THE IMPACTS OF GOVERNANCE ON AGRICULTURAL PRODUCTIVITY: AN INTERNATIONAL ANALYSIS

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AUTHOR DECLARATIONS

1. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

2. The program of advanced study of which this thesis is part has consisted of:

i) Research Methods course during the undergraduate study

ii) Examination of several thesis guides of particular universities both in Turkey and abroad as well as a professional books and journals on this subject.

Senem YILMAZ

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ABSTRACT

The Impacts of Governance on Agricultural Productivity: An International Analysis

The main aim of this study is to explain the interaction between governance and agricultural productivity and to expose the impacts of governance on agricultural productivity by a global context.

Agricultural productivity can be measured as the ratio of agricultural outputs to agricultural inputs via Data Envelopment Analysis (DEA). Model's inputs are agricultural land (km^2), fertility (tons), material (the number of tractors), labour. The output is produced add value in agricultural area as USD currency. In this study, we combined with DEA and a regression analysis as a worldwide context (includes 64 countries). For this purpose, first of all, we used DEA model to analyze the agricultural efficiency of countries by gathering data. DEA provide a description of the agricultural productivity of a country and its productivity change over time or between countries. And then in Panel Data Analysis, we used Worldwide Governance Indicators (WGI),i.e. Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption for worldwide countries.

Key words: Agricultural Efficiency, Governance, Worldwide Governance Indicators, Data Envelopment Analysis, Malmquist Index, Panel Data Regression.

KISA ÖZET

Yönetişimin Tarımsal Verimliliğe Etkisi: Uluslararası Bir Analiz

Bu çalışmanın ana amacı, yönetişim ve ziraî verimlilik arasındaki etkileşmeyi açıklamak ve global çerçevede ziraî verimlilik üzerine yönetişimin etkilerini göstermektir. Ziraî verimlilik, Veri Zarflama Analizi (VZA) yoluyla ziraî çıktıların ziraî girdilere oranı olarak ölçülebilir. Modelin girdileri; ziraî ekilebilir alan (km^2), kullanılan gübre (ton), kullanılan makina (traktör sayısı), işgücü (tarımdaki istihdam)'dır. Modelin çıktısı ise ziraî alanda (Amerikan doları birimiyle ölçülen) üretilmiş katma değerdir. Bu çalışmada VZA ile regresyon analizini birbirine bağlayarak global (64 ülkeyi kapsayan) bir araştırma yaptık. Bu amaçla öncelikle veri toplayarak ülkelerin ziraî verimliliklerini analiz etmek üzere VZA modelini kullandık. VZA bir ülkenin ziraî verimliliğinin ölçümünü verir ve ülkeler arasında yada ülkelerin zaman itibariyle verimlilik değişimlerini de ölçer. Daha sonra panel data analizinde Global Yönetişim İndikatörleri'nin (GYİ) yani; halkın sesi ve hesap verme sorumluluğu (Voice & Accountability), baskı ve şiddet içermeyen siyasi istikrar (Political Stability and Absence of Violence), devletin etkinliği (Government Effectiveness), düzenleme kalitesi (Regulatory Quality), hukukun üstünlüğü (Rule of Law), yolsuzluklarla mücadele (Control of Corruption)'yi kullanarak VZA'nın çıktısı olan üretilmiş katma değer üzerindeki etkisini araştırdık.

Anahtar Kelimeler: Ziraî Verimlilik, Yönetişim, Global Yönetişim İndikatörleri, Veri Zarflama Analizi, Malmquist İndeksi, Panel Data Analizi.

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LIST OF ABBREVIATIONS

DEA	Data Envelopment Analysis
DMU	Decision Making Unit
CCR	Charnes-Cooper-Rhodes
BCC	Banker-Charnes-Cooper
MFP	Multi-factor Productivity
TFP	Total Factor Productivity
TFPC	Total Factor Productivity Change
MENA	Middle East and North Africa
LDC	Less Developed Countries
WGI	Worldwide Governance Indicators
CRS	Constant Returns to Scale
VRS	Variable Returns to Scale
SFA	Stochastic Frontier Analysis
FE	Fixed Effects
RE	Random Effects
OLS	Ordinary Least Squares
FGLR	Fare-Grosskopf-Lindgren-Rots
GDP	Gross Domestic Product
VIF	Variance Inflation Factor

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PREFACE

The agricultural productivity and its measurement are very crucial to economical development in developing countries. In literature lots of studies exist on this subject. And also in recent years it has begun to realize that good governance significantly influences a country's agricultural productivity.

This thesis explores the interaction between governance and agricultural productivity by global context using 64 countries over the period 2002-2008.

I hope this thesis will be useful to people who wants to study this subject.

CHAPTER 1: INTRODUCTION

Agricultural productivity is called the productivity of the resources in agricultural production and is essential for country's economical growth and development level. Agricultural productivity and its improvement are very important for developing countries. In literature lots of studies exist on agricultural productivity and how to improve and measure it. Agricultural productivity depends on some factors such as land, fertility, irrigation, labour force, tools and machines, etc.

In recent years it has begun to realize that good governance also significantly influences a country's agricultural productivity. For measures of the quality of governance, the WorldBank's Worldwide Governance Indicators (WGI, such as Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption) have been produced.

The main aim of this study is to explain the interaction between governance and agricultural productivity and to expose the impacts of governance on agricultural productivity by an international context using 64 countries over the period 2002-2008. For 64 countries, data are gathered from the WorldBank database.

In this study firstly agricultural productivity as the ratio of agricultural outputs to agricultural inputs will be measured by Data Envelopment Analysis (DEA) which is the productivity measurement technique. Model's inputs are agricultural land (km^2), fertility (tons), material (the number of tractors), labour, and model's output is produced add value in agricultural area as USD currency. Using DEA (output-oriented CCR primal model) we will measure the total factor productivity change $(TFPC)$ of the countries by Malmquist index which determined the movements of countries efficiencies within time i.e. efficiency scores of the countries as an average in years 2002-2008.

