Professor Ion POPA, PhD
E-mail: ion.popa@man.ase.ro
Senior Lecturer Claudiu CICEA, PhD
E-mail: claudiu.cicea@man.ase.ro
Professor Cosmin DOBRIN, PhD
E-mail: cosmin.dobrin@man.ase.ro
Corina MARINESCU (PÎRLOGEA), PhD Candidate
E-mail: corina.pirlogea@ase.ro
The Bucharest Academy of Economic Studies
Daniel BOTEZ
E-mail: Daniel63331@yahoo.com
"Vasile Alecsandri" University Bacau

MODELING ENERGY'S CONTRIBUTION TO THE AGRICULTURE FIELD: EVIDENCE FOR EUROPEAN COUNTRIES

Abstract. *This paperwork mainly focuses on important determinants of agricultural and rural development in the context of globalization. The issue of globalization and its effect on agriculture with positive and negative aspects is analyzed. Then the relation of agriculture and economic growth is treated, as growth is a step that leads to development and then to progress. Furthermore, after the discussion about agriculture as an engine of growth, energy, the engine that facilitates agricultural production is also investigated. Finally, rural development indicators are used in a panel data approach to highlight their influence on agriculture production. A part of the model focuses on the influence of agriculture and energy consumption in agriculture on economic growth. Main findings reveal that: energy consumption within the sector positively influences agricultural output for almost all countries; a lower influence appears from investments (which mainly had a downward trend) and population working in agriculture.*

Key words: *agriculture, economic growth, energy consumption, rural development, globalization.*

JEL Classification C23, C51, J43, O13, O40, Q20, Q40

1. Introduction

In the new European Union context, it is very interesting to study the role of the agriculture and rural development to the economic growth and the living standards.

All countries experienced the transition from traditional agriculture to the modern one, based on new technology, which influenced not only this transition but also the economic growth. Therefore, investments in the field are recognized as

important determinant of agriculture's output (Cicea, Subic & Pirlogea, 2010). The growth we are talking about, also reflects the positive changes of labor productivity and income, changes that begun more than two centuries ago. All together refer to development which transformed the agriculture-based economies into industrial ones. It is true that there still are countries experiencing this transition, with lot of the labor force used in agriculture.

The improvements in labor productivity are not influenced only by technology but also by health conditions and education of the working force. For instance, healthy and well nourished individuals can work for longer hours. In the same time, schooling is equally important because is directly related to the skills of labor force. Both education and health standards contribute to a better potential of the field (Huffman & Orazem, 2007).

In the same European context, it makes sense the analysis of resources used for agricultural activities, with focus on energy. Energy is considered an engine for all activities developed by human and if related to agriculture, it can be seen both as an input and as an output for this economic sector. Farmers have encountered ways of earning extra income using energy and especially renewable energy. As a tendency of this century, renewable energy finds its place among agriculture's determinants.

In order to sustain the facts presented in this work, a panel data model is developed and analyzed; considerations about specific country results are discussed. The panel data model includes several rural development indicators and includes agriculture, at first as a dependent variable and then as an independent one.

2. Agriculture, Rural Development and economic growth in the current global economy

The current global economy builds itself on some processes of decision making and policies' implementation that relocate from the national level to local one. As Schuh (2002) expresses his opinion, this situation becomes ambiguous when it comes to understand where policy making and implementation occurs. This issue, as the author confirms, goes hand in hand with another so called failure that of recognizing the importance of strengthen the policies. Policies that deal with commodity markets tend to shift to the international level, as for the income and resource policies, they tend to shift to national level. In relation to this, the first type of policy is connected to the idea of losing sovereignty, while the second is seen as supporting democratic processes.

It is known the fact that globalization, as a long-run process, exerts some effects on national and international communities, but no one can say with confidence what kind of effects are those, either positive, either negative. Positive side of this process is to enhance interaction between countries, which in turn opens up new possibilities for the development of human civilization, especially in the economic sphere. Intensification of trade, investment and technology between different regions, facilitate contacts, familiarity with the cultures of other peoples are certainly beneficial for mankind.

