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Sustainability in the Agricultural sector of some EU countries

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Abstract
The present study will examine the possible ways of integrating sustainability indicators in assessing the performance of agriculture. We are examining the appropriate ways of calculating the output of the sector including the damages caused by and the benefits of agricultural production. The involvment of environmental pressure into the assessment of agricultural performance does not show significant changes in values.
Keywords: performance of agriculture, environmental pressure, sustainability

Introduction

Evaluating the results of agriculture is still of considerable importance, although the sector's contribution to GDP in developed regions is only 1-3%. However, feeding the population is of strategic importance. In consumption, food is of very high importance (15-20%), furthermore, the sector is a targeted area by large amounts of state and community (EU) grants and agricultural products represent a major proportion in foreign trade in many developed countries. We believe that two phenomena play a further role in shaping the central importance of agriculture:

a) while technical development tailors and dematerializes products and services to a large extent, it is less likely in food products, consequently further contraction in the sector is not anticipated;

b) a broader interpretation of the sector (multifunctional agriculture) opens two new dimensions: the environment and thus health and economic burden on the negative side (sustainability), whereas the appearance of new activities on the positive side (e.g. rural development, etc.). The former one means that we recognise and understand that agricultural activities have serious external effects, and on the other hand we recognise that agriculture holds previously neglected opportunities like alleviating employment, health or social problems.

In modern agriculture and among the objectives of the CAP, multifunctionality, rural development, the protection of the environment and sustainability are in the focus of attention, therefore, our earlier researches are extended by the examination of some factors influencing the state of the environment.

The main focus of this paper is on a new methodology with which we endeavoured to evaluate the relationship between the factors determining agricultural production and the output of the sector, and to assess performance when environmental indicators were included, and finally attempts are made to interpret these results.

In our recent researches we were investigating the potential methods for modelling the performance of agricultural sectors. First, a metric system was created followed by a test of its applicability in a comparative analysis of the agricultural performance of Denmark and Hungary. Second, an agricultural production function was applied to determine the potential and real output of the sector.

In this paper our research has been extended, a few indicators that represent the external impacts of agricultural production, i.e. indicators that express environmental pressure were taken into consideration. Environmental pressure and pollution as a consequence of agricultural activity has become an economic issue and significantly affects the sector's performance. The involvement of the new indicators - especially of the ones that express environmental pressure - is vital, because, as Stiglitz puts it, the attempt to revitalize the world economy, together with answers to be given to global climate crises, raises the question whether the traditional statistical metrics could give a proper indication of further action. In other words, the per capita GDP figure as a development indicator is questionable, since social and environmental concerns do not appear in it. The maintenance of competitiveness together with EU expectations requires the observation of the principle of sustainability. In the European Union the main goal of the CAP reform is to provide an ever increasing proportion of the subsidies to rural development and most importantly to environmental protection.

Material and Methods

In our research an attempt was made to develop a method with which the comparison of the outputs and inputs are possible, where inputs include social and cultural factors as well. We did not intend to measure productivity. Our aim was to determine in which country is the difference further from the potential output levels.

By applying the metric system, the performance of Denmark and Hungary's agricultural sector was compared and Danish agriculture proved to be a bit more efficient, which means that taking the higher amount of resources (inputs), the better circumstances and the higher level of management into consideration, Denmark achieved higher outputs. The results can be explained by the difference in the level of invested capital, the high" input efforts (high capital stock, major investments, advanced technology or a dense infrastructure) and the institutions that are functioning much better.

By applying Cobb-Douglas agricultural production functions, we studied two groups of 12 EU countries and we found that during the period 1999-2009 the real output levels were almost equal to the potential output levels in the 6 Central-East European countries whereas the performance of the group of 6 Western European countries was below their potential output levels.

Literature review

First, the relevant literature was reviewed and then the current knowledge on how to measure the performance of the sector was summarized. The basis of early researches was largely the simplest Cobb-Douglas production function where the dependent variable is the gross output or value added, while the independent variables are land, labour and capital. Later, more complex functions were developed, (fertilizer use, irrigation and other purchased services were taken into account), then a few decades ago, the impact of institutional economics appeared, and this is a particularly important aspect of our research.

Applying functions in agricultural production analysis started in 1944, firstly by Tintner and Brownlee, then by Heady. Estimates on agricultural productivity (TFP) were first published in the United States by Barton and Cooper (1948), and Cooper, Barton, and Brodell

(1947). To compare performance, value-added or productivity was studied. Productivity is defined as the difference between growth rates of input or as the ratio of output and input. Bhattacharjee studied the performance of agriculture in selected countries. He compared the 1955 performance of 22 countries, where the inputs considered were only land, labour, and fertilizers (Bhattacharjee, 1955).

