015	0.015	0.911	Poland	0.074	0.074	4.285
Luxembourg	0.022	0.022	1.289	Croatia	0.077	0.076	4.405
Finland	0.028	0.028	1.616	Romania	0.083	0.083	4.786
UK	0.030	0.030	1.753	Greece	0.086	0.086	4.957
France	0.031	0.031	1.805	Lithuania	0.100	0.099	5.730
Denmark	0.040	0.040	2.314	Czech	0.106	0.106	6.076
Italy	0.041	0.041	2.394	Slovakia	0.119	0.118	6.789
Sweden	0.055	0.055	3.201	Latvia	0.120	0.119	6.851
Netherlands	0.056	0.056	3.218	Estonia	0.122	0.121	6.959
Austria	0.057	0.057	3.303	Bulgaria	0.133	0.132	7.619
Ireland	0.066	0.066	3.829	Portugal	0.138	0.137	7.878
Hungary	0.069	0.069	3.966	EU (28)	0.069	0.069	3.971

Source: Calculations based on Eurostat database (Nov. 2016) relating to the cereal production

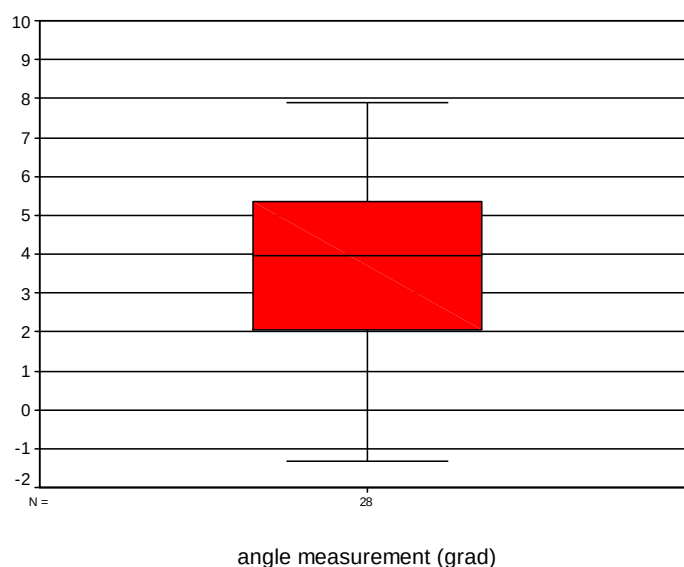


Figure 1. Boxplot Chart related to the series of statistic data related to the value of the angles measures in degrees rendered in Table 1

The states located after the center line are: Germany, Slovenia, Poland, Croatia, Romania, Greece, Lithuania, Czech, Slovakia, Latvia, Estonia, Bulgaria, Portugal. Some of them are those that between 1960 and 1990 got into contact with the socialist economy, and the average productions of cereals in the '90s were not so high as in the other states. The development policies applied there between 1990 and 2015 created the premise of agricultural development, the growths being visible, even if the effective differences between the two groups are still quite big. An exception case is represented by Germany, where the growth is continuous and with small oscillations for the entire time period between 1960-2015.

Table 2**Grouping of statistic data in quarters relating to the evolution of the cereals production (2000-2015)**

Quarter	State	Degree	Quarter	State	degree
1	Belgium	-1.335	3	EU (28)	3.971
	Cyprus	0.022		Germany	3.977
	Spain	0.911		Slovenia	4.091
	Luxembourg	1.289		Poland	4.285
	Finland	1.616		Croatia	4.405
	UK	1.753		Romania	4.786
	France	1.805		Greece	4.957
2	Denmark	2.314	4	Lithuania	5.730
	Italy	2.394		Czech	6.076
	Sweden	3.201		Slovakia	6.789
	Netherlands	3.218		Latvia	6.851
	Austria	3.303		Estonia	6.959
	Ireland	3.829		Bulgaria	7.619
	Hungary	3.966		Portugal	7.878

Observations somehow similar may be achieved also by following the coefficient of variation of the series of statistic data related to the total production of cereals at EU level. The coefficient of variation is represented by the ratio between the standard deviation and the average value, indicating the homogeneity of a series. The countries placed on the second part of the classification show a high variability of the cereal production, being characterized by multiple oscillations between 2000 and 2015.

Table 3**Values of the coefficient of variation calculated for the series of the total production of cereals**

State	Coefficient of variation	State	Coefficient of variation
Denmark	0.055	Ireland	0.106
Netherlands	0.067	Slovenia	0.122
France	0.077	Czech Republic	0.123
European Union (28)	0.080	Croatia	0.140
Luxembourg	0.083	Spain	0.151
Finland	0.083	Portugal	0.157
Germany	0.083	Slovakia	0.196
Italy	0.086	Hungary	0.199
United Kingdom	0.088	Bulgaria	0.260
Greece	0.088	Romania	0.265
Austria	0.092	Estonia	0.334
Poland	0.098	Lithuania	0.336
Sweden	0.100	Latvia	0.380
Belgium	0.101	Cyprus	0.563

Source: Calculations based on Eurostat databases (Nov. 2016) related to the production of cereals

Related to Romania, these oscillations may be explained by the high degree of attrition of lands, big differences concerning the technological potential and the preparation of farmers, aspects concerning the market of products and other inducing a permanent stability of the rhythm of grow of the agricultural productions, even under the conditions of a high degree of fertility of the agricultural lands. Table 3 indicates a classification of EU states according to the coefficient of variation. The similitudes between the two classifications must be also noted.

Studies concerning the variability of the cereal agricultural production were made in time, for at regional and at global scale, depending on different major factors of influence [1, 4, 5, 11, 19].

