An evaluation of technical efficiency and agricultural productivity growth in EU regions

Akande OP
August, 2012

An evaluation of technical efficiency and agricultural productivity growth in EU regions

Student: Olalekan Paul Akande (750329007090)
Supervisor: Dr. G. (Grigorios) Emvalomatis

Study load: 24 ECTS
Period: May – August 2012
Code Number: BEC-80424
Group: Business Economics Group (BEC)

Wageningen University, 2012

Abstract

The EU agricultural sector is in a continuous process of structural change which has significant implications for efficiency and productivity growth. To keep track of this changing process, related policies such as the Common Agricultural Policy (CAP) need to be evaluated based on productivity performances and efficiency of agricultural holdings. In this study, the Technical Efficiency (TE) and Total Factor Productivity (TFP) growth of agricultural holdings in the EU-15 region was measured using Data Envelopment Analysis (DEA) and agricultural data for a period of 11 years. An average technical efficiency of 87% was observed for the EU-15 region as a whole. By breaking the EU-15 into four regional groups, Western European Region was more efficient with the highest average technical efficiency of 95% while Central European Region shared the same technical efficiency level of 85% with Southern European Region. Meanwhile, the Northern European region was the least technically efficient (84%). The annual average TFP growth rate observed for all the regions in the EU-15 countries was between 3% and 4%. Decomposing TFP into its components, it was observed that TFP growth rate in the four regional groups were being driven by technology progress (technical change) and a decline in efficiency change particularly between the year 1999 and 2002. Subsequently up till 2005, the growth rate was driven by catch-up (efficiency change) while there seem to be technological regression. Both divergence and convergence (catch-up) trends were observed with a divergence trend in the productivity growth within the four regional groups from 2001 to 2006, but afterwards it was noted that all the four regional groups eventually converged to almost the same point.

Table of Contents

Table of Figures

List of Tables

1. Introduction

Agriculture has been and will continue to play vital roles for humanity because human welfare depends on the amount and stability of agricultural production, as determined by crop yield and cultivated area (Garibaldi et al., , 2011). The agricultural sector was one of the economic sectors to first get the European Union (EU) policymakers' attention. Subsequently, the first EU objectives of a common agricultural policy (CAP) was set up as contained in "Article 39 of the Treaty of Rome on the European Economic Community (EEC) (1957)" which focused on increasing agricultural productivity, stabilizing markets, and ensuring security of food supply at affordable prices to consumers across the EEC.

Agricultural productivity analysis has brought to fore that productivity progression or growth in the agricultural sector is inevitable if agricultural output is to grow at an appropriate rate of meeting the demands for food and raw materials through urbanization and industrialization (Hayami & Ruttan, 1970). There are different techniques available for analysing productivity growth and efficiency measurement in agriculture, but two which includes Total Factor Productivity (TFP) and Technical Efficiency (TE) would be measured and analysed in this study. Total factor productivity (TFP) growth is defined as the growth rate of output net of growth in inputs. It is the portion of output not explained by the increase of inputs used in production, and as such, its level is estimated by how efficiently and strongly the inputs are employed in production. Increases in TFP result usually from technological innovations or improvements (Comin & Hobijn, 2010; Emvalomatis, 2012). On the other hand, technical efficiency is defined as a state when a farm is able to achieve the maximum attainable output given a fixed level of inputs and the available technology (Färe, Grosskopf, & Lovell, 1983; Farrell, 1957).

1.1 Problem statement

Agriculture and agricultural policy have been vital issues in EU expansion, because agricultural policy falls within a complex framework of instruments of the CAP which prompts politically sensitive and accession issues (e.g. budget, World Trade Organization (WTO)). Also, agriculture is a politically sensitive issue in international negotiations (Swinnen, 2002). Since its formation, the EU has been attempting to eradicate the differences in productivity and agricultural income between regions, either by supporting the economically weaker regions or by strengthening the specific sectors of the economy in which agriculture is a central focus (Gorton & Davidova, 2004). Hence, the creation of EEC at the Treaty of Rome in 1957 for all regional development and other policy measures have been designed to facilitate the reduction of these differences, such as the so-called structural funds, investment loans, etc. Despite all these efforts, some vital question for the EU is, to what extent are these policy instruments really helping the relatively poor regions of Europe to catch up, what decides whether or not a region converges towards the average, falls behind or, alternatively, forges ahead of the others? (Fagerberg & Verspagen, 1996). Is there any data or results to prove that the differences and discrepancies in agricultural productivity growth and efficiency between regions are being eliminated? Does it appear to be convergent or divergent trends in productivity growth among regions?

Meanwhile, previous studies such as (Gorton & Davidova, 2001, 2004; Hughes, 2000; Mathijs & Swinnen, 1998; Rizov & Swinnen, 2004) that investigated the efficiency and productivity of agriculture in EU countries have noted large variations between farms in terms of their relative efficiency. This has sparked debates on future structural changes (Hughes, 2000) because understanding variations in technical efficiency will provide a basis for predicting structural change. Changes in the structure of agricultural production to be motivated by the dynamic interactions between improved technologies and the determination to feed the ever increasing human population (Chavas, 2001).

It is very crucial and inevitable to investigate technical efficiency of agricultural enterprises in EU regions at this period of economic upheavals, because the consequence of technical inefficiency could result in increased production cost of an enterprise thereby making it less competitive (Alvarez & Arias, 2004). However, most of the previous studies were based on comparing the efficiency and productivity growth of individual farms on a country by country basis. This study will investigate the technical efficiency and productivity growth of agriculture on the EU regional basis using aggregated data. It will be of interest to see which region is more efficient (technically) and which regions are less, also the issue of divergent or convergent trends in productivity growth will be assessed.

1.2 Research objectives and questions

To investigate and compare the technical efficiency of agricultural production in the EU 15 at the regional level. For this objective to be achieved, the following research questions were formulated:

- ✓ Which region is more or less efficient?

- ✓ What is the productivity growth rate in each of the EU 15 regions?
- ✓ Is there any divergence trend or convergence (catch-up) trend in the productivity growth between regions?

'This thesis is structured in the following way. Chapter two reviews relevant literatures related to the topic. It reviewed the agricultural production in the regions within the EU15 countries, the efficiency of production, trends in productivity growth (convergent or divergent). The chapter on materials and methods describes the data and the model employed, also the scenarios that were explored with the aim of answering our research objectives. The results are then presented in Chapter four and the results were discussed in relation to literature in Chapter five. In Chapter six, the conclusions and recommendations were presented.

2 Literature review

In this chapter, relevant studies on agricultural production in the regions within the EU-15 countries are reviewed. Then, technical efficiency in relation to agricultural production is examined. Different trends in total productivity growth such as convergent and divergent trends and their effects on agricultural production were also studied.

2.1 Agricultural production in the EU 15 regions

The present EU agriculture is predisposed to a large extent by EU policy. Not only because of the EU Common Agricultural Policy (CAP) and its attended support patterns but also by EU legislation and framework directives on sustainable use of the environment. Moreover, the structure of agriculture in the EU regions varies not only from country to country but also from region to region. What and where to produce a crop strongly depend on local conditions such as the type of land, the climate and infrastructures for agricultural production (Olsen, 2010). This fact as illustrated in Figure 1 and 2 below show the different types and quantity of agricultural crops and livestock products by different European countries.