Globalization is a geoeconomic, geopolitical and geocultural process. This process is not only an approximation, an integration of the economies of several countries. The act of changing of the economies requires a big transformation from closed systems to some parts of a global system. Transnational corporation becomes economic fundamental entity, who put factories and markets its products where it is more convenient, without taking into account existing borders. Entire regions are transformed into suppliers of raw materials and outlets for transnational corporations, without developing their own production.

The process of globalization requires highlighting few aspects arising with this issue: fewer trade restrictions, lower protection for trading countries, prices that are supposed to be international. These prices, for almost all products are in a tendency of growth due to trade liberalization, which raises implications for developed and developing countries (Meijerink & Roza, 2007). In fact, it is considered that significant rises in prices to certain products in agriculture have a negative impact on farmers' incomes and on poor countries' population. So, trade liberalization can contribute to price instability.

This aspect mentioned is a characteristic of globalization, in its international dimension, which can create opportunities, but also risks, like this one. In order to create only positive features, globalization should make a strong connection with domestic market policies.

An interesting part of globalization appears with biotechnology. Investments in the sector are needed, in order to improve total factor productivity (Cicea, Subic & Turlea, 2010). A connection with private sector can be established, in order to finance projects of infrastructure and technology for agriculture. There are financial institutions, as World Bank and other development banks that can influence the perception on agricultural sector by making investments and sustaining the importance of it, as influencing the economic growth of a country and contributing to poverty reduction. All this should reflect in the strategies and policies of all countries.

For example, some believe that "if the government of a developing country is keen on rural infrastructure, perhaps, external resources could support the development of the other necessary ingredients for growth and poverty reduction, such as rural education and health, with emphasis, of course, on sustainability of investments" (Sarris, 2001).

Another interesting perspective regarding globalization and its effect over the agriculture and rural development is dealing with three technological revolutions: one in the transportation sector, one in the communication sector, and one in the information technology sector. As a positive consequence of these revolutions, we can mention: decreasing costs of transactions (meaning also costs of transportation) which eased the international trade. As a negative consequence that could be rather called a negative effect, is the selfishness of developed countries, which benefited first from the technological revolutions and did not shared them with developing countries. And this represents an important aspect if we consider the fact that developed countries account for only 20 per cent of world's population.

The agricultural field in the context of globalization follows the development of international trade for products and in this sense, the development of agricultural markets. This growth in the two directions mentioned before, brings influences in a national economy from abroad.

In each economy is needed an engine of growth, which generates income and savings that lead to development (Cicea & Banacu, 2009). The sources of the engine of growth are considered sectors like transport, industry, tourism, but also agriculture and energy. In these sectors, expenditures for human capital and infrastructure development are required. There are countries for which growth was obtained through changes in agricultural productivity that has been in many cases supported by external donors. But this donors do not have the same contribution in every country, for instance for developing countries in Africa, this contribution is declining.

It is important that when obtaining higher incomes as a result of improved agricultural productivity to spend it in order to determine agricultural rural growth. If the incomes concentrate on labor investments, then people can get benefits in the form of employment. If they concentrate on imported goods, then the benefits are greatly reduced. So, these two aspects refer to the distribution of agricultural incomes and their pattern to provide rural development and agricultural growth.

According to some economists, it was noted that there may be both direct and indirect contributions to rural development increase from agricultural development, depending on the structure of the incomes (Vasilescu, Cicea, Popescu & Jean, 2010). Taking into account the period, the countries' specific features, the distributional variables, some authors worked to highlight the role of agriculture to economic growth and rural development, making use of indicators like agricultural productivity or poverty reduction.

As specified in Sarris (2001), there are some conditions that sustain the role of agriculture to growth and rural development. Among them, we mention the following:

- the improvements in technology should have low risk and stand in need for low capital;
- the existence of local labor force;
- the education and health of the existing labor force should be attentive addressed;
- the land should be fairly allocated;
- the property rights for land should be properly stipulated.

Another issue deals with supporting agricultural research in order to obtain growth, diminish poverty, enhance productivity and increase the marginal product of labor in agriculture.