Bombach and Paige (1959) were the first to apply more determinant factors, and many followed their example, inter alia, Hayami, and Ruttan (1970), Evens and Kislev (1975), Mundlak and Hellinghausen (1982), Antle (1983), Rao (1986, 1992) , Chavas (2001), who took other factors (such as buildings, machinery, live animals, crops and infrastructure) into account. Non-agricultural inputs (energy, pesticides) and the use of non-agricultural services (maintenance of machinery, rental of real estate, administrative, veterinary, insurance services), also formed part of the model in Maddison (1970), in Maddison and Ooststroom (1993) or in Maddison and Rao (1996).

The recognition of the influential role and measurability of human capital was first present in the works of Hayami and Ruttan (1970), and later became an integral part of the analysis.in Nguyen (1979), Yamada and Ruttan (1980) and Ruttan (2002). Some of the most important authors in the U.S. methodology are Kendrich and Grossman (1980), Jorgenson, Gollop and Fraumeni (1987), Ball, Bureau, Nehring and Sumwaru (1997), and Ball, Bureau, Butault and Nehring (2001). In the USDA analysis the inputs are land, labor, capital, fertilizers, pesticides, seeds, live animals, feed and energy.

In the methodology, applied (agricultural) technology appeard in the early and mid-90s, further detailes are in Crego, Larson, Butzer and Mundlak (1998). According to Mundlak the technology applied is determined by state variables like the scarcity of resources, price ratios, physical environment, or available technologies (Mundlak, 2000).

The results of institutional economics, described in detail in Glaeser, La Porta, Lopez-de-Silanez, Schleifer (2004), were embedded in the examination of the performance of agriculture a few decades ago. Over the past 50 years applied analysis together with statistical and mathematical methods became highly sophisticated. Now the Malmquist index is commonly used, for further reference see Coelli and Rao (2003), Bureau, Färe and Grosskopf (1995), Suhariyanto and Thirtle (2001), and RungsuriyawiboonLissitsa (2006a, 2006b).

One of the most comprehensive Hungarian studies of the discipline was done by Szűcs and Farkas, (Szűcs - Farkas, 2008). Many other researchers dealt with the measurement of domestic agricultural efficiency, including Nemessályi (1988), Baráth (2006), Lámfalusi (2005), with the competitiveness of Hungarian agriculture (Kiss, Judit, Udovecz Gábor, Csáki Csaba, Somai Miklós, Jávor András). TFP measurement using the Malmquist index was thoroughly dealt with by Farkas, Szűcs and Varga (2009).

Results and Discussion

A. Following a careful study of the scientific literature on measuring the efficiency, and based on Mundlak's study we designed a model with which we endeavoured to measure efficiency. Considering the results of Rao and Acemoglu, much attention was paid to the role of the growth-enhancing institutions, since we are convinced that the institutions have a major impact on production, on the incentive system and consequently on profitability and growth.
The efficiency of the two countries was compared with the help of a seven category metric system in which a time series of 20 years was taken into account.

Factors used for measuring the efficiency of Danish and Hungarian agriculture

The **output** was calculated by the sectoral output expressed as gross output at constant prices (Eurostat data).

1. Four **input** groups were applied:

***a*) land -** arable land and utilized agricultural area, croplands and pasture in hectares (FAO and Eurostat)

***b)* capital -** on agricultural capital sufficient amount of reliable data and time series are not available therefore, estimates are given based on several sources (machinery, equipment (tractors at basic price, FAO; harvesting machinery, milking machines FAOSTAT, animal stock Eurostat)

***c)* labour force -** only active workers employed in agriculture, the number of hours worked (AWU) (Eurostat)

***d)* quantity of chemicals used** - fertilizers and 5 pesticides (organic phosphates, herbicides, insects, fungicides and bactericides), the volume of mineral oils, FAO).