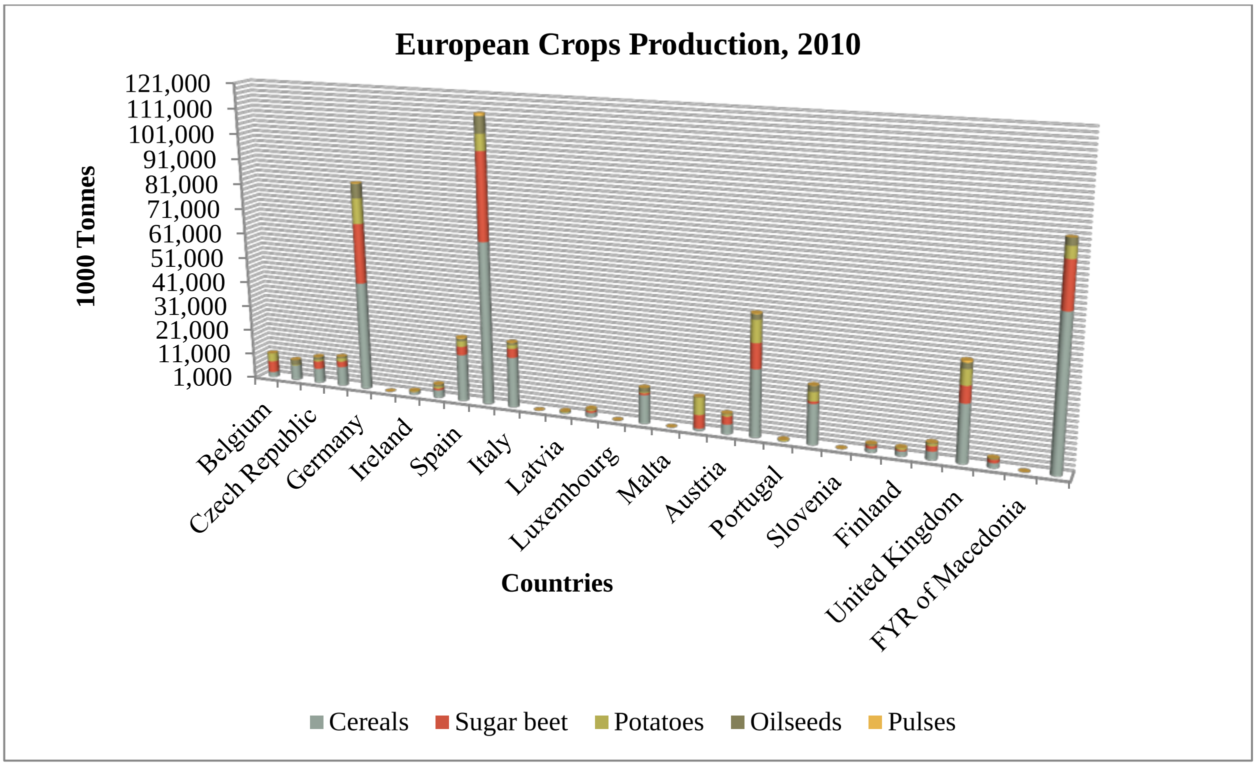


FIGURE 1 : AGRICULTURAL CROPS PRODUCTION BY EUROPEAN COUNTRIES

Source: Eurostat online data (2011)

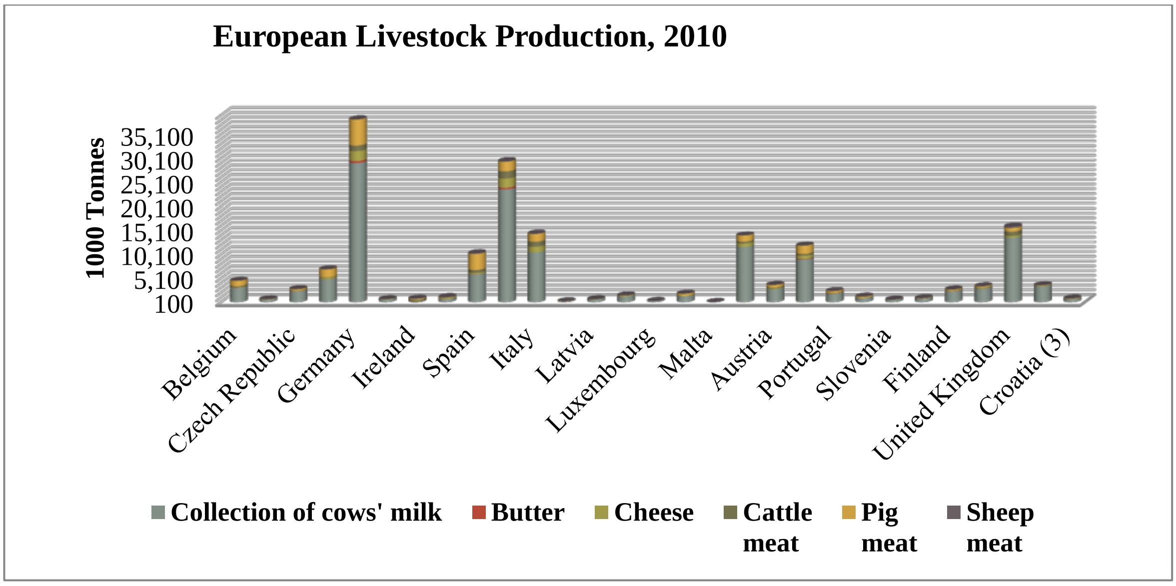


FIGURE 2: AGRICULTURAL LIVESTOCK PRODUCTION BY EUROPEAN COUNTRIES

Source: Eurostat online data (2011)

2.2 Techniques for measuring efficiency and productivity in agriculture

2.2.1 Technical efficiency in agricultural production

Technical efficiency (TE) is a component of economic efficiency (Farrell, 1957). It is defined as the ability of a firm to transform a given set of inputs into maximum achievable output given the available technology (Bravo-Ureta et al., 2007). Different types of frontier models based on the early work of Farrell (1957) have been developed for the measurement of technical efficiency. These models could be classified into parametric and non-parametric frontiers. Parametric frontier is further separated into two methods because they rely on a specific functional form (Aigner, Lovell, & Schmidt, 1977). These two groups are deterministic model which attributes any deviation to the inefficiency and the stochastic model which on the other hand tolerates statistical noise (Amara, Traoré, Landry, & Remain, 1999). Non-parametric models are usually based on mathematical programming and also known as data envelopment analysis (DEA) (Banker, Charnes, & Cooper, 1984), (Thiam, Bravo-Ureta, & Rivas, 2001).

2.2.2 Total factor productivity (TFP) growth

Total factor productivity (TFP) growth is defined as the growth rate of output net of growth in inputs (Emvalomatis, 2012). TFP growth describes the proportion of the actual output growth that is not brought about by increment of inputs (Englander and Mittelstiidt, 1988). TFP growth could also be decomposed into technology change and technical efficiency change. The decomposition of TFP growth into its two components of technological progress and changes in technical efficiency gives a clearer representation of the position of the production technology employed by firms (Kalirajan, Obwona, & Zhao, 1996). The decomposition helps to investigate the behaviour of technological progress if it is active or passive (stagnant) over time or if its potential has been fully realized. TFP growth is also an effective tool to analyse if there is divergent or convergent (catch-up) among the firms under consideration.

A decreasing technical efficiency (TE) of 92.32% to 83.72% was observed by (Tzouvelekas, Giannakas, Midmore, & Mattas, 1997) for farms in Greece, Southern Europe between 1987 and 1993. Similarly, a study by (Dios-Palomares & Martínez-Paz, 2011) observed a mean technical efficiency of 84.38% for olive oil production in terms of both quantity and quality in Spain also in Southern Europe. In a related research to evaluate technical efficiency in the horticultural production sector focusing on tomato and asparagus in Navarra (Spain) by (Iráizoz, Rapún, & Zabaleta, 2003), employing both a non-parametric and a parametric approach to a frontier production function reported a TE level of 0.75 and 0.81 for Asparagus and Tomato production respectively. Thereby, an average technical efficiency of 83.5% can be projected for crop farming in Southern Europe.

Latruffe et al., (2012) reported a technical efficiency of 74% for the dairy farms in two Central European (CE) countries (France and Hungary) during the period of 2001–2007. DEA approach was used under each country's production frontier. While a TE of 0.894 was observed by (Reinhard, Lovell, & Thijssen, 1999) for the Dutch intensive dairy farms also in Central Europe. But for Portugal Southern Europe, a TE of around 60%-70% for dairy farms according to (HALLAM & MACHADO, 1996). Comparing the two results from dairy farms in Central Europe and Southern Europe, it would be noted that the TE from Central Europe was higher than Southern Europe region at almost the same time frame.

The impact of milk quota system on TE of dairy farms in England and Wales (Western Europe) was also investigated by (Areal, Tiffin, & Balcombe, 2012). The study examined how milk quota market used by farmers affect the TE of their farms. The result is very interesting to note that due to the removal of milk quota system by 2015 from CAP policy system, the action will expose milk market in Europe to stiff competition and the farmers whose farms are not efficient enough may exit the milk production system.

In recent years, many studies have been conducted to investigate TFP growth in agriculture, manufacturing and other economic areas in the EU regions. An annual average TFP growth of 3.1% was observed for Dutch pot-plant production by (Lansink, 2000). In the Western Europe dairy production, an average annual TFP growth of 1.2% was reported by (Newman & Matthews, 2006). Similarly in Central Europe, an average annual TFP growth index was observed by (Brümmer, Glauben, & Thijssen, 2002). Another study that evaluated the trends of agricultural productivity growth of the EU15 countries was conducted by (Rungsuriyawiboon & Lissitsa, 2006) and showed an average TFP growth of 2.19% per annum for the EU15 countries. It was also observed that annual TFP growth of both regions during the period under consideration was largely due to technology progress.

All the studies so far reviewed both on technical efficiency analysis and TFP growth measurement conducted their researches on a country-level basis or some groups of countries within the EU region, except for work the of Rungsuriyawiboon and Lissitsa (2006) that did a comprehensive study of the EU15, EU10 and some countries in economic transition with the Central and Eastern Europe Countries (CEECs). This study therefore conduct a comprehensive analysis based on the regional levels of each country that make up the EU15 region thereby revealing the current performance of agricultural productivity in terms of technical efficiency and total factor productivity growth.

3 Materials and Methods

This chapter begins by the description of the data that were used for this study. The second section gives a brief explanation of the EU15 countries and their classification into regions. The last two sections describe the techniques that were used for analysis of this study and the model employed to run the analysis.

