REALITIES AND PERSPECTIVES ON THE MECHANIZATION OF ROMANIAN AGRICULTURE

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Abstract: *The mechanization of agriculture plays a fundamental role from a technical, financial and social point of view for sustainable development. Investments in high-performance agricultural machinery ensure cost reduction, increase soil quality processings and reduce environmental pollution. The purpose of the paper is to analyze the technical endowment with agricultural equipment of the Romanian farmers during 1990-2018. The following statistical indicators were studied for the analysis: the number of agricultural tractors, tractor plows, mechanical cultivators, mechanical seeders, chemical fertilizer spreaders, mechanical traction and dusting machines, self-propelled grain harvesters, self-propelled harvesters, harvester combines and potato harvesting machines, balers for straw and hay baling, and windrowers for fodder harvesting. The period analyzed was divided into two intervals: 1990-2006 pre-accession to the EU and 2007-2018 - post-accession to the EU. The limitation of the research consists in the fact that there are no statistical data regarding the number of obsolete machines which are used as scrap iron. Purchasing a 200 hp tractor meant scrapping three U650 tractors. Consequently, the pollution level was significantly reduced. A clear picture of the agricultural machinery park in Romania can be obtained only from the general agricultural census or from a structural survey based on questions related to the characteristics (size) of the machines, the power (horsepower) of the tractors, the mode of acquisition (new or second hand). It is interesting to find out from the total number of new machines how many were purchased by credit / leasing and how many were acquired as a result of accessing European funds. Even though agricultural production has increased significantly in recent years, Romania's trade deficit in agriculture is about one billion euros a year, generated by the fact that Romania exports raw materials and imports processed products. In order for Romania to increase the value of agricultural production, investments should be urgently directed not only towards mechanization but also to processing.*

Keywords*: agriculture, machinery, Romania, mechanization*

INTRODUCTION

The mechanization process covers all the tools used in agriculture, and also the motorized agricultural machinery and equipment. The mechanization brings a number of advantages to the agricultural process. It contributes to the increase of productivity, leads to the use of resources in the most efficient way, and has a major role in diminishing the dangers that derive from climate change, which are so menacing at the present moment.

The mechanization has reduced the labor force needed in the agricultural process, by using machines in as many stages as possible. In 2018 the volume of labor force was 1474 UAM (annual work units) compared to 2205 UAM in 2007 and 3460 UAM in 1998.

The potential of Romania in the agricultural field is significant owing to its large agricultural areas (PwC ROMÂNIA, 2017). Out of its total area, 58.78% is used for agriculture. In the EU the average is 45% agricultural land, out of the total area. Our country benefits from its geographic position, fertile soils in most of the country, and a temperate climate that favors agricultural crops (OANA COCA, 2018)). However, agriculture is not practiced efficiently in Romania and this is best shown by statistics. Although large areas of land are cultivated, the results obtained are comparable to countries that exploit a smaller area of land.

In Europe, the agricultural area covers 178.5 million ha. About half of this land is in France (15.9%), Spain (13.4%) and Germany (9.6%). In this ranking, Romania comes 6th, after Poland, holding 7.6% of the total agricultural area of the EU (BĂDAN DANIELA-NICOLETA, 2017).

The increase of agricultural production and the rational use of the land are two frequently discussed issues at global level. The population of the world is constantly growing, so the need for food is much more pressing. Under these circumstances, the state of the land is in a continuous process of degradation, due to pollution, climate change, chemical agents, etc.

In order to make agriculture more efficient, the energy consumption involved in the processes of production and processing of agricultural products should be reduced. This will lead to preserving the natural resources: water, air, or the soil.

MATERIAL AND METHODS

The purpose of the paper is to analyze the technical endowment with agricultural equipment of the Romanian farmers during 1990-2018. The following statistical indicators were studied for the analysis: the number of agricultural tractors, tractor plows, mechanical cultivators, mechanical seeders, chemical fertilizer spreaders, mechanical traction and dusting machines, self-propelled grain harvesters, self-propelled harvesters, harvester combines and potato harvesting machines, balers for straw and hay baling, and windrowers for fodder harvesting. The period analyzed was divided into two intervals: 1990-2006 pre-accession to the EU and 2007-2018 - post-accession to the EU. In this way, by comparing the averages, we focused on the presence or absence of significant differences in the agricultural machinery park of Romania. Also, the evolution of the worked surfaces with a tractor was analyzed according to the development region. To substantiate the conclusions of the research, we used the Student and Anova test.