2. Technological indicators that represent the level of technological development in a given country :

a) **R & D expenditure** - total expenditure on R&D as percentage of GDP (OECD, Eurostat and Danmarks Grundforskningsfond data).
b) **agricultural yields –** wheat yields, milk pre cow production, number of piglets per sow, eggs per laying hens (FAO**,** CSO, Dansk Landbrugsr adgivning Landscentret data)
c) animal density – number of animals per area, head/km^2 , FAO and Eurostat

3. Cultural factors: According to Weber, Fukuyama, and Mundlak, efficiency is determined by the quality of human capital and the behavioural patterns.
a) **religion** - the proportion of Protestants. Since we accepted Weber's view on protestant ethics, in our calculation we applied the **proportion of protestants** among all the religious population (CIA World Factbook), furthermore, based on the data of the World Value Survey we included data on **being religious**, i.e. the number of people going to church once a week, or the number of people who are atheists, agnostic, non-believers, based on the 2005 Zuckerman reports 2005.
b) **education -** only graduates from tertiary education (Agriculture, forestry and fishery) as the percentage of all graduates and the number of years spent in higher education (Eurostat)

4. Infrastructure: Mundlak examined the effects of quantifiable assets that have positive impact on productivity such as transport and communication infrastructure, health care, research and development or consultancy systems. In our study three branches of infrastructure were examined:
a) **transport infrastructure** - OECD and Eurostat figures, motorway density and density of railway lines
b) **communication network -** the proportion of households with home Internet access and phone subscriptions per 100 inhabitants, the duration of calls, Internet accessibility of households and companies (Eurostat and OECD)
c) **health infrastructure -** health expenditure as% of GDP measured in purchasing power parity per capita, life expectancy at birth, (WHO, OECD and Eurostat)

5. Institutions: According to Acemoglu, Johnson and Robinson (2001) in countries where the institutions are better, IP protection is stronger and policy distorts competition in a lesser extent. The value of physical and human capital is higher and their use is more effective. That is, the physical, legal and regulatory framework has a positive impact on economic development. The influence of institutions was measured by the Freedom House political rights and civil liberty scores in Mundlak et al. The model was expanded and the following factors were involved:

a) **civil liberties and political rights** (Freedom House – scores of freedom of assembly and association law, functioning of the legal system and the government)

b) **the confidence in institutions** (parliament, judiciary, church, armed forces, police, social security, health care, civil services) European Values Survey and World Values Survey

c) **mutual trust** (Halman, The European Values Study).

6. The physical environment can not be ignored, as agricultural production is highly dependent on the natural environment, so we took the following actors into account:

a) **number of sunshine hours**

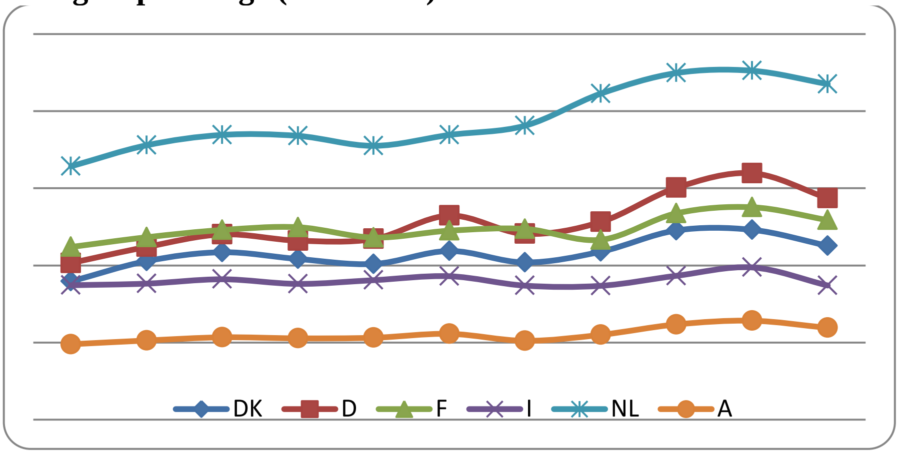
b) **water resources** – measured by the annual amount of precipitation (Statistical Yearbook 2009, KSH, Encyclopedia Britannica), and the amount of available freshwater (Eurostat).

Time series for the period between 1990 and 2007 were compiled for each of these factors, and then the averages for the period were compared (Danish data divided by Hungarian data). The weighted average of the ratios of the six main groups was compared to the gross output figures.

B. In the second step, the potential and real output paths were estimated by Cobb-Douglas type agricultural production functions with two independent variables (land and labour). Land is measured by the amount of Utilized Agricultural Areas (UAA) in hectares and labour was measured with Annual Work Units (AWU).