3.1 Description of the data

The dataset used for this study were obtained from the database published annually by the European Farm Accountancy Data Network (FADN). FADN started in 1965 and it consists of an annual survey carried out by the Member States of the European Union (EU). FADN is an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy in the EU region. The aim of the network is to gather accountancy data from farms for the determination of incomes and business analysis of agricultural holdings. FADN thereby provides representative data along three dimensions: region, economic size and type of farming. The system supplies data with different levels of aggregation focusing on the biggest commercial farms, which jointly in the given region or member state generate at least 90% of the standard gross margin (SGM). The total value of the SGM for each farm makes it possible to determine its economical size, which is expressed in European size units (ESU). In the FADN system, each region is represented by a certain set of average farms determined on the basis of a set of farms classified to a specific combination of type and economic size. FADN, at present has sample data that cover about 80,000 holdings which represent an aggregation of about 6,400,0000 farms in the EU-27 Member States. The sample covers approximately 90% of the total utilized agricultural area (UAA) and accounts for about 90% of the total agricultural production of the EU (FADN, 2010).

However, the production data for this study were selected from the regional level of the EU-15 countries and covers the years 1999 to 2009 (11 year). Data at farm level are not available for public use hence the choice data aggregated at the regional level. The 11-year period was chosen in order to observe the changes in productivity growth over a relatively long period of time. The production data contained two output variables and six input variables. The summary and definitions of both the output and input variables is presented below:

The two output variables are:

(1) Crop output: represented by the total value of output of crops and crop products (sales + farm use + farm house consumption) (Value in euros);

(2) Animal output: represented by the total value of output livestock and livestock products (livestock production + change in livestock value + animal products), all valued in euros.

The six input variables include:

(1) total labour input expressed in annual work units (AWU),

(2) the total utilized agricultural area (UAA), expressed in hectares (Ha)

(3) Buildings: Buildings and fixed equipment belonging to the holder (value in euros)

(4) Machinery: Machines, tractors, cars and lorries, irrigation equipment (except when of little value or used only during one year), (value in euros)

(5) Cost of materials expressed as total specific cost, total farming overheads, machinery and building current costs (value in euros).

(6) Livestock unit (LU): breeding and non-breeding livestock.

All values in euro were deflated from nominal euro to constant euro based on a fixed base year using the Agricultural Price Index (API) obtained from the statistical office of the European Union (EUROSTAT). Deflation back from nominal euro to constant euro is very important in order to eliminate the impact of inflation over time, to have a direct comparison to a base year and also to be able to observe the real growth in productivity.

3.2 THE EU-15 Countries

The EU-15 countries comprises of all the 15 countries which includes those that founded the European Union (EU) and the countries that joined the EU before 1996. The Member States include; Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. Each of these countries is further subdivided into regions. For the purpose of analysis and comparison in this study, we categorized the EU-15 region into four distinct regions (Table1).

TABLE 1: FOUR REGIONAL GROUPS OF EU-15 COUNTRIES

S/N	Region	Countries
1	Northern European Region	a. Denmark, b. Finland, c. Sweden
2	Central European Region	a. Austria b. Belgium, c. France, d. Germany e. Luxembourg, f. The Netherlands
3	Western European Region	a. Ireland, b. United Kingdom
4	Southern European Region	a. Greece b. Italy c. Portugal d. Spain

3.3 Data envelopment analysis (DEA)

The objective of the study was primarily achieved using Data Envelopment Analysis (DEA).

DEA is a "data-oriented" and non-parametric approach employed in the evaluation of relative efficiency or performance of a comparable set of peer entities known as decision-making units (DMUs). It is a quantitative and analytical technique involving measuring and evaluating performance and has the advantage of analysing multiple-input and multiple-output production technologies; this technique was first developed by Charnes et al. in 1978. DEA allows a researcher to evaluate the performance of individual DMUs taking only into account observed quantities of marketable inputs and outputs and does not require an assumption of a functional form relating inputs to outputs (Picazo-Tadeo, Gómez-Limón, & Reig-Martínez, 2011).

DEA could either be defined as input-oriented or output-oriented. It is input-oriented when frontier DMU seeks to maximize the possible proportional reduction in the use of inputs but keeping output levels constant. On the other hand, the output-oriented DEA assumes that DMUs seek to maximize the proportional increase in outputs but with fixed levels of inputs. If both input-oriented DEA and output-oriented DEA measures give the same efficiency scores, then a constant-return–to-scale (CRS) is assumed but a variable-return-to-scale (VRS) if they do not the same or equal efficiency scores (Tim J. Coelli & Rao, 2005). For this study, output-oriented Malmquist DEA was chosen in this study for the calculation of TFP. This is due to the assumption that most farmers worked with fixed inputs such as land and buildings that are difficult to contract and thereby focus more on increasing outputs with fixed input levels.The linear programming of the DEA used in this study is defined and explained based on (T. J. Coelli, Rao, O'Donnell, & Battese, 2005).

We first defined some notations used. Assume there are data on *N* inputs and *M* outputs for each of *I* regions (firms). The *i-th* region is represented by the column vectors x_i and q_i, respectively. The *NxI* input matrix*, x,* and the *MxI* output matrix, *Q*, represent the horizontally stacked data for all *I* regions. The linear programming is therefore as:

$$
\begin{aligned}
&\mathrm{Max}_{\lambda,\theta}\ \theta, \\
&\text{s.t.} \quad -q_i + Q\lambda \geq 0, \\
&\qquad \theta x_i - X\lambda \geq 0, \\
&\qquad I1'\lambda = 1 \\
&\qquad \Lambda \geq 0 \ldots \qquad (3.1)
\end{aligned}
$$

where θ is a scalar and λ, is a *I*x1 vector of constants. The value of θ obtained is the technical efficiency score for the i-th region. It satisfies $0<\theta \leq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient region.

DEA results give information on peers of each inefficient firm. This unique characteristic of DEA makes it more advantageous relative to Stochastic Frontier Analysis (SFA), because these peers are role models to project the inefficient firms to the production frontier. They also supply information on the quantity of inputs and output a firm could have been using or producing if it were technically efficient (Tim J. Coelli & Rao, 2005).

3.4 Malmquist Total factor productivity (TFP) growth

To measure the productivity growth, the Malmquist Total Factor Productivity (TFP) growth index according to (Tim J. Coelli & Rao, 2005) was employed. TFP growth index has the ability to compare multiple inputs with multiple outputs to measure change in productivity and determine the evolution of productivity over time. TFP is the residual growth in output which is explained by the increase in input use (Rungsuriyawiboon & Lissitsa, 2006). Malmquist TPF growth index can use DEA linear programming methods to construct a piece-wise linear production frontier for each year in the sample as described by Coelli and Rao, (2005). It also uses a distance functions which describe a multi-input, multi-output production technology without the need to specify a behavioural objective (such as cost minimization or profit maximization). Defining the distance function for DEA Linear programming according to (Färe, Grosskopf, Norris, & Zhang, 1994) as:

$$D^{o}_{t}(x_t,y_t) = \min\{\theta : (x_t,y_t/\theta) \in S_t)\} \quad (3.2)$$

Where $D^{o}_{t}(x_t,y_t) \leq 1$ if and only if $(x_t,y_t) \in S_t$. Also, $D^{o}_{t}(x_t,y_t) = 1$ if and only if (x_t,y_t) is located on the outer boundary of the feasible production frontier and this occurs if production is technically efficient.

The Malmquist TPF growth index measures the TFP change between two data points by calculating the ratio distances of each data point relative to a common technology (Färe, et al., 1994). This output oriented Malmquist TPF change index can be given as:

$$m_o(x_{t+1},y_{t+1}, x_t, y_t) = \left[\frac{D^{o}_{t}(x_{t+1},y_{t+1})}{D^{o}_{t}(x_t,y_t)} \text{ X } \frac{D^{o}_{t+1}(x_{t+1},y_{t+1})}{D^{o}_{t+1}(x_t,y_t)}\right]^{0.5} \quad (3.3)$$

The above equation gives the geometric mean of two TFP indices, in the first part, the technology in period *t* is used as reference technology and in the second part, the technology in period *t+1* is used reference. If $m_o > 1$, TFP increases from period *t* to period *t+1,* but if $m_o < 1$, TFP decreases from period *t* to period *t+1.*

The Malmquist TFP index can be decomposed into its components to show which component is the sources that contribute to the TFP growth. The above Malmquist TFP index can be re-written as shown below (equation 3.4); to highlight the decomposition.

$$m_o(x_{t+1},y_{t+1}, x_t, y_t) = \frac{D^{o}_{t+1}(x_{t+1},y_{t+1})}{D^{o}_{t}(x_t,y_t)} \left[\frac{D^{o}_{t}(x_{t+1},y_{t+1})}{D^{o}_{t+1}(x_{t+1},y_{t+1})} \text{ X } \frac{D^{o}_{t+1}(x_{t+1},y_{t+1})}{D^{o}_{t+1}(x_t,y_t)}\right]^{0.5}$$

The first ratio outside the brackets is the "efficiency change" component which measures the change in the output-orientated technical efficiency between periods *t* and *t* +1. The efficiency change component measures whether production is catching up with or falling behind the production frontier and assumed that this component captures diffusion of technology related to differences in knowledge and institutional setting (Rungsuriyawiboon & Lissitsa, 2006). The other part of the index inside the bracket (equation 3.3) is a measure of "technical change", the geometric mean of the shift in technology in time *t* and *t* +1 at input levels x_t and x_{t+1}.