In the second stage, we will use regression analysis to find the effects of Worldwide Governance Indicators and also education level, and country type denoting development level of country on country's efficiency (i.e. $TFPC$).

As far as we know our study is the first one that searches the effects of governance terms and education and country type on TFPC by combining with DEA and regression models.

This thesis consists of three chapters. In the next chapter, we will give Governance and Agricultural Productivity concepts, the definition of Worldwide Governance Indicators and literature review about governance and agricultural productivity.

In Chapter 3, entitled the same with the thesis title, we will explain the methods we used that are Data Envelopment Analysis, Malmquist Productivity Indexes, Education Index, Multiple Linear Regression and Panel Data Analysis; we will define our countries, inputs and output data sets in Data and Variables section. In Results and Analysis section we will execute our models, and then we will give some results.

In conclusion section, we will conclude our results.

CHAPTER 2: GOVERNANCE AND AGRICULTURAL PRODUCTIVITY

2.1. Concept of Governance

Governance has become a "hot" topic as evidence mounts on the critical role it plays in determining societal well-being. In 2003, The Secretary General of the United Nations, Kofi Annan, reflects a growing consensus when he states that "good governance is perhaps the single most important factor in eradicating poverty and promoting development". Not surprisingly, governance as a term has progressed from obscurity to widespread usage, particularly in the last decade.

The concept of governance may be usefully applied in different contexts – global, national, institutional and community. Understanding governance at the national level is made easier if one considers the different kinds of entities that occupy the social and economic landscape.

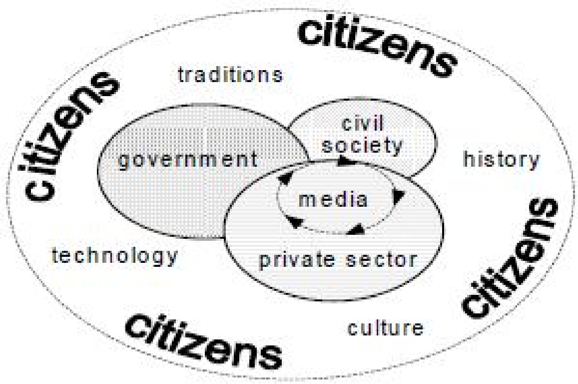

Figure 1: Four sectors of society [Graham et al. (2003)]

Figure 1 illustrates four sectors of society, situated among citizens at large: business, the institutions of civil society (including the voluntary or not-for profit sector), government and the media.

In principle, the concept of governance may be applied to any form of collective action. Governance is about the more strategic aspects of steering: the larger decisions about direction and roles. That is, governance is not only about *where to go,* but also about *who should be involved in deciding*, and in what capacity. There are four areas or zones where the concept is particularly relevant.

• Governance in ‘global space’, or global governance, deals with issues outside the purview of individual governments.

• Governance in ‘national space’, i.e. within a country: this is sometimes understood as the exclusive preserve of government, of which there may be several levels: national, provincial or state, indigenous, urban or local. However, governance is concerned with how other actors, such as civil society organizations, may play a role in taking decisions on matters of public concern.

• Organizational governance (governance in ‘organization space’): this comprises the activities of organizations that are usually accountable to a board of directors. Some will be privately owned and operated, e.g. business corporations. Others may be publicly owned, e.g. hospitals, schools, government corporations, etc.

• Community governance (governance in ‘community space’): this includes activities at a local level where the organizing body may not assume a legal form and where there may not be a formally constituted governing board [Graham et al. (2003)].

2.2. Worldwide Governance Indicators (WGI)

Since the 1990s, development researchers and practitioners have focused on “good governance” as both a means of achieving development and a development objective in itself. The World Bank has defined “good governance” as “epitomized by predictable, open and enlightened policy making; a bureaucracy imbued with a professional ethos; an executive arm of government accountable for its actions; and a strong civil society participating in public affairs; and all behaving under the rule of law". In response to the growing demand for measures of the quality of governance, a number of aggregate governance indicators have been produced, such as the World Bank's Worldwide Governance Indicators ("WGI"). The WGI rank countries with respect to six aspects of good governance: Voice and Accountability, Political Stability and Violence, Government Effectiveness, Rule of Law, Regulatory Quality, and Control of Corruption.

The Worldwide Governance Indicators are based on several hundred variables produced by 25 different sources, including both public and private (commercial) data providers. The WGI cover 213 countries and territories (Thomas, 2008).

The Worldwide Governance Indicators are defined as follows:

Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media (WorldBank,2011a).

Political stability and absence of violence measures the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism (WorldBank,2011b).

Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (WorldBank,2011c).

Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development (WorldBank,2011d).

Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence (WorldBank,2011e).

Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests (WorldBank,2011f).

Economists, including the authors of the indicators, have used the indicators to explore the relationship between governance and growth [Thomas (2008)].

Thomas (2009) dismisses the Worldwide Governance Indicators (WGI) as an "elaborate and unsupported hypothesis" because of the failure to demonstrate the "construct validity" of these indicators. Kauffman et al. (2009) in their response paper argue that "construct validity" is not a useful tool to assess the merits of the WGI, and even if it were, Thomas provides no evidence of any practical consequences of failure to meet the criteria of construct validity.

The six WGI are recognized by many researchers as the most effective tools for assessing the status of governance in different countries. However, these indicators are highly interrelated (Lio and Liu, 2008).

Table 1: Correlation matrix for the 2005 WGI (Thomas, 2008)

	Voice and Accountability	Political Stability and Violence	Government Effectiveness	Regulatory Quality	Rule of Law	Control of Corruption
Voice and Accountability	1.00					
Political Stability and Violence	0.70	1.00				
Government Effectiveness	0.79	0.75	1.00			
Regulatory Quality	0.80	0.72	**0.96**	1.00		
Rule of Law	0.78	0.81	**0.95**	**0.91**	1.00	
Control of Corruption	0.74	0.75	**0.95**	0.90	**0.95**	1.00

Table 1 shows the pair wise correlation among the governance indicators for the data for the year 2005 (Thomas, 2008).

