Regional and Business Studies (2010) Vol 2 No 2, 31-40
Kaposvár University, Faculty of Economic Science, Kaposvár

STATISTICAL AND 'GREEN' EVALUATION OF AGRICULTURAL EFFICIENCY IN DENMARK AND HUNGARY

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ABSTRACT

The present study will examine the possible ways of measuring the performance of agriculture by simple methodology, then by using statistical analysis and the ways of integrating sustainability indicators in measuring the performance of agriculture will be attempted. I am examining the appropriate ways of calculating the output of the sector including the damage caused by and the benefits of agricultural production. I present the almost 40 year old history of how to integrate the environmental components in the calculation of the GDP, then attempts will be made to investigate some environmental indicators that could be applied in the comparison of the efficiency of the Danish and Hungarian agricultural sector.
Keywords: green national accounts, sustainability indicators, efficiency, agriculture

INTRODUCTION

This interim study deals with sustainable agriculture in Denmark and Hungary and with the efficiency of the agricultural sector. Three steps of a recent research process are discussed in this present paper, in which some of the results were developed together with co-authors. The first step was to compare the potential ways of comparing the performance of agriculture, in the second step the methodology applied was justified and in the third step, the need of involving environmental indicators was discussed.

The involvement of the new indicators - especially 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 on 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, require to meet the principle of sustainability.

Environmental pressure and pollution as a consequence of agricultural activity has become an economic issue and significantly affects the sector's performance.

MATERIALS AND METHODS

Modelling the performance of the agricultural sector

In our recent researches we were investigating the potential methods for modeling the performance of the agricultural sector of Denmark and Hungary. Our first goal was to create a model without applying complex mathematical production functions.

Contrary to our expectations, and to our greatest surprise, we found that Hungary proved to be slightly more efficient. Because of the results we received we are convinced that the application of a new methodology is necessary since our findings are different from what was expected. While trying to find the possible explanations for the findings, we came to the conclusion that the hardly justifiable results can be due to the inadequacy in the applied methodology. Our aim is to assess the applicability of our methodology, and either to justify or to reject our results by using statistical methods. The more sophisticated method that was used is a linear regression analysis.

Comparative analysis of efficiency

Following a careful study of the scientific literature on measuring 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 six category metric system in which a time series of 20 years was taken into account.

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 weighed average of the ratios of the six main groups was compared with the gross output figures. Five different weights were applied and it was concluded that the most realistic version is described if the weight of the institutional and cultural determinants are 50%.

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). The factors that have influence on performance are the following:

1. *Inputs to agriculture*: Four groups of inputs were applied:
   a. *land* - arable land and utilized agricultural area, croplands and pasture in hectares (Eurostat)
   b. *capital* - machinery, equipment (tractors, harvesting machinery, milking machine), 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, insecticides, 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 behavioral 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* 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.
   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 a 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 to 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 factors 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).
   c. *temperature* - running mean temperatures

A short summary of what we found in our recent studies is the following: Although agricultural output in Denmark is only one and a half times more than output in Hungary, Denmark applies 1.6 times more input which determines the output level. In an earlier paper we discussed the factors that can be attributed to the Hungarian advantage (for further details see *Beke and Forgács*, 2009a).

Statistical methods for justifying the results

As it was mentioned earlier, because of the hardly justifiable results of the study a more sophisticated statistical analysis was necessary.

The dependant variable (Y) is the output of the sector which is influenced by the independent variables (X_1….$X_{m)}$. Only 5 of the determinant factors were studied because for institutions no time series were available. Correlation calculations were used to assess the relationship between the determinant factors and the output by applying correction calculations. Calculations were possible for 3 factors (inputs, infrastructure and technology). For the other factors (institutions, culture) the relationship with the output is not proved, and for the physical environment sufficient amount of data could not be collected.

1. Input :
   a. land use (UAA 1000ha),
   b. machinery (tractors, harvesting and milking machines together).
2. Technology - R & D expenditure - total expenditure on R&D as percentage of GDP.
3. Cultural factors – education: school expectancy (years in education).
4. Infrastructure length of motorways (km).
5. Physical Environment – number of sunshine hours (own compilations).

The results of the calculations for the 5 determinant factors and the output of the sector are depicted in *Table 1*.

As it can be seen, the relationship with technology (R & D expenditure) is strong both in Hungary in Denmark. The relationship with school expectancy is strong in Denmark, while in Hungary a weak negative relationship can be seen.

In conclusion, the methodology needs further development in justifying the adequacy of the model, since not enough data were available.

Table 1

Results of correlation calculations

	DK	**HU**
1. Input		
a. Land	-3.291	0.450
b. Machinery	0.057	0.010
2. Technology	410.108	2907.095
3. Cultural factors	556.535	-83.751
4. Infrastructure	-1.035	4.2211
5. Physical environment	- 0.691	-0.762

Involvement of green indicators

In the third stage of the study environmental indicators were involved and an additional group of determinant factors war integrated into the model. I was searching how the requirement for sustainability could be integrated in the measurement of the performance of agriculture. That is, how the currently measured output of the sector could be corrected by the damage caused or the benefits to natural resources.