Efficiency change can further be decomposed into two components which are the pure technical efficiency change (PEFFCH) and scale effect (SCH). Therefore, efficiency change is defined as: EFFCH = PEFFCH x SCH. EFFCH is the efficiency change measure under constant return to scale (CRS), PEFFCH is the efficiency change measured under variable return to scale (VRS) and the scale effect. Pure efficiency depicts the effect on the ability of a firm to be more efficient due new technologies (Färe, et al., 1994).

4. Results

This chapter presents the summary of the results of DEA and Malmquist TFP growth index from the DEAP software program. Since we have data of 101 regions for 11 years from the EU-15 countries, applying DEA involves solving 101*[(11*3)-2] = 3,131 LP problems. In the first section, information on the technical efficiency is presented while the second section presents the results of TFP growth index and TFP components.

4.1 Technical Efficiency

The average technical efficiency scores for all the period under consideration (1999 to 2009) is presented in **Table 2**. The result is presented according to each of the four regional groups with technical efficiency ranging from 84% for Northern European Region, 85% for Central European Region, 95% for Western European Region and 85% for Southern European Region. But an average technical efficiency of 87% for all the regions put together between the year 1999 and 2009. This implies that each of these regions is on average, producing 87% of the output that they could be potentially produced with the observed input levels. This results is the range of technical efficiency (88%) observed by (Tim J. Coelli & Rao, 2005) for Europe as continent between 1980 to 2000, but slightly higher than 86% that was observed by Rungsuriyawiboon and Lissitsa (2006) for EU-15 region. Though, two years (2004 and 2005) in particular exhibits high technical efficiency of 94% and 92% respectively. The changes in technical efficiency can be explained about the catch-up effect ascribed to TFP growth.

TABLE 2: MEANS OF TECHNICAL EFFICIENCY SCORES FOR THE FOUR REGIONAL GROUPS OF EU-15 COUNTRIES

Year	Northern European Region	Central European Region	Western European Region	Southern European Region
1999	0.91	0.89	0.93	0.80
2000	0.85	0.88	0.96	0.83
2001	0.85	0.87	0.93	0.87
2002	0.61	0.77	0.85	0.74
2003	0.85	0.81	0.96	0.86
2004**	0.96	0.87	0.98	0.94
2005**	0.94	0.86	0.97	0.93
2006	0.83	0.85	0.98	0.90
2007	0.82	0.83	0.96	0.83
2008	0.85	0.84	0.99	0.84
2009	0.79	0.82	0.94	0.83
Regional Means	**0.84**	**0.85**	**0.95**	**0.85**
Overall Mean	**0.87**			

**High technical efficiencies

In Figure 3, the plot of technical efficiency is presented showing the trends of technical efficiency change for each of the four regional groups of EU-15 through the periods of 199 to 2009 (11 years) that were studied. The technical efficiency plot indicated a sharp and significant decline in 2002 and then substantial rises during the period 2003 to 2005.

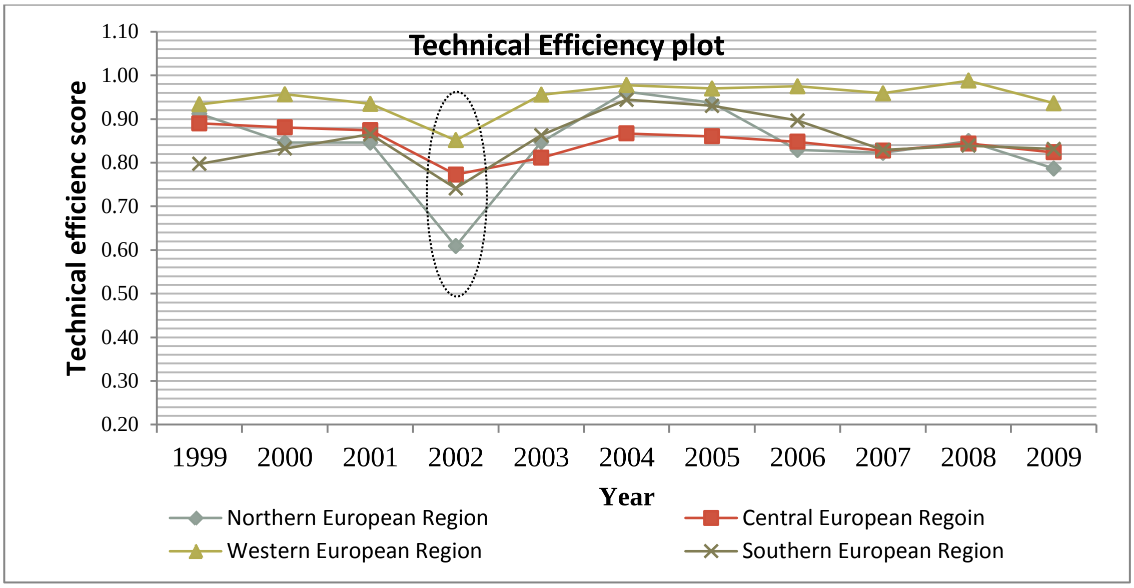


FIGURE 3: A PLOT OF TECHNICAL EFFICIENCY

4.2 Total factor productivity (TFP) growth index and its components

The annual averages of the components of TFP growth index; efficiency change and technical change are presented in **Table 3 and 4**, while the TFP change from one year to another is presented in Table 4.4. The results of the efficiency change and technical change reflects that TFP index components contribute more to the TFP growth rate. The results shows that TFP growth due to efficiency change is 2% for Northern European Region, 0% for Central European Region, 1% for Western European Region and 3% for Southern European Region while TPF growth due to technical change are 9%, 4%, 4% and 6% for Northern, Central, Western and Southern European Regions respectively. The annual average TFP growth rate observed in the study for all the regions in the EU-15 countries is between 3% and 4%. Looking at the four regional groups as depicted by Figure 4.1, though the four regions followed the same trends but more growth is observed from the year 2001 to 2006 in the Northern European Region (Denmark, Finland and Sweden) while less growth is observed in the Central European Region (Germany, France, Belgium, Netherlands, Luxembourg and Austria) at the same period of time. To understand why, the measure of TFP growth is decomposed into efficiency and technology-related effects. The efficiency-related part describes the catch-up aspect of the TFP growth while the technology-related (technical change) component results in the frontier-shift to the TFP growth.

We need to know which of the TFP components is driving the growth rate. Figure 4.2 a, b, c, and d showed clearly that the productivity growth for all four regions, with each region of Northern, Central, Western and Southern European Region posting TFP change of 4%, 3%, 3% and 4% respectively where technical change is contributing the larger share of 9%, 4%, 4% and 6%. And efficiency change contributing 2%, 0%, 1% and 3%. This implies that the four regional groups were being driven by technology progress (technical change) or frontier shift effect and a decline in efficiency change particularly between the year 1999 and 2002. Subsequently up till 2005, the growth rate was being driven by catch-up (efficiency change) while there seem to be technological regress. Except for Southern European Region (Greece, Spain, Italy and Portugal) with a high surge in Catch-up (efficiency change) until 2007.

TABLE 3: ANNUAL MEANS OF EFFICIENCY CHANGE FOR THE FOUR REGIONAL GROUPS OF EU-15 COUNTRIES

Year	**Northern European Region**	**Central European Region**	**Western European Region**	**Southern European Region**
1999	1.00	1.00	1.00	1.00
2000	0.93	1.03	1.01	1.10
2001	1.00	1.01	1.02	1.03
2002	0.67	0.83	0.82	0.85
2003	1.63	1.11	1.24	1.35
2004	1.18	1.12	1.07	1.15
2005	0.96	0.99	0.99	0.99
2006	0.89	0.98	1.00	0.94
2007	0.97	0.97	0.96	0.92
2008	1.02	1.03	1.03	1.01
2009	0.95	0.96	0.97	0.98
Regional Mean	**1.02**	**1.00**	**1.01**	**1.03**

TABLE 4: ANNUAL MEANS OF TECHNICAL CHANGE FOR THE FOUR REGIONAL GROUPS OF EU-15 COUNTRIES

Year	Northern European Region	Central European Region	Western European Region	Southern European Region
1999	1.00	1.00	1.00	1.00
2000	1.18	1.08	1.10	0.99
2001	1.12	1.06	1.16	1.12
2002	1.67	1.15	1.18	1.43
2003**	0.65	0.93	0.91	0.86
2004	0.90	0.91	0.89	0.85
2005	1.01	1.00	0.94	0.98
2006	1.10	1.09	0.99	1.07
2007	1.15	1.25	1.22	1.23
2008	1.17	1.01	1.14	1.05
2009	0.94	0.95	0.88	0.96
Regional Mean	**1.09**	**1.04**	**1.04**	**1.06**

The TFP change shown in **Table 5** depicts the changes that occurred in agricultural productivity during the period under consideration with 1999 serving as the base year. The average TFP change for the four regional groups were so different from each other, with Northern and Southern regions sharing 4% while Central and Western regions also sharing 3% annual TFP growth rate.