RESULTS AND DISCUSSIONS

1. Statistical analysis of the evolution of the number of agricultural equipment of Romania in the period 1990-2006

In Romania there are numerous farms, but the vast majority are small in size and have a low capacity for investment in state-of-the-art equipment. Innovation is the driving force of economic growth and development in today's knowledge-based society [9]. Globally, an efficient , modern, and technology-based agriculture is practiced. Intelligent systems are used, capable of locating the productive lands for certain varieties of plants, or determining the need for water or fertilizers, so that the maximum productions are obtained from each surface exploited. At the same time, European agricultural policies support the development of the agricultural processes and techniques used to combat climate change, to maintain a friendly relationship with the environment and to make an efficient use of production factors.

The causes of Romania's insufficient mechanization in the agricultural field are multiple, such as the lack of funds, insufficiently trained farmers, or the lack of irrigation systems, as a lot of the crops depend on the climatic conditions and precipitation, all leading to obtaining a poor production, especially in the drought years. The use of tractors in agriculture is vital for achieving results which can compete with other EU countries. The sheer number of agricultural tractors in use in Romania increased from 1990 to 2006 by 47498 pieces. The number of tractors used in Romania increased by 37.38% in 2006. Regarding the preparation of the land for crops, a simplification of the working procedures was also achieved. The number of plows used by a tractor increased by 89.44%, from 73159 (1990) to 138594 (2006).

Table 1

Statistical analysis of the evolution of the number of agricultural equipment of Romania in the period 1990-2006

	Mean	Standard Deviation	Coefficient of variation	Annual growth rate	Minimum	Maximum
Physical agricultural tractors	160492,88	13222,17	8,24	2	127065	174563
Ploughs for tractors	113684,47	21710,34	19,1	4,07	73159	138594
Mechanical cultivators	26017,71	1990,32	7,65	-0,24	23223	28596
Mechanical sowers	53521,24	10674,56	19,94	4,07	34988	67761
Chemical fertiliser spreaders	9897,2	630,86	6,37	-0,7	8635	10810
Mechanical sprayers and dusters	9704,47	3078,68	31,72	-5,16	5679	14991
Self-propelled combines for cereal harvesting	32128,59	6066,68	18,88	-3,01	24653	40695
Self-propelled combines for fodder harvesting	2836,71	1795	63,28	-11,76	724	5569
Combines and potato harvesters	3253,82	672,99	20,68	1,61	2345	4562
Straw and hay packing presses	11896,53	6648,83	55,89	-8,54	4730	21706
Windrowers for fodder harvesting	2852,59	1404,15	49,22	-8,28	1224	4981

Source: Own calculation based on the data provided by National Institute of Statistics [12].

The mechanical cultivators saw a reduction of 1022 machines in the number of those which were used, during the same period. Thus, only 96.26% of the cultivators used in 1990 were still functional in 2006.

The number of mechanical seeders increased by about 89.39%, between 1990-2006. Thus, a further 31983 seeders were used. Unfortunately, after 2005 the machines used to spread chemical fertilizers were no longer used. In the 1990s, immediately after the revolution, Romania had 10801 such seeders.The number of machines with mechanical traction used for sprinkling and dusting was also considerably reduced. Between 1990-2006, 8566 such machines came out of use. Only 42.86% of the machines owned in 1990 were functional.

The self-propelled combines used in the cereal harvesting process and those for feed harvesting decreased in number over the same period of time. Only 61.37% of the combines for cereals and 13.5% of those for fodder could still be used in 2006. However, the combines and machines used for potato harvesting increased by 29.09%. More precisely 872 such machines were added to the Romanian agricultural machinery park. The number of baling presses was reduced considerably, by 16506 machines, a reduction of 76.04%. Losses were also registered in the numbers of the windrowers for fodder harvesting, as 3731 such machines were removed from use. In 2006, only 25.1% of the windrowers used in 1990 were used.

The average of the period 1990-2006, with regard to the tractors used was 160492.88 tractors. The growth was significant, the annual rate being positive, of 2%. Thus the minimum number of tractors was used in 1990, and the maximum put into operation was in 2006.