My research was put into a new context because of the findings of a recent article, in which Stiglitz explained that it is time to modify our views on economic growth and the wealth of a nation (*Stiglitz*, 2009). At present, the per capita GDP figures are considered the most accurate way of measuring economic welfare, even though we are faced with a number of new phenomena which have a significant impact on our perception of well being. However, these phenomena are not part of the traditional macro-statistical accounts and are not reflected in the GDP measures. Stiglitz refers to three important areas of consideration such as:

a) *climate change***,** which is the consequence of pollution (it distorts the GDP measures because the current methodology does not take the degradation of the environment, of natural resources and of nature's assets into account)
b) *negative social phenomena***,** like the increasing income inequalities. If GDP is expressed in per capita figures, then, according to Stiglitz, we might have false ideas about the general welfare of the citizens of a given country. In a country with an even distribution of income for example, the per capita national income, as the mean, can show a realistic picture of an individual's income, but with an uneven distribution, when the majority of the wealth is concentrated in the hands of a minority, a great number of people may live below the average income level.
c) the *growing share of the government sector*, e.g. in education, health, infrastructure, (the problem is the value of output. It distorts GDP figures because their output is measured simply by the input values)

In his article published more than three decades ago, Weitzman argued that the net domestic product is considered a good measure of wealth, while prosperity is the

discounted value of future consumption, so human and natural capital should be included in capital stock (*Weitzman*, 1976).

According to Bartelmus and van Tongeren an early indicator of the trends and limits of sustainable economic growth may be the replacement of GDP by EDP (Ecological Domestic Product) or the extension of the scope of key variables in the dynamic growth models (*Bartelmus and van Tongeren*, 1994).

The potential indicators that can be used in the assessment of the performance of the sector are classified into two broad groups:

a. Agriculture *increases the value of the environmental stock* (natural wealth): for example, it keeps the soil in good condition, preserves the genetic resources of plants and livestock, preserves biodiversity, and does not pollute the environment (air, water, soil) by generating waste while providing employment and a livelihood for the rural population. The present study does not deal with the benefits of agricultural activity; it only deals with the destructive impacts on the environment and to the quality of life.
b. Efforts should be made to minimize undesirable impacts on the environment, so in this group I suggest indicators that quantify the *negative impacts* of agricultural activities.

In modern agriculture, and in particular in the developed countries, the attention is focused on the external effects. This is because, on the one hand, the environmental pressure (soil, water, air pollution), the consequence of intensive production, can be measured and on the other hand, social tensions (rising unemployment, deepening of income disparities) deepened as a consequence of the slowdown in economic growth rates and in particular because of the crisis of these days. The changing structure of the economy is manifested in the growth rate of the service sector, and in this expanding tertiary sector rural areas have to find their place by the diversification of rural activities, such as by the development of tourism or maintaining traditional rural activities and maintaining the landscapes.

As Stiglitz puts it – the attempts to revitalise the world economy and to tackle climate change raise the question whether the traditional statistical indicators (development indicators) provide an appropriate signal for acting, since social and environmental factors are excluded (*Stiglitz*, 2009). Competitive economic activities and the expectations of the EU require an agricultural activity which complies with the principle of sustainability. The environmental impact of agricultural activities, the levels of pollution and the environmental taxes, compensations and subsidies (to internalize the externalities) became an economic issue, which affects economic performance and is quantifiable.

Ball et al. (2004) highlighted the important role of integrating environmental damage (especially water pollution) and the beneficial effects resulting from agricultural activities in performance evaluation, namely in the calculation of productivity indices.

Based on the results of the first part of this study, through the example of Denmark and Hungary, I would like to introduce some of the environmental indicators that could be integrated into the measurement of the performance of

agriculture. I examine what negative impacts agriculture has on the environment, and its effects on growth.

Environmental indicators

By taking into account the methodology developed by *Ball et al.* (2004) I will depict the application of a number of indicators that express negative environmental impacts, which I believe represent the environmental damage caused by the agricultural sector and may significantly affect the sector's output.

Nitrogen balance

The gross nitrogen balance indicator accounts for all inputs and outputs on the soil surface, and includes all residual emissions of nitrogen from agriculture into soil, water and air. Due to the intensive animal production and higher productivity the application of inorganic nitrogen and phosphate fertilizers increased significantly. Because of the growing number of animal stocks the amount of additional nitrogen from manure is increasing. In the European Union the total amount of diffuse nitrogen - that is, 8.9 million tons of nitrogen from inorganic nitrogen fertilizers and 7.6 million tonnes of nitrogen from manure – was approximately 16.5 tons in 2003, almost 18 million tonnes in 1999 and 17.4 million tonnes in 1995. The nitrogen from agricultural sources is a gross indicator of the nutrient/nitrogen balance. The potential surplus of nutrients is calculated by the balance between nitrogen and phosphorus added to the agricultural system and nitrogen and phosphorus removed from the system per hectare of agricultural land. Nitrogen balance is calculated as the difference between the nitrogen intake (the principle inputs include volumes of nutrients as inorganic fertiliser, livestock manure, nitrogen fixation by crops and atmospheric deposition per hectare) and nitrogen output (the principle outputs include volumes of nutrients taken out by harvested crops and grass/fodder (*EEA Report*, 2007). In Europe the volume of nitrogen input is significantly higher than the volume of the output.