2.1. Energy opportunities for agriculture

In agriculture, energy can be seen in two different ways. First of all one can think of energy as an input to production (Schnepf, 2004); it is needed in the production cycle, directly as electricity or fuel and indirectly in the fertilizers, seeds and chemicals used in the processes. This particularly highlights the consumer role of agriculture in its trial to supply food for the population. Then, energy can be

thought of as an output of production, as agriculture-based energy production expanded in recent years. So, the agriculture developed its capacity of producing energy, for its own consumption or for national consumption, even if small related to population's need.

The energy produced is primarily renewable energy from sources like: biomass, wind power and solar. This option of agriculture-based renewable energy production reveals a contribution to rural development, as well as for national security and reducing the dependence on imports, not to mention the reduction of pollution and greenhouse gases emissions.

As far as we are concerned, the interest in exploring renewable energies is mainly due to environmental needs, exhaustible character of nonrenewable energy, security of energy supply and to the existing linkage between renewable energy and regional development. Most environmental issues have their origin in exploiting fossil fuels. The emissions of pollutants have direct effects such as: climate change with greenhouse gases, acid rain and air degradation. The second reason mentioned above refers to the fact that sooner or later traditional energetic resources of Earth will come to an end. Until then, other resources should be exploited too, in order to satisfy the increasing demand of energy. In the same time, renewable energy reflects an alternative for substituting conventional energy on long run and also for maintaining security supply on medium and long run. Security of supply can be seen as a possibility of continuous meeting of basic needs throughout internal sufficient resources, exploited with certain efficiency and various, stabile and accessible external resources.

The last existing relation of renewable energy with regional development points out to social progress. The development of renewable energy could bring positive effects in regional development and on labor market, could lead to increased social wellbeing and fight against poverty, offering employment opportunities (Midilli, Dincer & Rosen, 2007). For instance, the production of certain technology or the process of plants installation could be done in less developed regions. In addition to this, renewable energy exploitation allows that electricity can get to places where the national red cannot.

As we stated before, agriculture can find in renewables a source of energy and of money. With the aim to obtain income, agricultural sector uses wind and solar power to generate electricity to it and to consumers. These two sources are independent relative to the agricultural activity, but there is one source of renewable energy that is strong related and depends on the activities in agriculture: biomass. All organic material that have at their genesis the process of photosynthesis, can give energy after suffering a transformation (thermo chemical, biochemical**,** direct extraction of energy). So, all plants and organic waste can be used to obtain energy in its forms of power, fuel or heat, as well as for chemical industry.

The useful elimination of waste, mitigates emissions due to animal waste, favors rural activity and contributes to slowing down the transition from village to city**.** The impact on environment is reduced thanks to the small quantity of carbon dioxide that results from combustion. All plants absorb carbon dioxide to release

oxygen in the photosynthesis, but the volume of CO_2 absorbed is greater than the one released through combustion. There are also some disadvantages, like the random distribution of waste, which makes it difficult to be collected, transported and transformed into energy.

Besides waste or biomass residues there are also plants grown just for energy: crops, grasses, trees, oil plants. Crops are grown for food but they are also grown for energy. Corn is the most used energy crop, a base in the fermentation process whose result is ethanol. Other sources of biofuels are soybeans and sunflowers. Trees like poplar, willow, cottonwood and sweetgum grow fast and are excellent energy crops (Union of Concerned Artists, 2003).

Returning to the other two types of energy produced in agriculture, solar and wind, these are also clean and unlimited resources contributing to agricultural development. Solar energy is used usually for crop and grain drying, for greenhouses, for heating livestock buildings or homes or generating electricity by photovoltaic panels. Wind also offers opportunities for agriculture and farmers. Using wind generators of different capacities, farmers could obtain the energy they need in their activity. Allowing wind turbines to be installed on their land could bring them attractive income. The same thing could happen if they become themselves wind electricity providers.

The agriculture-based renewable energy growth strongly depends on governmental programs and incentives, as renewable energy is more expensive to produce and use than conventional one, based on fossil fuels. The agriculture gained an energetic feature and thanks to the great potential, this economic field has the capacity to sustain an important share of energy production.

So, it was necessary to include in the model, a variable describing and highlighting energy influence on agriculture. Similar approaches were made by other authors to establish the relationship between the two fields (Karkacier, Goktolga & Cicek, 2005; Hatirli, Ozkan & Fert, 2005; Bekhet & Abdullah, 2010).