A significant growth rate was achieved for the categories of plows and mechanical seeders (+4.07%). Also, potato harvesters had a positive growth rate (+1.61). Otherwise, all the agricultural machines studied saw a decrease in the number of those which were used, from year to year. The biggest loss was suffered by the number of self-propelled combine harvesters. Their deceleration rate was (-11.76). Next in the top of the numerical losses are the baling presses (-8.54) and the winches (-8.28). Mechanical sprinklers and dusters were used in smaller numbers, their reduction being of (-5,16).

The average number of 32128.59 cereal harvesters was reduced by an annual rate of (-3.01). The coefficient of variation indicates the degree to which there were variations (increases / reductions) in the number of machines used in agriculture. In the case of tractors, mechanical cultivators, and fertilizer spreaders, the variation was below the 10% threshold, being considered small. Therefore the increases and reductions in the number of machines were constant, without major variations from year to year.

However, some machines saw significant increases or reductions in the number of those which were used, with a coefficient of variation of over 20%. The machines with great variation in numbers were the windrowers for fodder harvesting, baling presses, potato harvesters, self-propelled combines for cereal harvesting and the machines with mechanical traction used for sprinkling and dusting. The numbers of other machines saw only a medium variation, with a cofficient between 10 and 20 %.

2. Statistical analysis of the evolution of the number of agricultural machines in Romania in the period 2007-2018

The impact of European funds on the Romanian economy in general and on agriculture in particular was significant [1]. Through the PNDR 2007-2013 and PNDR 2014-2020 programs, Romania has benefited from 7.034 billion euros for a number of 95993 projects, respectively 8.128 billion euros [5]. As the PNDR 2014-2020 is in progress, the number of projects that have been funded cannot be specified. The number of agricultural tractors continued to grow even after Romania's accession to the European Union.

Table 2

Statistical analysis of the evolution of the number of agricultural machines in Romania in the period 2007-2018

	Mean	Standard Deviation	Coefficient of variation	Annual growth rate	Minimum	Maximum
Physical agricultural tractors	191157,75	14846,13	7,77	1,79	174003	215980
Ploughs for tractors	153074,83	11532,72	7,53	1,71	139782	169964
Mechanical cultivators	28954,33	1131,82	3,91	0,91	27262	30632
Mechanical sowers	73989,92	4816,64	6,51	1,25	67674	81255
Mechanical sprayers and dusters	5629,5	255,27	4,53	-0,98	5293	6053
Self-propelled combines for cereal harvesting	25947	1020,88	3,93	0,79	24656	27485
Self-propelled combines for fodder harvesting	867	121,93	14,06	3,25	752	1104
Combines and potato harvesters	5040,92	726,64	14,41	3,88	3765	6108
Straw and hay packing presses	9882,92	3311,21	33,5	9,04	5399	14697
Windrowers for fodder harvesting	1317,33	169,58	12,87	0,94	1201	1817

Source: Own calculation based on the data provided by National Institute of Statistics [12].

The increase in the number of tractors over the 12 years (2007-2018) was by 24.12%, with 41,977 tractors. An increase by 21.59% in the plows used for the tractor was also registered. 30182 such machines were purchased for use. Mechanical cultivators also saw an

increase by 7.61%, with 2075 machines. Mechanical seeders increased by 16.16%, with 10938 new seeders which were put into use. Fertilizer spreaders were not used during this period.

Between 2007-2018, reductions in the number of machines were registered only in the case of sprayers and dusters with mechanical traction. 167 machines were scrapped. The number of combines for harvesting feed, cereals and potatoes increased by 343, 2808 and 2343 machines, respectively. Ballot presses significantly increased by 72.22%. 9298 new presses were used. The number of windrowers for fodder also increased by 10.24%. The highest growth rate of (+9.04) was registered in the case of baling presses. In 2018, 14697 presses were used. The average for the period 2007-2018 was 9882.917. The potatoes harvesters grew by an annual rate of (+ 3.88). During the analyzed period 5040.917 such combines were used on average. The number of combines for harvesting fodder also increased by a rate of (+3.25).