TABLE 5: ANNUAL MEANS OF TFP CHANGE FOR THE FOUR REGIONAL GROUPS OF EU-15 COUNTRIES

Year	Northern European Region	Central European Region	Western European Region	Southern European Region
1999	1.00	1.00	1.00	1.00
2000	1.10	1.09	1.09	1.07
2001	1.11	1.07	1.18	1.15
2002	0.98	0.91	0.92	1.07
2003	0.97	1.01	1.09	1.06
2004	1.04	1.02	0.95	0.97
2005	0.97	0.98	0.93	0.97
2006	0.98	1.07	0.99	1.00
2007	1.11	1.21	1.17	1.13
2008	1.19	1.05	1.17	1.03
2009	0.89	0.91	0.85	0.94
Regional Mean	**1.04**	**1.03**	**1.03**	**1.04**

In Figure 4, the plot of cumulative TFP indices is presented showing the trends of agricultural productivity growth rate of the four regional groups of EU-15 through the periods (11 years) that was studied. Though, each of the four regional groups has different growth rate but they all follow the same trend and react in the same way during the years under observation, as this can be observed between the periods 2001 to 2006; 2006 to 2008 and 2008 to 2009.

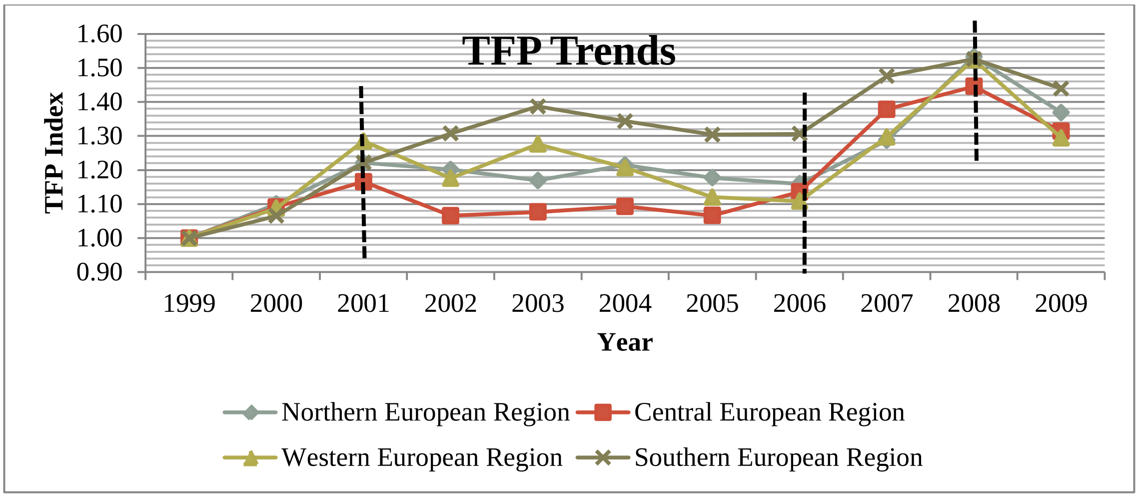
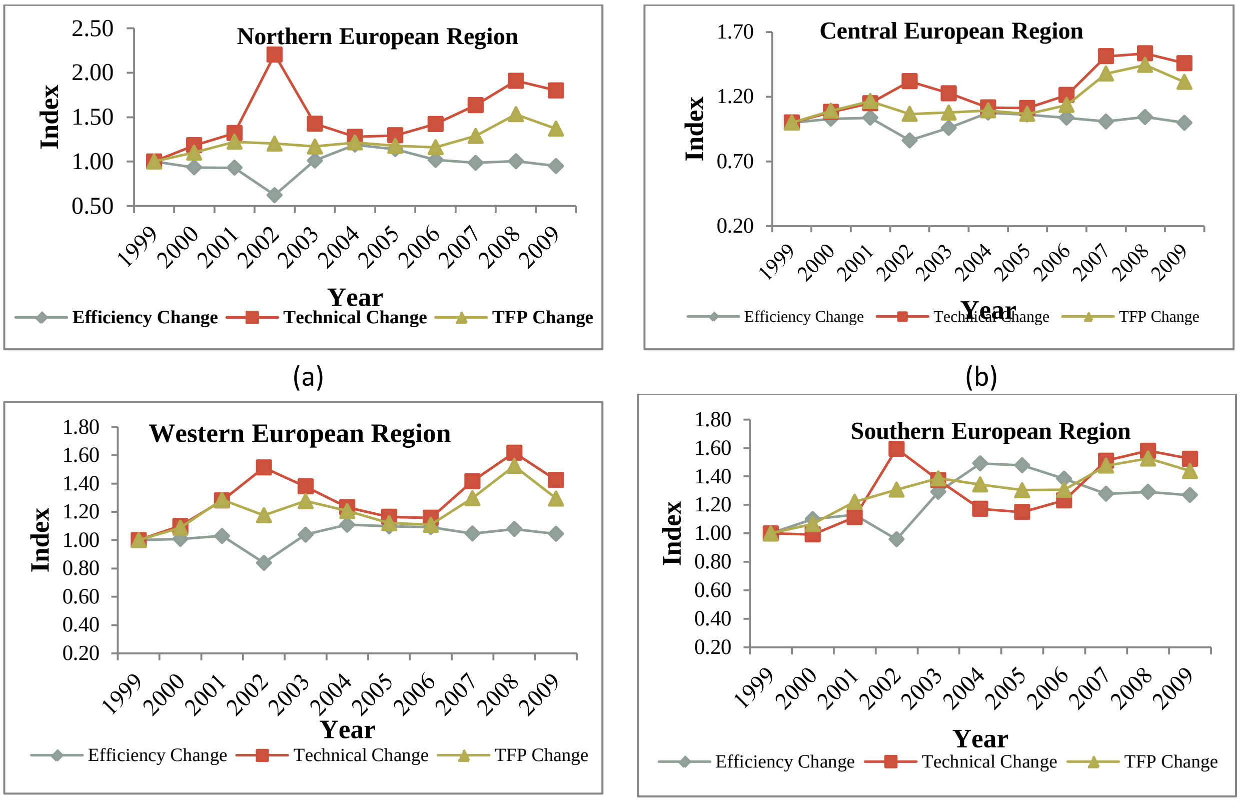


FIGURE 4: PLOT OF CUMULATIVE TFP INDICES

In **figure 6** (a to d), the plots of cumulative indices of TFP change and its two components; efficiency and technical change were presented. The plots clearly showed how each of the two TFP components contributed to high or low growth rate at every points of the study period.



(C) (D)

FIGURE 5: CUMULATIVE INDICES OF EFFICIENCY CHANGE, TECHNICAL CHANGE AND TFP CHANGE

5. Discussion

The broad objective of the research is to investigate and compare the technical efficiency of agricultural productivity growth rate in the EU 15 at the regional level. Therefore, the results obtained are discussed based on the following specific research objectives formulated and also in relation to previous studies.

1. To identify the regions that are more efficient and those that are not efficient in in relation to each other.
2. To estimate the rate of productivity growth in each of the EU 15 regions.
3. To identify any diverging trends in the productivity growth between regions.

The dataset for this study covers the years 1999 to 2009 (11 year) from EU regional aggregated agricultural production data of FADN. The period of years was chosen in order to observe the changes in productivity growth over a relatively long period of time. Data at farm level are not available for public use in the FADN database hence, the choice of regional level aggregated data. Also, an output-orientation was used for measuring efficiency; it could be argued that an input-orientation could also be used. But it is assumed that at least a number of the inputs are fixed (such as land, labour, building and capital) that are difficult to contract without affecting other inputs and outputs. It is thereby easier for farmers to focus on increasing outputs with fixed input levels.

DEA method was used in this research to evaluate technical efficiency and calculate Malmquist TFP growth index for agricultural production. Other technique such as SFA could also be used but with an assumption that the basic production technology is applicable or common to farm holdings and which is not the case in practice. DEA does not require such assumption, but efficiency is calculated relative to frontier by the DMUs that form the frontier not by the same production technology (Tim J. Coelli & Rao, 2005). Though DEA is without its own disadvantage, in the sense that it does not produce standard errors for the efficiency scores. DEA being a non-parametric model does not produce statistical tool but only shows the efficiency of different firms. Giving standard errors could have to show the variations between firms by constructing confidence intervals to explain the differences.