The present work is an improvement of a previous research in the field, results of which were presented at National Conference Management and Sustainable Development Strategies), September 28-29, 2012, Baia Mare, Romania.

3. Model specification and estimation

Considering all aspects presented above, we tried to build a model, in which to include several rural development indicators, in order to find evidence of influences on agriculture and its effect on economic growth. The model is based on panel data and consists of two regression equations that focus on the issues mentioned.

The rural development indicators used are: Net Production Value from Agriculture (constant 2004-2006) million international dollars (Faostat, 2012a), Final Energy Consumption in Agriculture millions tones oil equivalent (European Commission, 2011), Investments in Agriculture in million US dollars, calculated as the annual growth in Net Capital Stock in Agriculture (constant 2005 prices) USD million (Faostat, 2012b), Total active population in agriculture (Faostat, 2012c),

Gross Domestic Product, PPP constant 2005 international dollars (The World Bank, 2010).

The analysis covers the period from 1990 till 2007 and includes 17 countries from European Union, for which data available was found. Using the indicator called Agriculture Value Added expressed in constant 2000 US dollars (The World Bank, 2012), we managed to divide the countries in two groups. The first group includes the members states of EU with a level of value added from agriculture, inferior to 5000 million US dollars: Greece (GRC), Bulgaria (BGR), Ireland (IRL), Hungary (HUN), Denmark (DNK), Austria (AUT), Portugal (PRT) and Finland (FIN); the second one gathers 9 countries which exceed 5000 million US dollars: Sweden (SWE), Romania (ROM), Poland (POL), Netherlands (NLD), United Kingdom (GBR), Germany (DEU), Spain (ESP), Italy (ITA) and France (FRA).

To deal with both cross-sectional and time series data (Plasmans, 2006), the Pool Object from EViews 7 was used. The panel data model is specified as two regression equations. The first of one is a function of energy consumption in agriculture, the labor force working in the sector and the investments made each year in the field. All these three are expected to influence the agricultural production. The second one indicates the specific effects of agriculture and energy used in the field on GDP. All results were obtained by applying Least Squares method of estimation. The regression equations are expressed as:

$$NPV_{it} = a_i + b_i \times ENERGY_{it} + c_i \times INV_{it} + d_i \times POP_{it} + \varepsilon_{it} \quad (1)$$

$$GDP_{it} = e_i + f_i \times NPV_{it} + g_i \times ENERGY_{it} + \varepsilon_{it} \quad (2)$$

where NPV_{it} is the Net Production Value in Agriculture, *Energy* is the Energy consumption in Agriculture, *Inv* represents the investments in agriculture sector, *Pop* is Total active population in Agriculture, *GDP* is the Gross Domestic Product, *a* and e represent the intercepts (which differ for each cross-sectional unit), *b, c, d, f* and *g* are the coefficients to be estimated of the independent variables, *i* is the number of cross-sections, *t* is the period of time, ε_{it} is the error term.

So, the net agricultural production is at first a dependent variable, then an independent one. In the estimation method the cross-section fixed effects were corrected (by removing specific means from the variables, the regression is performed using the demeaned data) (Baltagi, 2005) and assuming the presence of cross-section heteroskedasticity, cross-section weights were included.

4. Main findings

The impact of energy consumption, investments and labor force in agriculture on net agricultural production was investigated by estimating equation (1) separately for the two groups of countries. Then the impact of energy consumption and net agricultural production on economic growth was found by estimating equation (2).

The statistical power of the relation established among the dependent variable and independent ones is suggested by the correlation coefficient R^2. According to values computed for each group of countries, the regressions could fit

almost perfectly, as the R^2 is greater than 98% for all of them. In the same time, the values of R^2 are greater than the values of Durbin Watson's test, fact that removes doubts about spurious regressions (Gujarati & Porter, 2010). For the Durbin Watson test (which is supposed to measure the serial correlation of residuals) is difficult to give a reasonable interpretation, as our model is based on time series and cross-sectional data, so it implies residuals from each cross-section (Melo, Gur & Plamen, 1999). In general, its values lie between 0 and 4. If the returned value is lower than 2, there is evidence of positive serial correlation (Wooldridge, 2002). There is also an interpretation that for panel data the DW test is supposed to have values between 1.9 and 2.2, in order to remove the doubt of specification errors (Akintoye, n.d.).