As the governance indicators are highly interrelated, one governance indicator may affect agricultural performance directly or indirectly by influencing other governance indicators. For example, corruption can affect agricultural performance by serving as an indirect tax that will raise transaction costs. Corruption will also reduce the government's effectiveness in terms of providing agricultural infrastructure such as roads, and will erode the people's confidence in the government and their willingness to abide by rules, and both will increase transaction costs in the agricultural sector. The status of communications in the rural areas that affect agricultural production is determined by whether the government can effectively provide the necessary telecommunications infrastructure and related services and/or adopt market-friendly policies in the telecommunications sector. Improvements in the communications in rural areas are helpful to enforcing contracts and monitoring the behavior of local government, and can therefore improve the efficiency of the judiciary system, enhance the quality of the regulatory framework, and better control corruption (Lio and Liu, 2008).

2.3. Agricultural Productivity

2.3.1. The Definition of the Productivity

By concerning with evaluating of performance especially concerning with evaluating the activities of organizations such as business firms, government agencies, hospitals, educational institutions, etc., evaluations take a variety of forms. Examples include cost per unit, profit per unit, satisfaction per unit, and so on, which are measures stated in the form of a ratio like the following,

$$\frac{Output}{Input}$$

This is a commonly used measure of efficiency. The usual measure of "productivity" also assumes a ratio form when used to evaluate worker or employee performance. "Output per worker hour" or "output per worker employeed" are examples with sales, profit or other measures of output appearing in the numerator. Such measures are sometimes referred to as "partial productivity measures." This terminology is intended to distinguish them from "total factor productivity measures", because the latter attempt to obtain an output-to-input ratio value which takes account of *all* outputs and *all* inputs. Moving from partial to total factor productivity measures by combining all inputs and all outputs to obtain a single ratio helps to avoid imputing gains to one factor (or one output) that are really attributable to some other input (or output). For instance a gain in output resulting from and increase in capital or improved management might be mistakenly attributed to labour (when a single output to input ratio is used) even though the performance of the labour *deteriorated* during the period being considered. However an attempt to move from partial to total factor productivity measures encounters difficulties such as choosing the inputs and outputs to be considered and the weights to be used in order to obtain a single output to single input ratio that reduce to a form like expression output/input [Cooper et al., 2003, pp.1-2].

2.3.2. Agricultural Productivity

The *productivity* term appeared in 1830. This term has been changed from qualitative to quantitative can be possible at the end of the nineteen century and the beginning of the twentieth century. Firstly the measurement of productivity has been made partially [Çelik, 2000].

Productivity is one of the unbiased measurements to determine a country's or a sector's economical growth and development level. But tightly, productivity mean is the relationship between input and output.

Agriculture is one of the life branches of the economy. Nowadays, people have more awareness about the agriculture.

Agricultural productivity is influenced by some factor series such as; irrigation, fertility, seed, medication, labor force, land, tools and machines and also the logistics, the storage and marketing of the product, input prices, product prices, tax, government incentives, supportive buying, business size, land ownership, the manufacturers' association status, social structure, educational and research facilities, the structure of a land and climatic condition [Çelik, 2000, pp. 13].

Agricultural productivity is a short name for the productivity of resources in agricultural production. Aside of the general interest in the working of the economy, there are several important reasons for our interest in agricultural productivity: food supply, growth aspects, competitive position of agriculture in the factor markets, off-farm labour migration, intersectoral flow of savings, farmers' income and more.

The concept of productivity, regardless of the actual method used in computing productivity calls for a comparison of changes in outputs and inputs. In that, it is implicitly assumed that regularity in the relationship between inputs and outputs prevails over time or across producers so that the results of one comparison are valuable in predicting the response of output to input changes in another experiment. It is this repetitious property that justifies the study of such input output relationships, usefully summarized in terms of the production function. Some writers or analysts avoid the use of the concept of a production function and some even object to it. However, the assumption of regularity in production gives rise to such a concept.

When the output obtained from a given set of inputs increases, we say that there is an improvement in productivity or more commonly, technical change. Such a comparison of two points with inputs held constant is a conceptual exercise because in reality inputs do not necessarily remain constant and while output grows, both outputs and inputs vary over time or among producers. Thus, in order to evaluate changes in productivity empirically it is necessary to determine the change in inputs and outputs. The various inputs do not ordinarily change at the same rate over the sample, so they have to be aggregated in order to yield a measure of total input change. Such an aggregation requires assigning weights to the contribution of the various inputs to output. The weights can be obtained by assuming that the observed factor shares provide an appropriate measure of the importance of the inputs in production. Such a procedure is based on some assumptions with respect to factor market behaviour which should not be taken at face value in empirical analysis. Thus, weights are obtained from empirical analysis using the available historical information. This procedure calls for the estimation of the production function [Mundlak, 1992].

2.3.3. The Effect of Governance on Agricultural Productivity

The institutions and policies affecting economic performance can be referred to as the governance infrastructure of a country. The governance infrastructure may affect agricultural performance in several ways. For instance, the government creates and maintains institutions that are crucial to the functioning of the market system. The protection of property rights and a judicial system administering justice and enforcing contracts strongly affect the incentives for production and investment. In addition, good governance underpins a competitive and low-transaction-cost environment, which encourages agricultural innovation and stimulates the adoption of new technologies and forms of organization. The government acts as an important provider of rural infrastructure, public goods and services, and essential information. The government also determines macroeconomic policies that affect both agricultural production and investment. In some countries, agricultural development has been seriously hindered by market-unfriendly policies that are a characteristic of bad governance.