5.1 Technical Efficiency

Technical efficiency is the ability of a firm to completely utilize a given set of inputs and technology into its maximum achievable output. It is a reflection of how efficiently a region is transforming available inputs and technology into outputs. The technical efficiency obtained in this study for each of the four regional groups of EU-15 countries ranged from 84% to 95%. Comparing the four regional groups, it is interesting to note that Western European Region which comprises of Ireland and United Kingdom is more efficient with the highest average technical efficiency of 95%. While Central European Region with countries like Germany, France, Belgium, Netherlands, Luxembourg and Austria share the same technical efficiency level with Southern European Region (Greece, Spain, Italy and Portugal). The least technically efficient region is Northern European Region (Denmark, Finland and Sweden) with 84% technical efficient. To this effect, it seems reasonable that if the real efficiency performance is to be assessed, regions within a country evaluation will give an accurate result than grouping two or more countries together, as the technical efficiency of all regions within each country that made up the EU-15 region as shown in **Appendix 1**.

5.2 Total factor productivity (TFP) growth index and its components

In this section, the empirical results of our TFP calculations are discussed. We provide information on TFP change, efficiency change and technical change for all the regions in the EU-15 countries. TFP growth is a reflection of growth rate or the rate of change in productivity brought about by either technological progress or increased technical efficiency. Hence, the decomposition of TFP into its components of technical change and efficiency change. The decomposition therefore shows that, the four regional groups were being driven by technology progress (technical change) or frontier shift effect and a decline in efficiency change particularly between the year 1999 and 2002. Subsequently up till 2005, the growth rate was being driven by catch-up (efficiency change) with technological regression except for Southern European Region (Greece, Spain, Italy and Portugal) with a high surge in Catch-up (efficiency change) until 2007.

To examine the question divergence trend or convergence (catch-up) trend in the productivity growth between regions. As it can be seen in Figure 4.1, there seem to be a divergence trend within the four regional groups from year 2001 to 2006, except for Southern European Region (Greece, Spain, Italy and Portugal) that maintained the level of divergent until 2008. It is also a point of interest to note that all four groups converged to almost the same point in the year 2008. The implication of TFP being driven by efficiency change and less of technical change during later part of the study period shows that framers are no longer invest in technology. This may not be unconnected with the global economic recession around that period, and if the trend continues, the policy implication is that the EU policy makers may need to adjust their agricultural policies especially as it relate to agro-technology.

6. Conclusion

The objective of the research is to investigate and compare the technical efficiency of agricultural production in the EU-15 at the regional level. For this objective to be achieved, the following research questions were formulated and are answered in the concluding section:

- ✓ Which region is more efficient and region is less efficient?.
- ✓ What is the productivity growth rate in each of the EU 15 regions?
- ✓ Is there any divergence trend or convergence (catch-up) trend in the productivity growth between regions?

For the purpose of comparison, we further categorized the EU-15 region into four distinct regional groups. The four distinct regional groups and countries that fall under them are:

d. Northern European Region: (Denmark, Finland, Sweden)
e. Central European Region: (Austria, Belgium, France, Germany, Luxembourg and The Netherlands)
f. Western European Region: (Ireland and United Kingdom)
g. Southern European Region: (Greece, Italy, Portugal and Spain)

For technical efficiency, the results presented show an average technical efficiency of 87% for all the regions put together between the year 1999 and 2009. This implies that each of these regions is on average, producing 87% of the output that they could be potentially produced with the observed input levels. Comparing the four regional groups, it is interesting to note that Western European Region is more efficient with the highest average technical efficiency of 95%. While Central European Region share the same technical efficiency level of 85% with Southern European Region. The least technically efficient region is Northern European with 84% technical efficient. Though, it was noted that if the real efficiency performance is to be assessed, regions within a country evaluation will give a more accurate result than grouping two or more countries together.

For productivity growth rate, the results show that TFP growth due to efficiency change is 2% for Northern European Region, 0% for Central European Region, 1% for Western European Region and 3% for Southern European Region. While TPF growth due to technical change are; 9%, 4%, 4% and 6% for Northern, Central, Western and Southern European Regions respectively. The annual average TFP growth rate observed in the study for the regions of the EU-15 countries is between 3% and 4%. After decomposing TFP into its components, it was observed that TFP growth rate in the four regional groups were being driven by technology progress (technical change) and a decline in efficiency change particularly between the year 1999 and 2002. Subsequently up till 2005, the growth rate was being driven by catch-up (efficiency change) with technological regression. Both divergence and convergence (catch-up) trends were observed. Divergence trend in the productivity growth within the four regional groups from year 2001 to 2006, it is also noted that all four groups eventually converged to almost the same point in the year 2008.

7.0 References

Aigner, D., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics, 6*(1), 21-37. doi: 10.1016/0304-4076(77)90052-5

Alvarez, A., & Arias, C. (2004). Technical efficiency and farm size: A conditional analysis. *Agricultural Economics, 30*(3), 241-250.

Amara, N., Traoré, N., Landry, R., & Remain, R. (1999). Technical Efficiency and Farmers' Attitudes toward Technological Innovation: The Case of the Potato Farmers in Quebec. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 47*(1), 31-43. doi: 10.1111/j.1744-7976.1999.tb00214.x

Areal, F. J., Tiffin, R., & Balcombe, K. (2012). Farm technical efficiency under a tradable milk quota system. *Journal of Dairy Science, 95*(1), 50-62.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science, 30*(9), 1078-1092.

Bravo-Ureta, B., Solís, D., Moreira López, V., Maripani, J., Thiam, A., & Rivas, T. (2007). Technical efficiency in farming: a meta-regression analysis. *Journal of Productivity Analysis, 27*(1), 57-72. doi: 10.1007/s11123-006-0025-3

Brümmer, B., Glauben, T., & Thijssen, G. (2002). Decomposition of Productivity Growth Using Distance Functions: The Case of Dairy Farms in Three European Countries. *American Journal of Agricultural Economics, 84*(3), 628-644. doi: 10.1111/1467-8276.00324

Chavas, J.-P. (2001). Chapter 5 Structural change in agricultural production: Economics, technology and policy. In L. G. Bruce & C. R. Gordon (Eds.), *Handbook of Agricultural Economics* (Vol. Volume 1, Part A, pp. 263-285): Elsevier.

Coelli, T. J., & Rao, D. S. P. (2005). Total factor productivity growth in agriculture: a Malmquist index analysis of 93 countries, 1980–2000. *Agricultural Economics, 32*, 115-134. doi: 10.1111/j.0169-5150.2004.00018.x

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). An Introduction to Efficiency and Productivity Analysis: Springer.

Comin, D., & Hobijn, B. (2010). An Exploration of Technology Diffusion. *American Economic Review, 100*(5), 2031-2059. doi: doi: 10.1257/aer.100.5.2031

Dios-Palomares, R., & Martínez-Paz, J. M. (2011). Technical, quality and environmental efficiency of the olive oil industry. *Food Policy, 36*(4), 526-534.

Emvalomatis, G. (2012). Productivity Growth in German Dairy Farming using a Flexible Modelling Approach. *Journal of Agricultural Economics, 63*(1), 83-101. doi: 10.1111/j.1477-9552.2011.00312.x

Fagerberg, J., & Verspagen, B. (1996). Heading for Divergence? Regional Growth in Europe Reconsidered*. *JCMS: Journal of Common Market Studies, 34*(3), 431-448. doi: 10.1111/j.1468-5965.1996.tb00580.x

Färe, R., Grosskopf, S., & Lovell, C. A. K. (1983). The Structure of Technical Efficiency. *The Scandinavian Journal of Economics, 85*(2), 181-190.

Färe, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries. *The American Economic Review, 84*(1), 66-83.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society. Series A (General), 120*(3), 253-290.

Garibaldi, L. A., Aizen, M. A., Klein, A. M., Cunningham, S. A., & Harder, L. D. (2011). Global growth and stability of agricultural yield decrease with pollinator dependence. *Proceedings of the National Academy of Sciences, 108*(14), 5909-5914. doi: 10.1073/pnas.1012431108

Gorton, M., & Davidova, S. (2001). The International Competitiveness of CEEC Agriculture. *World Economy, 24*(2), 185-200. doi: 10.1111/1467-9701.00351

Gorton, M., & Davidova, S. (2004). Farm productivity and efficiency in the CEE applicant countries: a synthesis of results. *Agricultural Economics, 30*(1), 1-16. doi: 10.1111/j.1574-0862.2004.tb00172.x

HALLAM, D., & MACHADO, F. (1996). Efficiency analysis with panel data: A study of Portuguese dairy farms. *European Review of Agricultural Economics, 23*(1), 79-93. doi: 10.1093/erae/23.1.79

Hayami, Y., & Ruttan, V. W. (1970). Agricultural Productivity Differences among Countries. *The American Economic Review, 60*(5), 895-911.