Water contamination

An important factor in environmental pressure is the deterioration of water quality resulting from agricultural production. The reasons for water contamination are the excessive use of organic fertilizers, mainly nitrogen leaching to groundwater and surface waters, the salinisation process, sediments from erosion leaching into surface waters, as well as livestock manure and the leaching of heavy metals in sewage sludge then to groundwater (*Czachesz and Fehér*, 2004). The sources of water pollution (rivers, lakes, seas, and groundwater) are sewage, industrial activities, and in particular agricultural activities. The direct damage from such pollution is a limited option for recovery of contaminated water or a significant increase in costs related to water pollution. Indirect damage resulting from water quality deterioration is the degradation of the natural environment, health hazards destruction of marine life, losses of fisheries, a reduction in recreation and sports facilities and lower quality products. The quality of water can be measured either directly by chemical analysis of water samples or indirectly by the level of the

emission of pollutants (fertilizers, pesticides) (*EEA Report*, 2007). Israeli researchers have developed a new method in which a laser beam illuminates the algae in the water, then the researchers record the sound waves which reveal the type and extent of contamination.

Water abstraction
The amount of water used for agricultural purposes greatly affects the environment. The main areas of agricultural water use are irrigation, fish farming and animal husbandry. Irrigation and fish farming can be handled together, mainly because in Hungary they represent the greatest demand for the abstraction of surface waters. Agricultural irrigation and fisheries are the main sources of water abstraction.

Air pollution
Besides industry and transport, agriculture is the third largest pollutant. To measure air pollution the amount of greenhouse gas emissions was used.

Waste generated by agriculture
This includes the amount of manure from livestock, liquid manure, dead animals, vegetable waste, fishing and hunting. Waste can cause contamination indirectly e.g. air, water, soil contamination, can cause a stink or can evoke unpleasant aesthetic or visual effects.

RESULTS AND DISCUSSION

Slightly modifying the model, the distortive factors (religion) were disregarded and the calculations were based on figures for only one year. An additional factor is animal density and to demonstrate the importance of environmental protection a 10% weight was applied.

Efficiency is calculated by the ratio of the values for Denmark and Hungary (DK/HU) for the year 2006. When no data were available for both countries for 2006 then figures for 2004 were applied in the calculation.

The results can be seen in *Table 2*: in 2006 the sector was more efficient (1.03) in Denmark. In comparison with data excluding environmental pressure figures, efficiency was 1.07. The difference is not significant therefore, as a conclusion it can be stated that the involvement of the consequences of environmental pressure into the comparison of the efficiency of agriculture is not justified in this study. The results might not be surprising given that both countries, although Denmark is a high income country and Hungary is a middle income country, are members of OECD, and both of them are EU member states, which means similar regulatory framework.

The concept of an environmentally adjusted measure of the performance of agriculture is a current issue since agricultural activities contribute to environmental degradation and have diverse environmental impacts which threaten to undermine the sustainability of agriculture.

Table 2

Factors including environmental pressure in measuring the efficiency of the agricultural sector in Denmark and Hungary

Factors	DK/HU
Education	0.35
Infrastructure	2.05
Technology	2.16
Institutions	1.2
Inputs	0.73
Physical environment	0.89
Environmental pressure	1.57
Weighed average of factors	1.33
Output	1.37
Efficiency	1.03

This paper is concerned with the question of whether comparison of Danish and Hungarian agriculture can be compared with the use of the determinant factors applied, then statistical analysis was used to justify the appropriateness of the methodology, then integrating environmental indicators in the inputs to agriculture was attempted.

Based on the results of this study environmental components incorporated into the measurement of the performance of the agricultural sector do not alter the results that were received without applying the environmental indicators. Environment-related input-output analysis is vital if the general welfare of a nation is assessed and if environmental degradation is highlighted.

CONCLUSIONS

Today, GDP per capita measures continue to be the main indicator for economic welfare and progress. The current system of national accounts neglects environmental resources unless they can be expressed in monetary terms or are marketable. Many of the "services" of nature (such as the work of wind, water) is free of charge, consequently are not reflected in GDP measures. If the nation exploits its natural resources then it is included in the national income figures because they mean income and output. However, the degradation or destruction of natural resources is not counted in the national accounts.

There are currently no comprehensive environmental indicators which could be used *alongside* GDP. The ecological footprint can not be fully applied, therefore, the European Commission seeks to introduce the pilot version of the environmental load index in 2010. This indicator will reflect the environmental damage caused within the EU, and will include the major environmental policy issues, namely climate change, energy use, biodiversity, air pollution, health impacts, water use,

water contamination, waste generation and the use of natural resources and will provide information to policy-makers.

ACKNOWLEDGEMENTS

I am heartily thankful to my colleague, Anna Forgács, who supported me in any respect during the completion of the study.

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