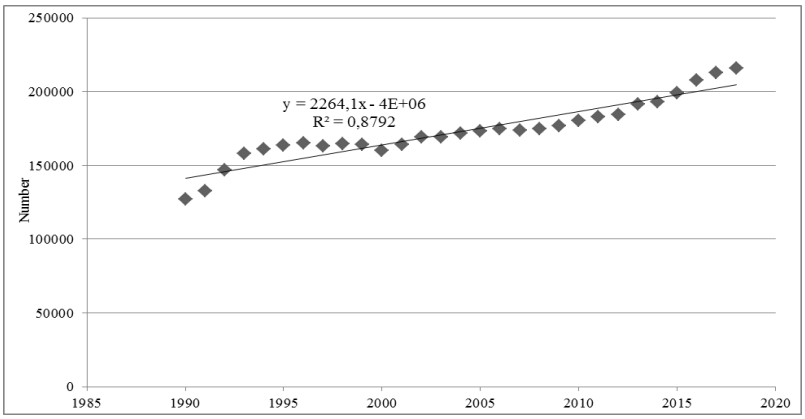

Figure 1. Dynamics and regression of tractors, Romania, 1990-2018 (number of tractors)
Source: Own design based on the data provided by National Institute of Statistics [12].

The agricultural tractors and the plows for tractors in use increased annually by a rate close to (+1.79) and respectively (+1.71). In 2018, 215980 tractors and 169964 plows for tractors were registered. The number of mechanical seeders increased, not so rapidly as the other machines. The rate was (+1.25). On average, 73989.92 seeders were used annually. The rest of the machines saw increases of less than 1%. The number of agricultural tractors in use, tractor plows, mechanical cultivators, mechanical seeders, mechanical traction and dusting machines, self-propelled grain harvesters changed little from year to year. The coefficient of variation was up to 10% for these machines. The number of combines for fodder, potato and fodder combines underwent relatively significant changes. The variation of their number is considered to be medium, according to the calculated coefficient, which is between 10 and 20%. Ballot presses saw a significant increase in their number.Therefore, their variation from year to year was great. The calculated coefficient of variation was 33.5%.

3. T Test (Student's T-Test)

Statistical analysis of the comparison of cattle in the period 1990-2006 with 2007-2018 Is considered [23]:

H_0 - there is no significant difference between the two analyzed periods P1 (1990-2006) and P2 (2007-2018) = $t_c < t_{(\alpha;n-k)}$; $p \geq \alpha$.

H_1 - there is a significant difference between the two periods P1 (1990-2006) and P2 (2007-2018) = $t_c \geq t_{(\alpha;n-k);}$ $p<\alpha$.

The calculations resulted in two types of significance presented in the following two tables.

Table 3

Machines for which there is a significant difference between the two compared periods
(t-Test: Two-Sample Assuming Unequal Variances)

	Calculated value of test t	Probability associated with the test	The theoretical value of the test t
Physical agricultural tractors	5,728882	4,60298E-06	1,717144374
Ploughs for tractors	6,322971	6,42693E-07	1,708140761
Mechanical cultivators	5,037952	1,52018E-05	1,70561792
Mechanical sowers	6,965176	1,67157E-07	1,71088208
Combines and potato harvesters	6,72381	3,68825E-07	1,713871528

Source: Own calculation based on the data provided by National Institute of Statistics [12].

t Critical one-tail – the one-dimensional critical value for the significance threshold $\alpha = 0,05$

The table above shows the agricultural equipment for which $t_{stat} > t_{\text{Critical one-tail}}$ and $p<0,05$.

Since the calculated t value is higher than the Critical one-tail t value, then H0 can be rejected in favor of alternative hypothesis H_1 and it can be concluded that there are significant differences between 1990-2006 and 2007-2018 for the following agricultural machines: physical agricultural tractors, ploughs for tractors, mechanical cultivators, mechanical sowers and combines and potato harvesters. The number of these machines increased in the post-accession period to the European Union due to the access of European funds by farmers. We mention that this type of machine is intended for cereal cultivation.

Table 4

Machines for which there is no significant difference between the two compared periods
(t-Test: Two-Sample Assuming Unequal Variances)

	Calculated value of test t	Probability associated with the test	The theoretical value of the test t
Chemical fertiliser spreaders	-5,43099	2,77E-05	1,745884
Self-propelled combines for cereal harvesting	-4,11939	0,000358	1,739607
Self-propelled combines for fodder harvesting	-4,50969	0,000178	1,745884
Straw and hay packing presses	-1,07416	0,146504	1,708141
Windrovers for fodder harvesting	-4,46222	0,000171	1,739607

Source: Own calculation based on the data provided by National Institute of Statistics [12].