Hughes, G. (2000). Total productivity of emergent farm structures in Central and Eastern Europe (pp. 61-87). Wallingford: CABI Publishing.

Iráizoz, B., Rapún, M., & Zabaleta, I. (2003). Assessing the technical efficiency of horticultural production in Navarra, Spain. *Agricultural Systems, 78*(3), 387-403.

Kalirajan, K. P., Obwona, M. B., & Zhao, S. (1996). A Decomposition of Total Factor Productivity Growth: The Case of Chinese Agricultural Growth before and after Reforms. *American Journal of Agricultural Economics, 78*(2), 331-338. doi: 10.2307/1243706

Lansink, A. (2000). Productivity growth and efficiency measurement: a dual approach. *European Review of Agricultural Economics, 27*(1), 59-73. doi: 10.1093/erae/27.1.59

Mathijs, E., & Swinnen, J. F. M. (1998). The economics of agricultural decollectivization in east Central Europe and the former Soviet Union. *Economic Development and Cultural Change, 47*(1), 1-26.

Newman, C., & Matthews, A. (2006). The productivity performance of Irish dairy farms 1984–2000: a multiple output distance function approach. *Journal of Productivity Analysis, 26*(2), 191-205. doi: 10.1007/s11123-006-0013-7

Picazo-Tadeo, A. J., Gómez-Limón, J. A., & Reig-Martínez, E. (2011). Assessing farming eco-efficiency: A Data Envelopment Analysis approach. *Journal of Environmental Management, 92*(4), 1154-1164.

Reinhard, S., Lovell, C. A. K., & Thijssen, G. (1999). Econometric Estimation of Technical and Environmental Efficiency: An Application to Dutch Dairy Farms. *American Journal of Agricultural Economics, 81*(1), 44-60. doi: 10.2307/1244449

Rizov, M., & Swinnen, J. F. M. (2004). Human capital, market imperfections, and labor reallocation in transition. *Journal of Comparative Economics, 32*(4), 745-774. doi: 10.1016/j.jce.2004.08.002

Rungsuriyawiboon, S., & Lissitsa, A. (2006). Agricultural productivity growth in the European Union and transition countries: IAMO Halle (Saale).

Swinnen, J. F. M. (2002). Transition and Integration in Europe: Implications for Agricultural and Food Markets, Policy, and Trade Agreements. *World Economy, 25*(4), 481-501. doi: 10.1111/1467-9701.00445

Thiam, A., Bravo-Ureta, B. E., & Rivas, T. E. (2001). Technical efficiency in developing country agriculture: a meta-analysis. *Agricultural Economics, 25*(2-3), 235-243. doi: 10.1111/j.1574-0862.2001.tb00204.x

Tzouvelekas, V., Giannakas, K., Midmore, P., & Mattas, K. (1997). Technical efficiency measures for olive-growing farms in Crete, Greece. *International Advances in Economic Research, 3*(2), 154-169. doi: 10.1007/bf02294936

EC. (2011). Europe in figures – Eurostat yearbook 2011: Agriculture, forestry and fisheries. Retrieved from http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/CH_08_2011/EN/CH_08_2011-EN.PDF

Olsen Ole, (2010), A regional picture of farming in Europe — what, where and how much? **European Statistical Data Support.** http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database

8.0 Appendix

Appendix 1: Technical Efficiency scores of all regions in the EU-15 countries according to the four regional groups

	Northern European Region		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1	(DAN) Denmark	(0370) Denmark	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	(SUO) Finland	(0670) Etela-Suomi	0.80	0.85	0.79	0.50	0.70	1.00	0.97	0.91	0.88	1.00	0.89
3	(SUO) Finland	(0680) Sisa-Suomi	0.97	0.90	0.90	0.35	0.76	0.93	0.89	0.86	0.81	0.94	0.87
4	(SUO) Finland	(0690) Pohjanmaa	0.93	0.81	0.84	0.44	0.80	0.97	0.91	0.81	0.75	0.81	0.75
5	(SUO) Finland	(0700) Pohjois-Suomi	0.93	0.84	0.92	0.37	0.85	1.00	0.95	0.81	0.81	0.86	0.84
6	(SVE) Sweden	(0710) Slattbygdslan	0.88	0.78	0.80	0.87	0.93	0.97	0.97	0.81	0.99	0.81	0.75
7	(SVE) Sweden	(0720) Skogs-och ...	0.96	0.89	0.83	0.74	0.94	1.00	1.00	0.75	0.69	0.70	0.64
8	(SVE) Sweden	(0730) Lan i norra	0.81	0.71	0.69	0.61	0.79	0.83	0.81	0.68	0.66	0.68	0.56
		Annual Mean	**0.91**	**0.85**	**0.85**	**0.61**	**0.85**	**0.96**	**0.94**	**0.83**	**0.82**	**0.85**	**0.79**

	Central European Region												
1	(BEL) Belgium	(0340) Belgium	0.92	0.98	1.00	0.81	0.83	1.00	1.00	1.00	1.00	1.00	1.00
2	(DEU) Germany	(0010) Schleswig-Holstein	0.87	0.94	0.91	0.78	0.85	1.00	1.00	0.96	1.00	1.00	0.99
3	(DEU) Germany	(0020) Hamburg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	(DEU) Germany	(0030) Niedersachsen	0.91	0.97	0.97	0.77	0.81	0.91	0.93	0.97	0.98	0.92	0.92
5	(DEU) Germany	(0050) Nordrhein-Westfalen	0.90	1.00	0.95	0.85	0.88	1.00	1.00	0.92	0.95	1.00	1.00
6	(DEU) Germany	(0060) Hessen	0.73	0.74	0.76	0.58	0.64	0.77	0.76	0.76	0.79	0.81	0.73
7	(DEU) Germany	(0070) Rheinland-Pfalz	0.68	0.70	0.71	0.69	0.74	0.78	0.78	0.86	0.91	0.74	0.76
8	(DEU) Germany	(0080) Baden-Württemberg	0.78	0.75	0.74	0.53	0.65	0.82	0.78	0.81	0.82	0.77	0.71
9	(DEU) Germany	(0090) Bayern	0.84	0.82	0.83	0.55	0.68	0.81	0.79	0.73	0.86	0.80	0.74
10	(DEU) Germany	(0100) Saarland	0.74	0.77	0.83	0.65	0.68	0.67	0.68	0.71	0.74	0.78	0.75
11	(DEU) Germany	(0112) Brandenburg	1.00	1.00	1.00	0.98	0.99	0.99	0.99	1.00	1.00	1.00	1.00
12	(DEU) Germany	(0113) Mecklenburg	0.95	1.00	0.91	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	(DEU) Germany	(0114) Sachsen	0.98	1.00	1.00	0.91	0.93	1.00	1.00	1.00	1.00	1.00	1.00
14	(DEU) Germany	(0115) Sachsen-Anhalt	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00
15	(DEU) Germany	(0116) Thueringen	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

16	(FRA) France	(0121) Île de France	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
17	(FRA) France	(0131) Champagne-Ardenne	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18	(FRA) France	(0132) Picardie	0.98	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19	(FRA) France	(0133) Haute-Normandie	0.88	0.86	0.86	0.76	0.73	0.88	0.80	0.79	0.76	0.81	0.82
20	(FRA) France	(0134) Centre	0.68	0.79	0.75	0.75	0.80	0.79	0.79	0.83	0.89	0.88	0.91
21	(FRA) France	(0135) Basse-Normandie	1.00	0.92	0.91	0.74	0.81	0.85	0.86	0.75	0.73	0.77	0.71
22	(FRA) France	(0136) Bourgogne	0.76	0.80	0.77	0.70	0.64	0.68	0.68	0.66	0.65	0.75	0.69
23	(FRA) France	(0141) Nord-Pas-de-Calais	0.92	0.87	0.87	0.82	0.81	0.88	0.80	0.76	0.67	0.79	0.76
24	(FRA) France	(0151) Lorraine	0.86	0.79	0.77	0.71	0.69	0.72	0.76	0.68	0.63	0.73	0.64
25	(FRA) France	(0152) Alsace	1.00	1.00	0.93	0.99	0.96	0.99	0.97	0.90	0.94	0.91	0.99
26	(FRA) France	(0153) Franche-Comté	0.99	0.91	0.92	0.87	0.83	0.83	0.89	0.80	0.73	0.77	0.75
27	(FRA) France	(0162) Pays de la Loire	0.98	0.89	0.89	0.64	0.69	0.83	0.85	0.79	0.67	0.80	0.81
28	(FRA) France	(0163) Bretagne	1.00	1.00	1.00	0.92	1.00	1.00	1.00	1.00	0.96	1.00	0.98
29	(FRA) France	(0164) Poitou-Charentes	0.83	0.86	0.83	0.76	0.85	0.85	0.80	0.82	0.80	0.73	0.66
30	(FRA) France	(0182) Aquitaine	0.88	0.82	0.80	0.70	0.72	0.83	0.76	0.73	0.69	0.67	0.73
31	(FRA) France	(0183) Midi-Pyrénées	0.64	0.53	0.58	0.49	0.48	0.57	0.56	0.51	0.47	0.50	0.48
32	(FRA) France	(0184) Limousin	0.97	0.80	0.74	0.54	0.69	0.76	0.82	0.74	0.64	0.63	0.59
33	(FRA) France	(0192) Rhônes-Alpes	0.71	0.68	0.64	0.49	0.55	0.69	0.67	0.59	0.50	0.55	0.50
34	(FRA) France	(0193) Auvergne	0.98	0.79	0.78	0.61	0.71	0.71	0.76	0.72	0.68	0.69	0.63
35	(FRA) France	(0201) Languedoc-Roussillon	0.85	0.95	0.99	0.84	0.89	0.79	0.70	0.77	0.80	0.91	0.83
36	(FRA) France	(0203) Provence-Alpes-Côte	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
37	(FRA) France	(0204) Corse	0.59	0.58	0.61	0.62	0.59	0.61	0.54	0.53	0.40	0.45	0.51
38	Luxembourg	(0350) Luxembourg	1.00	0.85	0.89	0.66	0.77	0.80	0.80	0.97	0.80	0.89	0.74
39	Netherlands	(0360) The Netherlands	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	(OST) Austria	(0660) Austria	0.82	0.89	0.83	0.27	0.59	0.90	0.93	0.87	0.63	0.71	0.64
		Annual Mean	**0.89**	**0.88**	**0.87**	**0.77**	**0.81**	**0.87**	**0.86**	**0.85**	**0.83**	**0.84**	**0.82**