It is evident that the agricultural productivity in many developing countries is lagging far behind that of the developed countries. A substantial body of literature in this area mainly attributes this divide to cross-country heterogeneity in tangible assets and technologies. In recent years, there has been a growing interest in the effect of governance on agricultural performance. However, most of the research in this area has consisted of case studies, and little cross-country evidence has been presented in the related literature [Lio and Liu, 2008].

2.4. Literature Review

Some researches has been done on Agricultural Productivity Analysis in some regions such as Nigeria [Fakayode et al. 2008], India [Dayal, E., 1984], Vietnam [Minh and Long, 2008], OECD Countries [Park and Jensen, 2007], MENA region [Jemma and Dhif, 2005] and European Union and Eastern Region[Serrao, A., 2003], etc. In [Kaufmann et al., 2007], governance indicators are defined as Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Some of these studies include DEA and Malmquist Index to find Total Factor Productivity (TFP); and one of them [Lio and Liu, 2008] is related to the governance, and adopts two linear regression methods to test the hypothesis that better governance improves agricultural productivity.

Dayal (1984) employed three indexes of agricultural productivity—land productivity, labour productivity and aggregate productivity—to measure and map productivity patterns in India. There are large regional inequalities in the levels of productivity. Regression analysis reveals that the spatial variation of land productivity is positively related to fertilizer use, irrigation and urban-industrial development and is negatively related to population density. Labour productivity is positively associated with agricultural wages and fertilizer use and negatively with the density of agricultural workers on the net sown area. Aggregate productivity is positively associated with fertilizer and irrigation use and negatively with the densities of population and agricultural workers. The significant explanatory variables in the regressions explain 61 per cent of land productivity, 57 per cent of labour productivity and 42 per cent of aggregate productivity.

Developing countries often tax agriculture heavily a practice that might affect the productivity as well as the quantity of resources allocated to agriculture. Fulginiti and Perrin (1993) estimated a variable-coefficient cross-country agricultural production function with past price expectations among the determinants of the production coefficients. Productivity's responsiveness to those expectations implies that had these developing economies eliminated price interventions, agricultural productivity would have increased on average by about a fourth.

Millan and Aldaz (1998) applied nonparametric programming techniques to productivity growth of the agricultural sectors of the seventeen Spanish regions over the period 1977-1988. They linked productivity changes based on conventional inputs to other economic, geographic and institutional issues. They found that average technical change in the Spanish regions grew at an annual rate of 2.9%, but with great regional variation.

Fulginiti and Perrin (1997,1998) examined changes in agricultural productivity in 18 developing countries over the period 1961-1985. They used two quantity-based methods, a non-parametric, output based Malmquist index and a parametric variable coefficients Cobb-Douglas production function to examine, whether their estimates confirm results from other studies that have indicated declining agricultural productivity in less developing countries' (LDC). The results confirmed previous findings indicating that at least half of these countries have experienced productivity declines in agriculture. They also found that those countries that tax agriculture most heavily had the most negative rates of productivity change.

Thirtle et. al. (2000) applied nonparametric Data Envelopment Analysis (DEA) methods leads naturally to regional multi-lateral Malmquist multi-factor productivity (MFP) indices for agriculture in the eighteen regions and the commercial sector of Botswana, which is an African country, from 1981 to 1996. MFP indices are aggregated to give a MFP for the sector. The DEA approach is appropriate because there are no prices for the major inputs such as land and labour. The small size of cross section is overcome by using the sequential version of the Malmquist, which accumulates the annual data, so increasing the stability of the frontier. The regional MFPs are the natural peer group for producing a national MFP, so the problem of choosing peers, in earlier work on international comparisons does not arise. From the analysis of the MFP series for the eighteen regions and the commercial sector they showed that there was no evidence of convergence. That is, the poorer regions stayed poorer, rather than catched up. There was also no clear evidence that the commercial sector performed significantly better than the traditional farmers.

Rungsuriyawiboon and Lissitsa (2002) is empirically implemented by using a panel data set of European Agriculture on 44 countries over the time period of 1992-2002 to measure and compare the productivity growth among the European Union countries via Malmquist TFP index using the nonparametric technique of DEA to fit distance functions index. This approach is nonstochastic and assumes a constant return to scale on the frontier technology. The advantages of this approach are that it requires data only on quantities and provides what sources are attributed to productivity growth. This information is very useful for policy makers in designing suitable policies to promote the productivity of firms in the industry. They applied this approach to measure and decompose productivity growth in European agricultural production. Their main objective is to measure and compare the levels and trends in agricultural productivity among the European countries.

Serrao (2003) used stochastic frontier analysis (SFA) and DEA to examine the sources of agricultural productivity growth over time and of productivity differences among countries and regions in European Union over the period 1980-1998. A comparison of the mean productivity scores obtained by the two approaches show that DEA results are higher than in SFA results, because DEA fits a tighter (more flexible) than the translog frontier. This study is a valuable warning for people to be carefully about the effects of the methodology choice upon their results and to use more than one approach if they suspect that it may have some influence.

Coelli and Rao (2005) examined the levels and trends in agricultural output and productivity in 93 developed and developing countries that account for a major portion of the world population and agricultural output. They made use of data drawn from the Food and Agriculture Organization of the United Nations (FAO) and their study covers the period 1980-2000. Due to the nonavailability of reliable input price data, the study used DEA to derive Malmquist productivity indices. The study examined trends in agricultural productivity over the period. Issues of catch-up and convergence, or in some cases possible divergence, in productivity in agriculture are examined within a global framework. The paper also derived the shadow prices and value shares that are implicit in the DEA-based Malmquist productivity indices, and examined the plausibility of their levels and trends over the study period.