The table above shows the agricultural equipment for which $t_{stat} < t_{\text{Critical one-tail}}$ și $p<0,05$.

Since the calculated t value is lower than the Critical one-tail t value, then H_0 is accepted and it can be concluded that there are no significant differences between 1990-2006 and 2007-2018 for the mentioned agricultural equipment. The machines in this second category are destined especially for the fruit and vegetable sectors that were and still are in decline.

4. ANOVA test

The Anova test was meant to verify the influence of the development regions in Romania on the number of agricultural machines.

The following table presents the results obtained after verifying the influence of the regions on the number of agricultural machines [24]. The F test was used for this verification.

I considered H_0 - the regions are not a factor influencing the number of machines ($F<F_{(\alpha; k-1; n-k)}$; $P\geq\alpha$)

H_1 - regions are a factor influencing the number of machines ($F\geq F_{(\alpha; k-1; n-k)}$; $P<\alpha$)

Table 5

Centralized results obtained from calculations for each type of agricultural equipment
(Anova: Single Factor)

	SS	df	MS	F	P-value	F crit		
						0,05	0,01	0,001
Physical agricultural tractors	1,58E+10	7	2,26E+09	164,7101	1,25E-84	2,050622	2,719924	3,628
Ploughs for tractors	8,98E+09	7	1,28E+09	81,56607	4,48E-58	2,050622	2,719924	3,628
Mechanical cultivators	5,46E+08	7	77940214	213,0537	2,8E-95	2,050622	2,719924	3,628
Mechanical sowers	2,59E+09	7	3,7E+08	94,63436	2,49E-63	2,050622	2,719924	3,628
Mechanical sprayers and dusters	95329575	7	13618511	54,27095	7,6E-45	2,050622	2,719924	3,628
Self-propelled combines for cereal harvesting	5,29E+08	7	75523010	86,21321	5,22E-60	2,050622	2,719924	3,628
Self-propelled combines for fodder harvesting	2194893	7	313556,2	5,999316	2,03E-06	2,050622	2,719924	3,628
Combines and potato harvesters	1,07E+08	7	15322074	165,055	3,68E-82	2,052966	2,719924	3,628
Straw and hay packing presses	82928606	7	11846944	16,89591	7,26E-18	2,050622	2,719924	3,628
Windrowers for fodder harvesting	2996373	7	428053,3	13,22095	3,06E-14	2,050622	2,719924	3,628

Source: Own calculation based on the data provided by National Institute of Statistics [12].

Conclusion: for all the analyzed agricultural equipment F> Fcrit and the value of P-value <0.001, which makes us reject H_0 and accept H_1. Thus we can conclude that the development regions are a factor which influences the number of agricultural machines existing in each area.

CONCLUSIONS

The periods 1990-2006 and 2007-2018 had a different evolution in terms of the number of agricultural machines. While some machines increased in number in both periods, others suffered significant losses. To begin with, we analyze the changs in number of tractors and tractor plows. They grew steadily, from year to year in both intervals analyzed. In the period 1990-2006 both types of machines saw more significant increases in the number of the machines which were used, especially in the case of plows, where the rate was (+4,07).

Mechanical cultivators decreased relatively slightly in the pre-accession period (-0.24), and after 2007 they saw a slight increase in the number of those which were used (+0.91).

The mechanical seeders saw increases in number, much more significant in the period 1990-2006, when the annual rate was (+4.07). Chemical fertilizer spreaders have not been used since 2005 in Romania.

The only machines that decreased in number in both periods analyzed are the machines with sprinklers and dusters with mechanical traction. The rate of decline was more pronounced in the period 1990-2006 (-5.16) and relatively lower in the period 2007-2018 (-0.98).

Self-propelled cereal harvesters declined before joining the EU (-3.01), but after 2007 they saw a slight increase in numbers. The combines and machines used for potato harvesting increased in number in both periods, but between 2007-2018 this growth had a higher rate (+3.88).

For three types of machinery, namely the self-propelled combine harvesters, the balers for straw and hay and the feeders, the evolution was similar in the analyzed time periods. Between 1990 and 2006 the number of these machines declined severely and much fewer were used, but after 2007 they steadily increased in number, from one year to another .The largest decrease was in the number of the combines for harvesting feed (-11.76) and the biggest increase was registered in the case of the baling presses (+9.04).