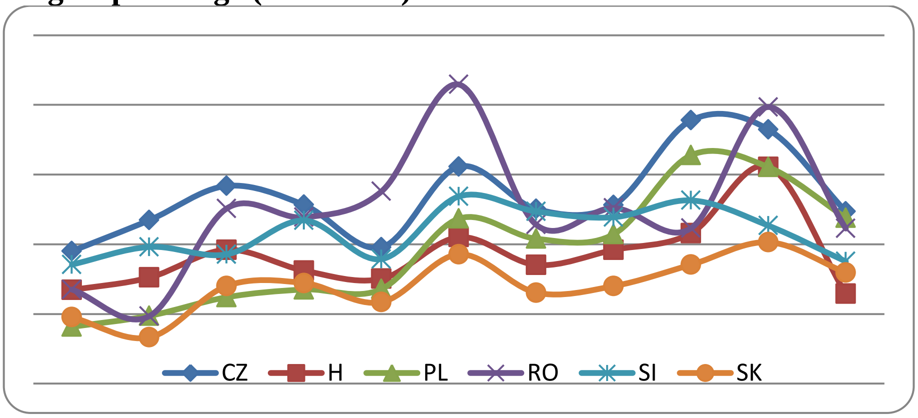
The values of constants were estimated by fitting the real terms logarithms of independent variables by two variables linear regression. The potential paths were estimated for 6 western and 6 eastern countries. With real labour input and utilized agricultural area figures we estimated the potential agricultural output (Y') of each Western European country by applying the constructed Western European production function. The potential output was compared to the real output (Y). The same was applied to Eastern European countries then the ratio of Y/Y' was calculated. Finally, the average difference from the potential output of the period was calculated then subcontinental averages were calculated and the performance of each countries were compared to them. Figures nr. 1 and 2 illustrate the results for the 12 countries.

Figure nr. 1
The performance of 6 Western European countries as a percentage of the group average (1999-2009)



Source: own compilation based on Eurostat figures

Figure nr. 2
The performance of 6 East European countries as a percentage of the group average (1999-2009)



Source: own compilation based on Eurostat figures

As for the Western European countries, the Netherlands exceeded the group average by almost 80%, Denmark was 9% less, and when the difference from the potential output was evaluated, the results for the Netherlands were almost twice as much. Denmark exceeded its own potential output level by only 8%.

In East European countries, the Czech Republic was 12% higher than the group average while Hungary was 5% less. Regarding the difference from the potential output, the Czech Republic was 14% higher while Hungary was 3% less.

C. In modern agriculture, and in particular in the developed countries, the attention is focused on the external impacts of production. The reason is that environmental pressure, the consequence of agricultural production, has appeared, become intense and well-measurable. Moreover, social tensions (rising unemployment, deepening of income disparities) have deepened as a consequence of a slowdown in economic growth rates and in particular in today's crisis. The changing structure of the economy is manifested in the growth rate of the expanding service sector in which rural areas have to find their place by the diversification of rural activities, such as by the development of tourism or by the maintenance of traditional rural activities and by maintaining the landscapes.

On the basis of the above mentioned, the earlier research (part A) was expanded, and the main focus was on the examination of environmental risks caused by agriculture. Furthermore, our aim was to examine whether the widely accepted view of Denmark's exceptionally high performance is true or only true in comparison to other countries having no similar features. An important modification is that only one year (2006) was studied instead of a time series of 20 years. Based on the methodology developed by the Americans (Ball, Lovell, Luu and Nehring, 2004), a number of selected indicators were applied which we believe that characterize the environmental damage caused by the agricultural sector.

a) Nitrogene balance

An indicator of nitrogene pressure from agricultural sources is the difference between the gross nitrogene/nutrient balance, that is the nitrogene input entering the soil by inorganic fertilizers, livestock manure, feedstuff, biological nitrogene fixation per hectare of utilized agricultural area, and the nitrogene use, that is the amount of nitrogene leaving the soil by harvested crops, harvested forage crops and weeds (EAA 2007). Due to intensive livestock production and higher productivity, a marked increase in inorganic nitrogen and phosphate fertilizer use can be seen. The bigger amount of manure and the higher number of animals kept causes additional nitrogen pressure. In the European Union the pressure caused by total diffuse nitrogen was approximately 16.5 tons in 2003, 17.4 million tonnes in 1995 and almost 18 million tonnes in 1999.