F-statistic for the regression equations is significant and the probability that comes with the test, facilitates the rejection of null hypothesis of the test, that of all the slope coefficients, excluding the intercept in the regression are zero (Stock & Watson, 2003).

The t-statistic is computed to test the hypothesis of a coefficient being equal to zero. For rejecting or accepting this hypothesis, the probability associated to the test should be observed (Quantitative Micro Software, 2009). This probability is also called a marginal significance level and for a value greater than a significance level (for instance 10%), one should accept the null hypothesis. If the given value of the probability is lower than 10%, then the hypothesis that the true coefficient is zero, is rejected.

For the first Group of countries all coefficients associated to variables are correctly estimated. For the second Group of countries, all coefficients could pass the hypothesis of equality to zero. The chosen independent variables explain more than 99% from the variation in agricultural production for both groups of countries.

The regression equations associated to the first and second group of countries (with all coefficients correctly estimated) are presented below:

- *Multiple linear regressions for the first group of countries*:

$$NPV\_AUT = -7027.356 + 1977.774 - 288.636 \times ENERGY\_AUT - 0.259 \times INV\_AUT + 3.371 \times POP\_AUT \quad (3)$$

$$NPV\_BGR = -4572.593 + 1977.774 + 1189.179 \times ENERGY\_BGR + 0.241 \times INV\_BGR + 2.0909 \times POP\_BGR \quad (4)$$

$$NPV\_DNK = 332.441 + 1977.774 - 3153.947 \times ENERGY\_DNK + 0.171 \times INV\_DNK + 8.125 \times POP\_DNK \quad (5)$$

$$NPV\_FIN = -436.322 + 1977.774 + 952.546 \times ENERGY\_FIN + 0.066 \times INV\_FIN - 0.407 \times POP\_FIN \quad (6)$$

$$NPV\_GRC = -3487.308 + 1977.774 - 3764.082 \times ENERGY\_GRC - 0.1202 \times INV\_GRC + 3.153 \times POP\_GRC \quad (7)$$

$$NPV\_HUN = 10159.427 + 1977.774 + 3659.728 \times ENERGY\_HUN + 0.168 \times INV\_HUN - 2.569 \times POP\_HUN \quad (8)$$

$$NPV\_IRL = 2639.507 + 1977.774 + 680.403 \times ENERGY\_IRL - 0.111 \times INV\_IRL - 0.271 \times POP\_IRL \quad (9)$$

$$NPV\_PRT = 2392.205 + 1977.774 + 686.484 \times ENERGY\_PRT - 0.15 \times INV\_PRT - 0.161 \times POP\_PRT \quad (10)$$

- *Multiple linear regressions for the second group of countries*:
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$$NPV\_DEU = -63770.633 + 21182.441 + 7542.695 \times ENERGY\_DEU + 0.315 \times INV\_DEU + 0.002 \times POP\_DEU \quad (11)$$

$$NPV\_ITA = 49268.306 + 21182.441 - 1918.693 \times ENERGY\_ITA - 0.12001 \times INV\_ITA - 0.0018 \times POP\_ITA \quad (12)$$

$$NPV\_NLD = -14572.565 + 21182.441 + 728.18 \times ENERGY\_NLD + 0.571 \times INV\_NLD + 0.00064 \times POP\_NLD \quad (13)$$

$$NPV\_ROM = -12643.117 + 21182.441 + 225.956 \times ENERGY\_ROM + 0.179 \times INV\_ROM - 0.0000668 \times POP\_ROM \quad (14)$$

$$NPV\_SWE = -13605.7 + 21182.441 + 725.083 \times ENERGY\_SWE - 0.099 \times INV\_SWE - 0.0037 \times POP\_SWE \quad (15)$$

$$NPV\_ESP = -23283.231 + 21182.441 + 3821.158 \times ENERGY\_ESP + 1.614 \times INV\_ESP + 0.002 \times POP\_ESP \quad (16)$$