Jemaa and Dhif (2005) provided a database of TFP growth technical efficiency and input productivity for 12 MENA (Middle East and North Africa) region's countries and their potential competitors in terms of agricultural products into the European market. Using the metafrontier approach (Rao et. al. 2003), technical efficiency scores are corrected by the coefficient of technology gap since production technologies are different in the two regions. The effects of some salient determinants of technical efficiency are assessed in order to identify the reasons of discrepancies between these two regions.

Lio and Liu (2008) examined the relationship between governance and agricultural performance by employing the World Bank's Aggregate Governance Indicators. Based on a cross-country panel sample, two methods are employed to test the hypothesis that better governance fosters agricultural productivity. The empirical results of both methods support the hypothesis. As for the first method, the estimation results of the widely-used inter-country aggregate agricultural production function show that a country with better governance can produce more agricultural outputs, given the same amounts of agricultural inputs, the same education level, and the same climate condition. As for the second method, the empirical results of a structural equation model reveal that, given the same amounts of agricultural capital stock and land, an agricultural worker in a country with better governance produces more. Better governance can indirectly improve agricultural productivity by driving agricultural capital accumulation. Their empirical work lends support to the claim of Hayami and Ruttan (1985) that governance is a basic factor explaining the poor economic performance of many developing countries. In order to improve the agricultural performance of many developing countries, apart from physical and education investments, more emphasis should be placed on improving the governance infrastructure of these countries.

Fakayode et al. examined empirically the place of infrastructure in the agricultural productivity of majority farm households in Nigeria, using farm level data from Ekiti State, Nigeria. The study specifically surveyed eight infrastructures: roads, health centers, market centers, water supply, electricity supply, banks, communication gadgets and education and their influence on the agricultural productivity in the study areas. Data for the study were gathered from one hundred farm households and fifteen discussant groups selected across the study area. The study data were analysed the TFP and the Ordinary Least Squares (OLS) regression analysis. Results indicate that most of the road infrastructures in the study area were in a bad state of disrepairs. The status of infrastructures availability were for health facilities (86.6 per cent), market (93.3 per cent), pipe-born water (86.6 per cent), electricity (66.7 per cent), bank (73.3 per cent), communication facilities (93.3 per cent), primary school (100.0 per cent), secondary schools (86.6 per cent) and higher institutions (0.0 per cent). However, the infrastructural index computed for the study area was revealed to be low, 0.32. The food farm TFP for the farm households averaged 2.4 while land size, fertilizers and rural infrastructural indices were shown to significantly influence farms productivity levels. The study therefore calls for the rehabilitation of roads in the rural areas, a reasonable reduction in transport fares and the initiation of researches on labour saving devices for agriculture in the study area.

Minh and Long (2008) used DEA approach to estimate technical efficiency for the agriculture production activities in sixty provinces of Vietnam in the period 1990-2005. Measurements under different technology specifications show that the average technical efficiency was not high, and thus the provinces could have a large room to improve their agricultural production efficiency. The application the rank statistics technique indicates that the studied provinces had stable relative efficiency positions over time i.e. at least one province was consistently technically better or worse than the others. Further, under the specification of variable returns to scale (VRS), the results from a Monte Carlo simulation show that the DEA estimators of technical efficiency with and without bootstraps are not really different.

As policymakers and researchers focus more on the impact of governance in economic development, they have required measures of the quality of governance to set policy or to conduct analyses. A number of measures of the quality of governance have been created. Among these are the Worldwide Governance Indicators, which rank countries on six aspects of "good governance". Critics have focused on problems of bias or lack of comparability that raise questions about the utility of these indicators. However, a more fundamental question is whether they measure what they purport to measure. Thomas (2008) considered the construct validity of the indicators and raised the risk that researchers and policymakers may be relying on wrong data, rather than poor data.

Bayramoglu (2010) was researched production performance in agriculture of Turkey during the periods 1981-2008. Agricultural production can be improved by some factors such as right amount of chemical applications, use of high quality production materials, utilization of suitable machinery, increasing of cultivated and irrigated land and adaptation of water saving irrigation technologies. Real agricultural gross domestic product as a representative of total agricultural production was used. To express this, Logarithmic regression model was applied. In model chemical fertilizers use as crop nutrient element, tractors number and milk yield per animal were used as explanatory variables. The variables explained 92.6% variation on the real agricultural gross domestic product. In result of model, production elasticity of chemical fertilizers as plant nutrients, milk yield per cow and tractor number were calculated as 7.8%, 9.4%, 28.2%, respectively.

CHAPTER 3: THE IMPACTS OF GOVERNANCE ON AGRICULTURAL PRODUCTIVITY: AN INTERNATIONAL ANALYSIS

3.1. Methods

3.1.1. Data Envelopment Analysis (DEA)

In 1957 a paper was published in the journal of the Royal Statistical Society by MJ Farrell on *The Measurement of Productive Efficiency*. This paper provided the background for Data Envelopment Analysis (DEA).

Data Envelopment Analysis is itself a basic concept and an effective tool for measuring efficiency. DEA, first demonstrated by Charnes, Cooper and Rhodes at 1978 [Ahn et al., 1988] can be applied to empirical data via different types of models to obtain estimates of the relative technical efficiency of a group of Decision Making Units (DMUs). It uses values of multiple outputs and inputs for each DMU and mathematically selects efficient DMUs. Evaluating each DMU, the amounts and sources of its inefficiencies are also determined.

In DEA, the organizational units such as cities, hospitals, banks, schools, products, firms, teams, etc. are serve as DMUs. Guiding principles to use in choosing DMUs are:

(1) each DMU should be identified as an entity which is responsible for the resources it uses and the outputs it produces and

(2) the number of DMUs utilized should be large enough to provide an adequate number of degrees of freedom—as determined by the number of DMUs relative to the number of outputs and inputs used in the study—to help ensure that the resulting efficiency measures are meaningful.