In Europe the nitrogen input significantly exceeds the amount of nitrogene use. The difference between the input and output sides of the nitrogen circle is the so-called nitrogen surplus which damages the environment.

b) Water contamination

An important environmental impact factor is the deterioration of water quality resulting from agricultural activities. This is due to the leaching of nitrogene from inorganic and organic fertilizers used in the replenishment of soil into groundwater and surface water, to the salinisation process, as well as due to livestock manure (slurry poses the greatest risk), and to the leaching of heavy metals from sewage sludge into groundwaters (Czachesz – Fehér 2003).

The sources of water contamination are industrial activities, slurry and in particular agricultural activities. The direct damage from pollution (e.g. limited opportunities for the recovery of polluted waters) result from the lack of pre-cleaning process following the significant increase in water treatment costs).

Indirect losses linked to water pollution are the deterioration of the natural environment, the destruction of marine life, health hazards, recreation, sports facilities are of inferior quality due to the deterioration in water quality.

Water quality can be measured indirectly by the level of pollutant emissions (fertilizers, pesticides), or by the chemical analysis of water samples (EEA Report,). An Israeli researcher has developed a new method in which a laser beam illuminates the algae in water, and the researchers recorded the sound waves to reveal the type and extent of contamination.

c) Water abstraction

Agricultural water use greatly affects the environment. The main areas of agricultural water use are irrigation, fish farming and animal husbandry. Of these, irrigation and fish farming must be handled together, mainly because they represent the abstraction of surface waters.

d) Air pollution

Agriculture is the third largest pollutant afterIndustry and transport. To measure air pollution the amount of greenhouse gas emissions was used.

e) Waste generated in agriculture

This includes manure from livestock farms, liquid manure, dead animals, vegetable waste, and waste generated in fishing and hunting. Waste indirectly cause air, water or soil contamination, stink or unpleasant visual aesthetic effects**.**

The model applied in the previous study (A) was slightly modified and a 7th factor was involved to elaborate a new metric system (here only the modifications are mentioned in brackets).

1. Agricultural inputs:

a*) land, *b) capital **(**only machines, equipment, tractors, harvesters, milking machines and animal stock, ***c)* labour** (only active workwer involved in agriculture, the number of hours workedAWU), ***d)* quantity of chemicals used**

2. Technological indicators:

***a)* expenses on Research and Development, *b)* yields**

3. Cultural factors:

a) **education** (only graduates from tertiary educaton as the percentage of all graduates)

4. Infrastructure:

***a)* transport infrastructure, *b)* communication network** (the proportion of households with internet access and phone subscriptions per 100 inhabitants) ***c)* health infrastructure**

5. Institutions:

Only confidence in institutions

6. The physical environment:

a)* number of sunshine hours**, ***b) water resources **(precipitation** only), ***c)* temperature**

7. Environmental pressure:

***a)* nitrogene balance** (OECD Factbook) kg nutrient/ha)

***b)* water contamination** – fertiliser use /ha and amount of organic phosphates (Eurostat és FAO)

***c)* water abstraction:** felszíni és felszín alatti édesvizek a rendelkezésre álló vízkészletek százalékában (Eurostat)

***d)* air pollution**: greenhouse gas emission as a result of agricultural activities (per capita emission in CO_2 equivalent Eurostat)

e) tonnes of **waste** generated by agricultural activities (farming, fishing and hunting, Eurostat)
f) **animal density**: number of live animals (head/km^2) (FAO and Eurostat), which pollutes the environment by excessive amount of livestock manure that contaminates waters and the soil, by stinking substances, dust, germs, ammonia (greenhouse gas) emission, and energy use

The results of our study are summarised in Table nr. 1. Religion was not considered since it distorted the results. The weights applied were: 0,1 0,1 0,3 0,05 0,4 0,05. Weights applied when environmental pressure was included were: 0,1 0, 1 0,3 0,05 0,35 0,05 0,05. The determinant factors are culture, infrastructure, technology, institutions, inputs, physical environment, and environmental pressure.

Table nr. 1. Efficiency ratios in Denmark and Hungary (2006)

Efficiency calculations	DK/HU
Efficiency ratios	1,07
Efficiency ratios with environmental pressure	1,04

Source: own compilation

When the performance of **Denmark and Hungary** is compared, Denmark shows a 7% higher result. However, when environmental pressure is taken into consideration Denmark's higher performance seems to be less considerable.

Conclusion

The involvment of environmental pressure into the calculation does not result in significant changes in values. On this basis we are convinced that agricultural efficiency in Denmark and Hungary is less considerable in a regional comparison. Although exploitation of natural resources and pollution is a global issue that must be tackled, the need to integrate them into national accounts has not been proven in this context.

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