In order to become competitive on European and global markets, it is necessary to increase the efficiency with which agricultural land is exploited. In this respect, the main objective should be the increase of productivity. This can be achieved by replacing current technologies with state-of-the-art agricultural equipment.

In Romania, at this moment, the tractor park largely comprises machines produced before 1989. To be competitive, productive and efficient in the agricultural sector, it is necessary to use the latest machinery, whose performance cannot be compared with that of a tractor older than 30 years. A state-of-the-art agricultural machine has a number of advantages and features. It has a high harvesting capacity, losses are minimized, and fuel consumption is reduced. According to studies and reports at European level, the agricultural machinery market is constantly expanding. It is estimated that in the period 2018-2023, the agricultural machinery market could grow by 5.8% in all countries in Europe.

Although there have been increases in the number of machines used in Romania, this increase is still considered slow. One problem that hinders the process of modernizing the agricultural park in Romania is the difficult procedure for purchasing agricultural equipment from European funds. The purchase of a modern, efficient agricultural machine is recommended to any farmer. This would be considered the most viable investment.

In the future, digital technology should be more extensively introduced in the agricultural sector. Tractors with self-driving function are already in use. Other machines equipped with innovative equipment will be available and even robots with artificial intelligence, intended for agricultural use, will be launched.

It must be borne in mind that the mechanization technology currently used in our country is very poor and insufficient. Although the number of used machines has increased in recent years, there are still a number of issues that Romania has to address: the small size and large fragmentation of the agricultural land, the existence of a significant number of subsistence farms, the insufficient use of European funds, the poor infrastructure and lack of up-to-date information of many farmers.

The number of machines has increased, more or less, for each category. This increase is largely due to the accession to the EU and the access to European funds, which allowed the renewal of the agricultural park. The extent to which this renewal has been achieved depends on the level of farmers and farms in Romania.

Romanian agriculture is characterized by a relatively large number of small farms. There are about 3.5 million small farms, of about 3 ha / farm in size. Unfortunately, on such a farm it is difficult to implement modern technologies. These semi-subsistence or subsistence farms have a low yield and are not competitive, due to the lack of adequate equipment and the lack of proper training of the rural aging population (OANA COCA, 2018).

In addition to technology, great attention must be paid to the need to conserve and protect the environment. Various pollution factors and chemical agents, lead to soil degradation with direct effects on agricultural productivity. A clear interdependence relationship must be established between the agricultural economy and the ecology (CONSTANTIN FLORENTINA, 2011). Agriculture is the main source of income for a significant number of people. The contribution of Romanian agriculture to the formation of the GDP is 4.8%. In the EU the average is 1.2% (OANA COCA, 2018).

BIBLIOGRAPHY

ALBU LUCIAN-LIVIU (coordonator) (2018), *The impact of Romania's accession to the European Union on the Romanian economy. Sectoral analysis (industry, agriculture, services, etc.)*, European Institute of Romania, Bucharest, p. 151, available at the address: http://www.ier.ro/sites/default/files/pdf/SPOS_2017_Studiul%201_FINAL.pdf, [accessed on 02/07/2018].

ANGHELACHE CONSTANTIN (2018), *Structural analysis of Romanian agriculture*, în Revista Română de Statistică - Supliment nr. 2 / 2018, pp. 11-18, available at the address: http://www.revistadestatistica.ro/supliment/wp-content/uploads/2018/02/RRSS_02_2018_A1_EN.pdf, [accessed on 11/11/2019]

APIMAR (The Association of Agricultural Machinery Manufacturers and Importers in Romania), https://www.agrim.ro/apimar/, [accessed on 13/11/2019]

BĂDAN DANIELA-NICOLETA (2017), *Analysis regarding the fleet and the farm equipment in Romania compared to the European Union*, în Research Institute for Agricultural Economy and Rural Development, 8th Edition of the International Symposium, Agrarian economy and rural development realities and perspectives for Romania, available at the address: http://www.symposium.iceadr.ro/arhive/archive-2017/volume-2017, [accessed on 2/11/2019]

BULIGA-ȘTEFĂNESCU AURELIAN (2019*), Research on the impact of accession to the European Union on the evolution of farms in our country. Case study: Olt County*, PhD thesis, USAMV Bucharest, p. 31