For DEA, several essential mathematical programming models exist in literature. Basic DEA models with accompanying interpretive possibilities are as follows [Charnes et al., 1994]:

1. The CCR ratio model (1978)
   i) yields an objective evaluation of overall efficiency and
   ii) identifies the sources and estimates the amounts of the thus-identified inefficiencies;
2. The Banker-Charnes-Cooper (BCC) model (1984) distinguishes between technical and scale inefficiencies by
   i) estimating pure technical efficiency at the given scale of operation and
   ii) identifying whether increasing, decreasing, or constant returns to scale possibilities are present for further exploitation;
3. The Multiplicative Models (Charnes et al., 1882, 1983) provide
   i) a log-linear envelopment or
   ii) a piecewise Cobb-Douglas interpretation of the production process (by reduction of the antecedent 1981 additive model of Charnes, Cooper, and Seiford); and
4. The Additive Model (as better rendered in (Charnes et al., 1985) and the extended Additive Model (Charnes et al., 1987)
   i) relate DEA to the earlier Charnes-Cooper (1959) inefficiency analysis and in the process
   ii) relate the efficiency results to the economic concept of Pareto optimality as interpreted in the still earlier work of T. Koopmans (1949) in the volume that published the proceedings of the first conference on linear programming.

While each of these models addresses managerial and economic issues and provide useful results, their orientations are different and, more importantly, they generalize and provide contact with these disciplines and concepts. Thus, models may focus on increasing, decreasing, or constant returns to scale as found in economics that are here generalized to the case of multiple outputs. They may determine an efficient frontier that may be piecewise linear, piecewise log-linear, or piecewise Cobb-Douglas with, again, generalization to the multiple-output/input situations being achieved in the process. They may utilize non-Archimedean constructs, and they may focus on either input reduction or output augmentation to achieve efficiency.

These basic DEA models are generally given in [Charnes et. al., 1994]. Primal and dual characterizations for each model are also presented, and comparisons between models are developed via geometric portrayals of the corresponding envelopment surfaces, return-to-scale properties, projections onto the efficient surface, and invariance of measurement units.

Essentially, the various models for DEA each seek to establish which subset of n DMUs determine parts of an *envelopment surface*. The geometry of this envelopment surface is prescribed by the specific DEA model employed. To be efficient, the point P_j corresponding DMU$_j$ must lie on this surface. Units that do not lie on the surface are termed inefficient, and the DEA analysis identifies the sources and amounts of inefficiency and/or provides a summary measure of relative efficiency. The envelopment surface, called the efficient frontier serves to (1) characterize efficiency and (2) identify inefficiencies.

Let's assume that there are n DMUs to be evaluated. Each DMUs consumes varying amounts of m different inputs to produce s difference outputs. Specifically, DMU$_j$ consumes amounts $X_j = \{x_{ij}\}$ of inputs $i = 1,\ldots,m$ and produces amounts $Y_j = \{y_{rj}\}$ of outputs $r = 1,\ldots,s$. For these constants, which generally take the form of observations, we assume $x_{ij} > 0$ ve $y_{rj} > 0$. The $s \times n$ matrix of output measures is denoted by Y, and the $m \times n$ matrix of input measures is denoted by X.

In this section we will shortly examine the CCR ratio model, because the CCR and BCC models were originally derived from the ratio forms:

3.1.1.1. CCR Input Ratio Form:

The essential characteristic of the CCR ratio construction is the reduction of the multiple-output/multiple-input situation (for each DMU) to that of a single 'virtual' output and 'virtual' input. For a particular DMU the ratio of this single virtual output to single virtual input provides a measure of efficiency that is a function of the multipliers. This ratio, which is to be maximized, forms the objective function for the particular DMU being evaluated, so that symbolically

$$\max_{u,v} \; h_o(u,v) = \frac{\sum_r u_r y_{ro}}{\sum_i v_i x_{io}}. \qquad (1)$$

where it should be noted that the variables are the u_r's and v_i's (the y_{ro}'s and x_{io}'s being the observed output and input values, respectively, of DMU$_o$, (the DMU to be evaluated). Of course, without further additional constraints (developed below) equation (1) is unbounded. The additional set of (technological) constraints (one for each DMU) reflects the condition that the ratio of virtual output to virtual input of every DMU should be less than or equal to unity. By simultaneously evaluating multiple inputs and outputs common to each unit; each DMU is thus assigned an efficiency score. The original formulation of DEA model is called the "CCR (input-oriented) ratio form" is

$$\max_{u,v} \frac{\sum_r u_r y_{ro}}{\sum_i v_i x_{io}}$$

$$\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \leq 1 \quad \text{for } j = 0,1,\ldots,n$$

$$\frac{u_r}{\sum_i v_i x_{io}} \geq \varepsilon \quad \text{for r} = 1,\ldots,s \qquad \text{(CCR-IR)}$$

$$\frac{v_i}{\sum_i v_i x_{io}} \geq \varepsilon \quad \text{for i} = 1,\ldots,m$$

It is a family of fractional linear programs; each linear program measures the relative efficiency of a particular DMU. Even though the modeling is nonlinear, under appropriate transformations the efficiency rating can be derived from an equivalent linear program. The above ratio form yields an infinite number of solutions; if (u^*, v^*) is optimal, then $(\beta u^*, \beta v^*)$ is also optimal for $\beta > 0$. One can define an equivalence relation that partitions the set of feasible solutions of (CCR-IR) into equivalence classes. The Charnes and Cooper variable transformation [Charnes and Cooper, 1962] for linear fractional programming selects a representative solution. (i.e., the solution $(u \ , v \ )$ for which $v^T X_o = 1$) from each equivalence class and yields the following equivalent linear programming problem:

$$\max_{\mu,v} w_o = \sum_r \mu_r y_{ro}$$

$$\text{s.t.} \qquad \sum_i v_i x_{io} = 1$$

$$\sum_i \mu_r y_{rj} - \sum_i v_i x_{ij} \leq 0 \qquad \text{(CCR}_\text{D}\text{-I)}$$