$$NPV\_FRA = 1045.316 + 21182.441 + 4128.973 \times ENERGY\_FRA - 0.754 \times INV\_FRA + 0.00026 \times POP\_FRA \quad (17)$$

$$NPV\_GBR = 77919.071 + 21182.441 + 2340.076 \times ENERGY\_GBR + 0.725 \times INV\_GBR - 0.0066 \times POP\_GBR \quad (18)$$

$$NPV\_POL = -357.445 + 21182.441 - 1220.954 \times ENERGY\_POL - 0.15 \times INV\_POL + 0.0000306 \times POP\_POL \quad (19)$$

Next are presented the results of estimating coefficients for the regression equations that analyze economic growth in relation to energy consumption in agriculture and net agricultural production value. These two independent variables are responsible for more than 95% of GDP variation for both groups of countries.

- *Multiple linear regressions for the first group of countries*:

$$GDP\_AUT = -326783.475 - 82869.604 + 105.557 \times NPV\_AUT + 388078.071 \times ENERGY\_AUT \quad (20)$$

$$GDP\_BGR = 174691.55 - 82869.604 - 18.448 \times NPV\_BGR + 69704.97 \times ENERGY\_BGR \quad (21)$$

$$GDP\_DNK = 141114.367 - 82869.604 + 46.559 \times NPV\_DNK - 171157.982 \times ENERGY\_DNK \quad (22)$$

$$GDP\_FIN = 102612.317 - 82869.604 + 144.748 \times NPV\_FIN - 205821.159 \times ENERGY\_FIN \quad (23)$$

$$GDP\_GRC = -164482.1002 - 82869.604 - 5.563 \times NPV\_GRC + 469635.101 \times ENERGY\_GRC \quad (24)$$

$$GDP\_HUN = 215600.868 - 82869.604 + 19.522 \times NPV\_HUN - 152692.65 \times ENERGY\_HUN \quad (25)$$

$$GDP\_IRL = -244795.737 - 82869.604 + 59.95 \times NPV\_IRL + 599321.535 \times ENERGY\_IRL \quad (26)$$

$$GDP\_PRT = 102042.209 - 82869.604 + 46.172 \times NPV\_PRT - 19362.35 \times ENERGY\_PRT \quad (27)$$

- *Multiple linear regressions for the second group of countries*:

$$GDP\_DEU = 2090616.136 + 1178565.968 + 42.679 \times NPD\_DEU - 792722.096 \times ENERGY\_DEU \quad (28)$$

$$GDP\_ESP = -1256492.854 + 1178565.968 + 18.213 \times NPV\_ESP + 234453.818` \times ENERGY\_ESP \quad (29)$$

$$GDP\_FRA = 970240.299 + 1178565.968 - 19.087 \times NPV\_FRA + 77299.583` \times ENERGY\_FRA \quad (30)$$

$$GDP\_GBR = 3645429.05 + 1178565.968 - 135.66 \times NPV\_GBR - 786297.485` \times ENERGY\_GBR \quad (31)$$

$$GDP\_ITA = -2655073.074 + 1178565.968 + 29.588 \times NPV\_ITA + 650157.131 \times ENERGY\_ITA \quad (32)$$

$$GDP\_NLD = 27736.904 + 1178565.968 - 91.552 \times NPV\_NLD + 96922.85 \times ENERGY\_NLD \quad (33)$$

$$GDP\_POL = -1074410.023 + 1178565.968 + 15.467 \times NPV\_POL + 15804.489 \times ENERGY\_POL \quad (34)$$

$$GDP\_ROM = -1021489.414 + 1178565.968 + 3.386 \times NPV\_ROM - 15805.359 \times ENERGY\_ROM \quad (35)$$

$$GDP\_SWE = -726557.022 + 1178565.968 + 47.988 \times NPV\_SWE - 407944.112 \times ENERGY\_SWE \quad (36)$$