CONCLUSIONS

The angular coefficient of the regression straight line becomes a quite stable indicator of the economic evolution. Its application for the study of the evolution of the agriculture in EU states leads to possible hierarchizing, the results obtained for the indicated examples being however, according to expectations and in accordance with the opinions already made up in the reality of the economic European context.

There are also noted multiple similitudes compared to the classification, by using the coefficient of variation of the series of statistic data.

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REFERENCES

- [1]. CERNAY C., BEN-ARI T., PELZER E., MEYNARD J.-M., MAKOWSKI D., 2015, Estimating variability in grain legume yields across Europe and the Americas, Scientific Reports 5: 11171.
- [2]. CIOLAC R., PETROMAN C., PETROMAN I., RUJESCU C., STANCIU S., MARTIN. S, TUCUDEAN. A. R., 2013, Research on agro-tourism stage and traditional products recovery through this activity in the Alps Mountain-Trento Province. In The sixth international conference Rural development Proceedings. Vol.6 book 1, 74-79.
- [3].DORWARD A., 2013, Agricultural labour productivity. food prices and sustainable development impacts and indicators, Food Policy 39, 40-50.
- [4]. EVANS L. T., 1996, Crop evolution. adaptation and yield, Cambridge University Press.
- [5]. GOBIN A., KERSEBAUM K.C., EITZINGER J., TRNKA M., HLAVINKA P., TAKÁČ J., KROES J., VENTRELLA D., MARTA A.D., DEELSTRA J., LALIĆ B., NEJEDLIK P., ORLANDINI S., PELTONEN-SAINIO P., RAJALA A., SAUE T., ŞAYLAN L., STRIČEVIC R., VUČETIĆ V., ZOUMIDES C., 2017, Variability in the Water Footprint of Arable Crop Production across European Regions, Water 9, 93.
- [6]. HERA C. (COORD), OTIMAN P.I. (COORD), ALEXANDRI C., LUCA L., BĂNEȘ A., FEHER A., IONEL I., PETICILA A., RUJESCU C., RUSU M., 2015, Securitate și siguranță alimentară. In: Vlad I.V. (Coord) 2015. Strategia de dezvoltare a României în următorii 20 de ani. Ed. Academiei Române. Vol. I. 2015

- [7]. **KESAVAN P.C., SWAMINATHAN M.S.**, 2007, Strategies and models for agricultural sustainability in developing Asian countries. *Philos Trans R Soc Lond B Biol Sci.* 2008 Feb 27; 363(1492): 877–891.
- [8]. **MONTGOMERY D. C., PECK E. A., VINING G.**, 2015, Geoffrey. Introduction to linear regression analysis. John Wiley & Sons.
- [9]. **PINGALI P.L.**, 2012, Green Revolution: Impacts. limits. and the path ahead. *Proc Natl Acad Sci U S A.* 109(31): 12302–12308.
- [10]. **PIRVULESCU. L., TUCHILA. C., RUJESCU. C., BORDEAN. D. M., BANES. A.**, 2008, Comparative statistic studies concerning the nutritious value of some groups of foods. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture*, 65(2), 345-350.
- [11]. **RAY D.K., GERBER J.S., MACDONALD G.K., WEST P.C.**, 2015, Climate variation explains a third of global crop yield variability, *Nature Communications* 6: 5989.
- [12]. **RISSE-KAPPEN T.**, 1996, Exploring the nature of the beast: international relations theory and comparative policy analysis meet the European Union. *JCMS: Journal of Common Market Studies*, 34(1), 53-80.
- [13]. **ROBERTSON G.P., SWINTON S.M.**, 2005, Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. *Frontiers in Ecology and the Environment* 3(1), 38-46.
- [14]. **RUJESCU C.I, FEHER A., BĂNEȘ A., OTIMAN P.I.**, 2016, Bazele economico-matematice ale unor modele de prognoză a producției și consumului agroalimentar în România „Economie agroalimentară și dezvoltare rurală în țările din Sud-Estul Europei: provocări pentru viitor”, Editura Academiei Române, București, ISBN 978-973-27-2682-2, pp. 270-280.
- [15]. **RUJESCU C.I., FEHER A.**, 2016, Repartiția optimă a unor culturi agricole pornind de la un capital fixat „Economie agroalimentară și dezvoltare rurală în țările din Sud-Estul Europei: provocări pentru viitor”. Editura Academiei Române. București. ISBN 978-973-27-2682-2, pp. 296-303.
- [16]. **SALA F.**, 2011, *Agrochimie*. Editura EUROBIT, Timișoara. pp. 13-22.
- [17]. **SALA F., RUJESCU C., CONSTANTINESCU C.**, 2016, Causes and solutions for the remediation of the poor allocation of P and K to wheat crops in Romania. *AgroLife Scientific Journal* 5(1), 184-193.
- [18]. **SCHMIDT M.G.**, 2002, Political performance and types of democracy: Findings from comparative studies. *European Journal of Political Research*, 41(1), 147-163
- [19]. **TARRANT J.R.**, 1987, Variability in world cereal yields. *Trans. Inst. Br. Geogr.* N.S. 12, 315-326.
- [21]. **TILMAN D., CASSMAN K.G., MATSON P.A., NAYLOR R., POLASKY S.**, 2002, Agricultural sustainability and intensive production practices. *Nature* 418, 671-677.
- [21]. <http://data.worldbank.org/indicator/AG.YLD.CREL.KG?end=2014&start=1961&view=chart>. Accessed march 2017
- [22]. <http://ec.europa.eu/eurostat>. Accessed november 2016