$$\mu_r \geq \varepsilon$$

$$v_i \geq \varepsilon$$

whose LP dual problem is as follows:

$$\min_{\theta,\lambda,s_r^+,s_i^-} \quad z_o = \theta - \varepsilon\sum_r s_r^+ - \varepsilon\sum_i s_i^-$$

$$\text{s.t.} \qquad \sum_j \lambda_j Y_j - s^+ = Y_o$$

$$\theta X_o - \sum_j \lambda_j X_j - s^- = 0 \qquad \text{(CCR}_\text{P}\text{-I)}$$

$$\lambda_j \ , s_r^+, s_i^- \geq 0$$

<u>**Input-Oriented CCR Primal**</u> <u>**Input-Oriented CCR Dual**</u>

(CCR$_P$-I) **(CCR$_D$-I)**

$$\min_{\theta,\lambda,s^+,s^-} \quad z_o = \theta - \varepsilon\cdot\mathbf{1}s^+ - \varepsilon\cdot\mathbf{1}s^-$$

$$\text{s.t.} \qquad Y\lambda - s^+ = Y_o$$

$$\theta X_o - X\lambda - s^- = 0$$

$$\lambda \ , s^+, s^- \geq 0$$

$$\max_{\mu,\nu} \quad w_o = \mu^T Y_o$$

$$\text{s.t.} \qquad \nu^T X_o = 1$$

$$\mu^T Y - \nu^T X \leq 0$$

$$-\mu^T \leq -\varepsilon\cdot\mathbf{1}$$

$$-\nu^T \leq -\varepsilon\cdot\mathbf{1}$$

The term Data Envelopment Analysis, as coined in Charnes, Cooper and Rhodes [Charnes et al., 1978], was suggested by the formulation CCR Primal in which, as may be observed, an optimal solution envelops the inputs from below and the outputs from above. So the primal problem on the left is referred to as the *envelopment form* while dual problem on the right is the *multiplier form*. The CCR dual formulation may be interpreted so that the objective is to maximize the virtual output for DMU$_o$ with (a) virtual input constrained to unity, and (b) no virtual output can exceed the virtual input value used in its production with, also, (c) all variables restricted to be positive with values at least as great as $\varepsilon > 0$ [Ahn et al., 1988].

The variable θ appears in the primal problem, and the constant ε, a non-Archimedean (infinitesimal) constant, appears both in the primal objective function and as a lower bound for the multipliers in the dual problem. The (scaler) variable θ is the (proportional) reduction applied to all inputs of DMU$_o$ (the DMU being evaluated) to improve efficiency. This reduction is applied simultaneously to all inputs and results in a radial movement toward the envelopment surface. The presence of the non-Archimedean ε in the primal objective function effectively allows the minimization over θ to preempt the optimization involving the slacks. Thus, the optimization can be computed in a two-stage process with maximal reduction of inputs being achieved first, via the optimal θ^*; then, in the second stage, movement onto the efficient frontier is achieved via the slack variables (s^+ and s^-). Evidently the following two statements are equivalent:

1. A DMU is efficient if and only if the following two conditions are satisfied:
   (a) $\theta^* = 1$,
   (b) all slacks are zero.
2. A DMU is efficient if and only if $w_0^* = z_0^* = 1$.

The nonzero slacks and the value of $\theta^* \leq 1$ identify the sources and amount of any inefficiency that may be present [Charnes et al., 1994, pp.32].

3.1.1.2. CCR Output Ratio Form:

Alternately, one could have started with the output side and considered instead the ratio of virtual input to virtual output as given by

$$\min_{u,v} \frac{v^T X_o}{u^T Y_o}$$

$$\text{s.t.} \quad \frac{v^T X_j}{u^T Y_j} \geq 1 \quad \text{for } j = 1, \ldots, n \qquad \text{(CCR-OR)}$$

$$\frac{u}{u^T Y_o} \geq \varepsilon \mathbf{1}$$

$$\frac{v}{u^T Y_o} \geq \varepsilon \mathbf{1}$$

Again, the Charnes-Cooper variable transformation [Charnes and Cooper, 1962] for linear fractional programming, that is $\mu^T = u^T / u^T Y_o$, $v^T = v^T / u^T Y_o$, yields CCR_D-O with its associated dual problem, CCR_P-O.

Output-Oriented CCR Primal (CCR_P-O)	**Output-Oriented CCR Dual (CCR_D-O)**
$\max_{\theta,\lambda,s_r^+,s_i^-} \quad z_o = \phi + \varepsilon \cdot \mathbf{1}s^+ + \varepsilon \cdot \mathbf{1}s^-$	$\min_{\mu,v} \quad q_o = v^T X_o$
s.t. $\quad \phi Y_0 - Y\lambda + s^+ = 0$	s.t. $\quad \mu^T Y_o = 1$
$X\lambda + s^- = X_o$	$-\mu^T Y + v^T X \geq 0$
$\lambda, s^+, s^- \geq 0$	$\mu \geq \varepsilon \cdot \mathbf{1}$
	$v \geq \varepsilon \cdot \mathbf{1}$

In the dual linear programs for the input-oriented CCR model, it should note that neither the convexity constraint ($\mathbf{1}\lambda = 1$) nor the variable u_o appears in the formulation. If the convexity constraint $e^T \lambda \geq 1$ is added to formulation CCR primal and the objective function of the CCR dual is replaced by $\max_{v} \; w_0 = \mu^T Y_0 + u_0$, than it is obtained input-oriented BCC primal problem. The absence of the convexity constraint enlarges the feasible region for CCR primal from the convex hull considered in the BCC primal model to the *conical* hull of (or the convex cone generated by) the DMUs. The result is a reduction in the number of efficient DMUs.