5. Discussion

As a whole, the model's regressions have an acceptable R^2, with very significant F-statistic values. Analyzing the t-statistic test and standard errors, we observed that all coefficients are correctly estimated passing the hypothesis of equality to zero. In some cases, the estimated values of some coefficients are negative and the theory suggests they should be positive. For instance, t-statistic and its associated probability could not help to reject the possibility of having negative coefficients for the variable representing labor force in Great Britain, Sweden, Romania and Italy. This factor was expected to exert a positive influence on agricultural production for reasons mentioned before in this work. As a matter of fact, all independent variables used in this analysis should have had a positive impact on the chosen dependent variables. There are certain situations for which, their influence is negative. To exemplify, we select the results for energy consumption in agriculture in relation to net agricultural production. Negative relation appears in the case of Denmark, Greece, Italy, Austria and Poland. These shows that if the energy consumption in agriculture raises with one million tons of oil equivalent, then the net agricultural production value drops down with almost 1220 million international dollars for Poland, with almost 289 million for Austria, with 1918.693 million for Italy and with more than 3000 million for Denmark and Greece. It is a great influence and it states that agricultural production responds much to small changes in energy consumption, for these countries. The negative relation could be influenced by changes in agricultural energy flows in the considered period. In the same time, for the other countries, evidence of strong, positive relation between the two variables considered, appears.

Going further with the results analysis, Investments and Total active population in agriculture were found as minor agriculture inputs. By this, we want to suggest the low influence on agriculture's net production.

For Investments in agriculture, this happens as, mainly, for almost all countries agriculture suffers a process of disinvestment. For Total active population the weak relationships and sometimes negative, (case of Great Britain, Sweden, Romania and others) appear as a consequence of lack of skilled labor force. The

best relationship revealed is for Denmark, where if the number of those working in the sector increases with 1 million, than the net agricultural production also increases but with 8.125 million international dollars. For investments in agriculture, almost all relations formed with agriculture's output are sub unitary, except one, for Spain. Therefore, in Spain, if agriculture receives an amount of investments higher with 1 million dollars, this reflects an increase of 1.614 million dollars in agriculture's production.

Furthermore, the econometric estimation results revealed that economic growth is influenced in a considerable manner by energy consumption in agriculture and in a reduced form by agriculture's production value. So, it counts more the activities undertaken and resources used in agriculture than the overall result. This strongly point out to the field of energy, which is indeed a stimulus for economic growth. For the first group of countries, the ones with a smaller agriculture value added, energy consumption has a positive influence on GDP per capita only in Austria, Bulgaria, Greece and Ireland. For the second group, studying the evolution of this indicator, a decrease in the agricultural energetic consumption was found, so this may have influenced the appearance of negative relationship.

Finally, the influence of net agricultural production on economic growth was obtained. For Netherlands, Bulgaria, Greece, France and Great Britain, a higher output in agriculture causes a decrease in GDP per capita. If observing the agricultural production in the investigated period, we remark a great fall at the beginning of the period, followed by a fluctuating course. The greatest influence received from agriculture by GDP per capita is the one revealed for Finland, where an increase of 1 in NPV raises the GDP with 144.748.

6. Conclusions

This work aimed to highlight the role of agriculture to rural development and economic growth in the context of globalization. The new global economy also deals with the concept of sustainable development, so besides agriculture, the theme of sustainable resources used in agriculture was addressed**,** with focus on renewable energy. Thus, after undertaken the theoretical work, an applied investigation was made, using a model based on panel data. Countries from European Union were included in this analysis and important findings revealed specific characteristics for each one. For these countries, rural development indicators were examined over the period 1990-2007 with the purpose of evidencing the theoretical aspects presented or the inconsistencies with theory. These indicators were combined in order to form two important parts of our model: one describing agriculture's determinants and one shaping the influence energy and agriculture exert on economic growth. The regression equations in the model were estimated using Ordinary Least Squares method and specific features for panel data. In the first equation, the variation of net production from agriculture, representing the dependent variable is influenced by three independent variables: energy consumption in agriculture, total active population in agriculture and investments in the same field. In the second equation, the dependent variable is GDP per capita; its variation is explained for about 95% by energy consumption in

agriculture and net production value in agriculture. Even though exceptions appear, the relation established between energy consumption in agriculture and these two dependent variables are positive and with great impact. Changes in energetic consumption are reflected as important changes in agriculture's production and economic growth.

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