	Western European Region												
1	(IRE) Ireland	(0380) Ireland	0.85	0.76	0.72	0.57	0.88	0.99	0.91	0.89	0.97	1.00	0.64
2	(UKI) United Kingdom	(0411) England-North	1.00	1.00	1.00	0.89	1.00	1.00	1.00	0.99	0.95	1.00	1.00
3	(UKI) United Kingdom	(0412) England-East	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	(UKI) United Kingdom	(0413) England-West	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	(UKI) United Kingdom	(0421) Wales	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	(UKI) United Kingdom	(0431) Scotland	0.73	0.95	0.83	0.67	0.81	0.85	0.88	0.95	0.80	0.91	0.91
7	(UKI) United Kingdom	(0441) Northern Ireland	0.96	0.98	1.00	0.83	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Annual Mean	**0.93**	**0.96**	**0.93**	**0.85**	**0.96**	**0.98**	**0.97**	**0.98**	**0.96**	**0.99**	**0.94**
	Southern European Region												
1	(ELL) Greece	(0450) Makedonia-Thraki	0.56	0.65	0.70	0.75	0.77	0.85	0.76	1.00	1.00	1.00	1.00
2	(ELL) Greece	(0460) Ipiros-Peloponissos-Nissi	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	(ELL) Greece	(0470) Thessalia	0.61	0.64	0.75	0.84	0.90	1.00	1.00	1.00	0.76	0.87	0.68
4	(ELL) Greece	(0480) Sterea Ellas-Nissi	0.78	0.74	0.76	0.72	1.00	1.00	0.91	0.82	0.76	1.00	1.00
5	(ESP) Spain	(0500) Galicia	1.00	0.96	1.00	0.44	0.98	1.00	1.00	1.00	1.00	1.00	1.00
6	(ESP) Spain	(0505) Asturias	1.00	1.00	1.00	0.34	1.00	1.00	1.00	0.94	0.79	0.98	0.95
7	(ESP) Spain	(0510) Cantabria	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	(ESP) Spain	(0515) Pais Vasco	0.76	0.61	0.74	0.49	0.55	0.98	0.94	0.60	0.66	0.59	0.59
9	(ESP) Spain	(0520) Navarra	0.76	0.79	0.91	0.56	0.74	0.82	0.95	0.87	0.79	0.68	0.67
10	(ESP) Spain	(0525) La Rioja	1.00	1.00	1.00	0.90	1.00	1.00	0.98	1.00	1.00	0.85	0.71
11	(ESP) Spain	(0530) Aragón	1.00	1.00	1.00	0.53	0.93	1.00	1.00	1.00	1.00	0.86	0.92
12	(ESP) Spain	(0535) Cataluna	0.80	0.92	1.00	0.53	0.78	1.00	1.00	1.00	0.66	0.69	0.75
13	(ESP) Spain	(0540) Baleares	0.88	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.53	0.55	0.47
14	(ESP) Spain	(0545) Castilla-León	1.00	1.00	1.00	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	(ESP) Spain	(0550) Madrid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	(ESP) Spain	(0555) Castilla-La Mancha	0.91	0.97	0.79	0.78	0.87	0.94	0.76	0.86	0.90	0.80	0.59
17	(ESP) Spain	(0560) Comunidad Valenciana	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

18	(ESP) Spain	(0565) Murcia	0.90	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00
19	(ESP) Spain	(0570) Extremadura	0.81	0.72	0.71	0.52	0.95	0.94	0.99	0.92	0.70	0.80	0.74
20	(ESP) Spain	(0575) Andalucia	0.55	0.92	0.92	0.94	0.83	0.88	0.89	0.80	0.92	0.79	0.68
21	(ESP) Spain	(0580) Canarias	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
22	(ITA) Italy	(0221) Valle d'Aoste	0.76	0.76	0.82	0.24	0.60	0.77	0.83	0.73	1.00	0.54	0.79
23	(ITA) Italy	(0222) Piemonte	0.61	0.62	0.61	0.62	0.68	0.79	0.81	0.68	0.63	0.65	0.63
24	(ITA) Italy	(0230) Lombardia	1.00	0.86	0.99	0.79	1.00	1.00	1.00	1.00	0.97	1.00	1.00
25	(ITA) Italy	(0241) Trentino	0.65	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26	(ITA) Italy	(0242) Alto-Adige	0.74	0.89	0.77	0.70	0.84	1.00	1.00	0.76	1.00	1.00	0.93
27	(ITA) Italy	(0243) Veneto	0.71	0.87	0.78	0.73	0.81	0.93	0.92	0.75	0.75	0.85	0.85
28	(ITA) Italy	(0244) Friuli-Venezia	0.59	0.81	0.78	0.78	0.86	1.00	1.00	0.89	0.94	0.80	0.84
29	(ITA) Italy	(0250) Liguria	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	(ITA) Italy	(0260) Emilia-Romagna	0.81	0.72	0.85	0.86	0.92	1.00	1.00	1.00	0.87	0.91	0.93
31	(ITA) Italy	(0270) Toscana	0.64	0.76	0.88	1.00	0.99	0.91	0.98	0.97	0.85	0.94	1.00
32	(ITA) Italy	(0281) Marche	0.49	0.59	0.67	0.72	0.78	0.78	0.70	0.79	0.72	0.66	0.76
33	(ITA) Italy	(0282) Umbria	0.45	0.54	0.55	0.54	0.57	0.85	0.79	0.80	0.61	0.68	0.59
34	(ITA) Italy	(0291) Lazio	1.00	0.85	1.00	0.87	0.79	1.00	0.94	0.87	0.70	0.72	0.80
35	(ITA) Italy	(0292) Abruzzo	0.72	0.75	0.73	0.71	0.66	0.88	1.00	0.76	0.51	0.56	0.43
36	(ITA) Italy	(0301) Molise	0.77	0.73	0.67	0.52	0.76	1.00	1.00	1.00	0.76	1.00	1.00
37	(ITA) Italy	(0302) Campania	0.80	0.77	0.91	0.89	0.84	1.00	1.00	0.86	0.85	0.76	0.74
38	(ITA) Italy	(0303) Calabria	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
39	(ITA) Italy	(0311) Puglia	0.74	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	(ITA) Italy	(0312) Basilicata	0.68	0.68	0.85	0.71	0.75	0.85	0.86	0.78	0.58	0.58	0.49
41	(ITA) Italy	(0320) Sicilia	0.77	0.84	1.00	1.00	1.00	1.00	1.00	1.00	0.96	1.00	1.00
42	(ITA) Italy	(0330) Sardegna	0.79	0.71	0.79	0.49	0.69	0.91	0.76	0.79	0.54	0.59	0.73
43	(POR) Portugal	615	0.56	0.58	0.56	0.41	0.54	0.76	0.66	0.62	0.51	0.63	0.61
44	(POR) Portugal	(0630) Ribatejo e Oeste	0.64	0.72	0.95	0.56	0.81	0.99	1.00	0.94	0.55	0.83	1.00
45	(POR) Portugal	(0640) Alentejo e do Algarve	0.42	0.36	0.43	0.40	0.48	0.64	0.38	0.45	0.37	0.44	0.42
46	(POR) Portugal	(0650) Açores	1.00	1.00	1.00	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Annual Mean	**0.80**	**0.83**	**0.87**	**0.74**	**0.86**	**0.94**	**0.93**	**0.90**	**0.83**	**0.84**	**0.83**