COMISIA EUROPEANĂ (2016), *Productivity in EU Agriculture – Slowly but Steadily Growing*, EU AgriculturalMarkets Briefs, Nr. 10, decembrie 2016, available at the address: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/trade/documents/agri-market-brief-10_en.pdf, [accessed on 7/11/2019]

CONSTANTIN FLORENTINA, CIOBANU LAURA (2011), *Aspects of technical progress in Romanian agriculture. Compared to some EU countries*, in Economia. Seria Management, Volume 14, Issue 2, 2011, pp. 473-483, available at the address: http://www.management.ase.ro/reveconomia/2011-2/19.pdf, [accessed on 2/11/2019]

MDRAP (2015), *Strategia de dezvoltare teritorială a României*, https://www.fonduri-structurale.ro/Document_Files/Stiri/00017493/7hctm_Anexe.pdf, [accessed on 10/11/2019]

OANA COCA (2018), *The study of the capital relation - innovation - performance in agriculture. A financial-accounting approach*, PhD thesis summary, Alexandru Ioan Cuza University in Iași, available at the address: https://doctorat.feaa.uaic.ro/doctoranzi/pagini/Coca_Oana/Documents/REZUMAT%20TEZA%20DE%20DOCTORAT%20-%20OANA%20COCA%20-%20CONTABILITATE.pdf, [accessed on 20/10/2019].

POPESCU AGATHA, DINU TOMA, STOIAN ELENA, IONELA MITUKO VLAD (2017), *Trends in agriculture endowment with machinery in Romania 2007-2015*, p. 291-300, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 17, Issue 2, 2017, available at the address: http://managementjournal.usamv.ro/pdf/vol.17_2/Art40.pdf, [accessed on 2/11/2019]

PwC ROMÂNIA (2017), *The potential of developing the agricultural sector in Romania*, available at the address: https://www.juridice.ro/wp-content/uploads/2017/03/Raport_PwC-agricultura.pdf, [accessed on 10/11/2019]

NATIONAL INSTITUTE OF STATISTICS, Tempo-online Data Base, 2019, http://statistici.insse.ro:8077/tempo-online/

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT (MADR), https://www.madr.ro/

EUROSTAT, https://ec.europa.eu/eurostat/data/database

https://finantariagricole.ro/sfat/tendinte-in-mecanizarea-agriculturii/, [accessed on 7/11/2019]

https://ec.europa.eu/transparency/regdoc/rep/1/2018/RO/COM-2018-773-F1-RO-MAIN-PART-1.PDF, [accessed on 2/11/2019]

http://www.agroinfo.ro/beta/vegetal/romania-are-una-dintre-cele-mai-intinse-suprafete-de-teren-agricol-58-78-din-suprafata-totala-media-in-ue27-45, [accessed on 9/11/2019]

http://www.europarl.europa.eu/factsheets/ro/sheet/104/politica-agricola-comuna-in-cifre, [accessed on 9/11/2019]

http://www.madr.ro/docs/dezvoltare-rurala/programare-2014-2020/Strategia-de-dezvoltare-rurala-2014-2020-versiunea-I-22-nov-2013.pdf, [accessed on 8/11/2019]

http://www.europarl.europa.eu/factsheets/ro/sheet/103/politica-agricola-comuna-pac-si-tratatul, [accessed on 28/10/2019].

http://www.madr.ro/docs/dezvoltare-rurala/programare-2014-2020/analiza-dezvoltarii-rurale-agricultura-iulie-2013.pdf, [accessed on 10/11/2019].

http://www.madr.ro/docs/minister/programul-national-reabilitare-irigatii-.pdf, [accessed on 10/11/2019].

http://www.real-statistics.com/students-t-distribution/two-sample-t-test-uequal-variances/, [accessed on 14/11/2019]

http://www.real-statistics.com/one-way-analysis-of-variance-anova/basic-concepts-anova/, [accessed on 14/11/2019]

https://finantariagricole.ro/ziar/cum-se-justifica-investitia-intr-un-utilaj-agricol-modern/, [accessed on 13/11/2019]

https://www.gazetadeagricultura.info/masini-si-utilaje-agricole/551-utilaje-agricole/21824-cum-arata-piata-utilajelor-agricole-in-prezent-si-unde-se-indreapta.html, [accessed on 14/11/2019]

https://www.agroinfo.ro/economic/raport-oficial-iunie-2019-structura-fermelor-din-romania, [accessed on 11/11/2019]