In an input orientation, the objective is to produce the observed outputs with a minimum resource level. For the CCR input orientation, the efficient projection is given by $\left(X_0, Y_0\right) \rightarrow \left(\hat{X}_0, \hat{Y}_0\right) = \left(\theta^* X_0 - s^{-*}, Y_0 + s^{+*}\right)$ or, equivalently, $\left(\hat{X}_0, \hat{Y}_0\right) = \left(X\lambda^*, Y\lambda^*\right)$. It is shown that "If a DMU is characterized as efficient in the CCR model, it will also be characterized as efficient with the BCC model; the converse does not necessarily hold" (see Ahn et al., 1988] for theoretical differences in efficiency characterizations of different DEA models). Differences in the actual efficiency scores/projections simply reflect the metrics used in the models.

For the BCC and CCR ratio formulations, a change in orientation simply amounts to inverting the ratio. The effect is less obvious for the linear programming formulations of them, since the Charnes-Cooper transformation in fractional programming selects the denominator of the ratio for the normalizing constraint and uses the numerator of the ratio as the objective function of the equivalent linear program. Thus, the effect of passing from an input to an output orientation for the BCC and CCR models is the observed rearrangement of normalizing constraint and objective function for the (multiplier side) linear program.

The choice of a particular DEA model determines the implicit return-to-scale properties; the geometry of the envelopment surface (with respect to which efficiency measurements will be made); and the efficient projection, i.e., the inefficient DMU's path to the efficient frontier [Charnes et al., 1994, pp.23-46].

In this thesis, to make the number of efficient DMUs reduce we will use the output-oriented CCR primal model.

3.1.2. Malmquist Productivity Indexes

One quantity-based conceptual approach to measuring productivity change is to compare observed change in output with the imputed change in output that would have been possible from the observed input changes, the imputation being based on the production possibilities set for either the current or the subsequent period. Since in the multiple-output, multiple-input situation the concept of a production function is not operable for such a comparison, Caves et al. (1982) proposed using the ratio of two distance functions to implement this measure of productivity change. They named index after Malmquist in 1953 who had proposed constructing quantity indexes as ratios of distance functions. Since two Malmquist ratios are available for any time interval (depending on whether the reference technology is that of the initial period or the subsequent period), [Fare et al., 1992] proposed the use of the geometric mean of the two. This Malmquist index has the additional feature that it can be decomposed into the product of a pure efficiency change component, a scale efficiency change component and a technological change component. In terms of data requirements, the Malmquist index requires only quantity data whereas the indexing approaches to productivity measurement require data on prices as well as quantities of inputs and outputs.

To define and decompose the output-based malmquist index of productivity change, by following Fare et al. first we define the output distance function a time t is defined as

$$D^t(x^t, y^t) = \inf\left\{\theta \middle| (x^t, \frac{y^t}{\theta}) \in S^t\right\}$$

where the production technology S^t is defined as the set of all feasible input be the $x^t = (x^1, \ldots, x^m)$ and output pairs $y^t = (y^1, \ldots, y^r)$ for each time period $t = 1, \ldots, T$.

In words, the distance θ is the ratio of the current output basket to the maximum achievable multiple of that basket given the current level of inputs. Note that $D^t(x^t, y^t) = 1$ if and only if (x^t, y^t) is on the boundary or frontier of technology, and $D^t(x^t, y^t) \leq 1$ if and only if $(x^t, y^t) \in S^t$. These concepts can be illustrated for the case of a single output and single input as in Fig 2. Here the boundary of the technology is represented as S^t_{CRS} for a constant returns-to-scale (CRS) technology, or S^t_{VRS} for a variable returns-to-scale (VRS) technology. Observed production at t, (x^t, y^t) is interior to the period-t boundary. The distance function $D^t(x^t, y^t)$ is the ratio of observed output to maximum output attainable for input x^t with year t technology, or $0a/0b$ (for CRS technology). In Fig. 2 this distance is less than one, and it is said that the observed point is not Farrell efficient. The distance function $D^{t+1}(x^t, y^t)$ relates observed output to the maximum attainable with year $t+1$ technology, or $0a/0f$.

In the multiple-output-multiple-input case, the notion of a production function is no longer adequate to describe the frontier, but the output distance function, $D^t(x^t, y^t)$ nonetheless, completely characterizes the technology and the efficiency of any input-output combination with respect to that technology. The Caves et al. (1982) version of the Malmquist productivity change can be expressed as

$$m^t = \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \text{ , or } \quad m^{t+1} = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}.$$

The reference technology for the first ratio is S^t, and for the second it is S^{t+1}. If $m > 1$, productivity has increased between t and $t+1$. The Fare-Grosskopf-Lindgren-Rots (FGLR) index measures productivity change as the geometric mean of the above two indexes, or

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}.$$

An index with value greater than unity reveals improved productivity. They note that this expression can be factored as

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$$

where the ratio outside the brackets measures the change in relative efficiency (i.e., the change in the distance of observed production from maximum feasible production) between years t and $t+1$, while the bracketed term measures the shift in technology between the two periods evaluated at x^t and x^{t+1} (or technical change). Technical efficiency and technical change indexes exceeding unity reflect gains in those components.

For the case of scalar output and input and a CRS technology, this index and its components can again be illustrated in Fig. 2, where technical advance has occurred. In terms of the distances along the y-axis, the index becomes

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{c}{d} \frac{b}{a} \left[\frac{c/e}{c/d} \frac{a/b}{a/f} \right]^{\frac{1}{2}}$$

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{c}{d} \frac{b}{a} \left[\frac{d}{e} \frac{f}{b} \right]^{\frac{1}{2}}$$

and in terms of the production function, it is

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{\dfrac{y^{t+1}}{f^{t+1}(x^{t+1})}}{\dfrac{y^t}{f^t(x^t)}} \left[\frac{f^{t+1}(x^t)}{f^t(x^t)} \frac{f^{t+1}(x^{t+1})}{f^t(x^{t+1})} \right]^{\frac{1}{2}}.$$

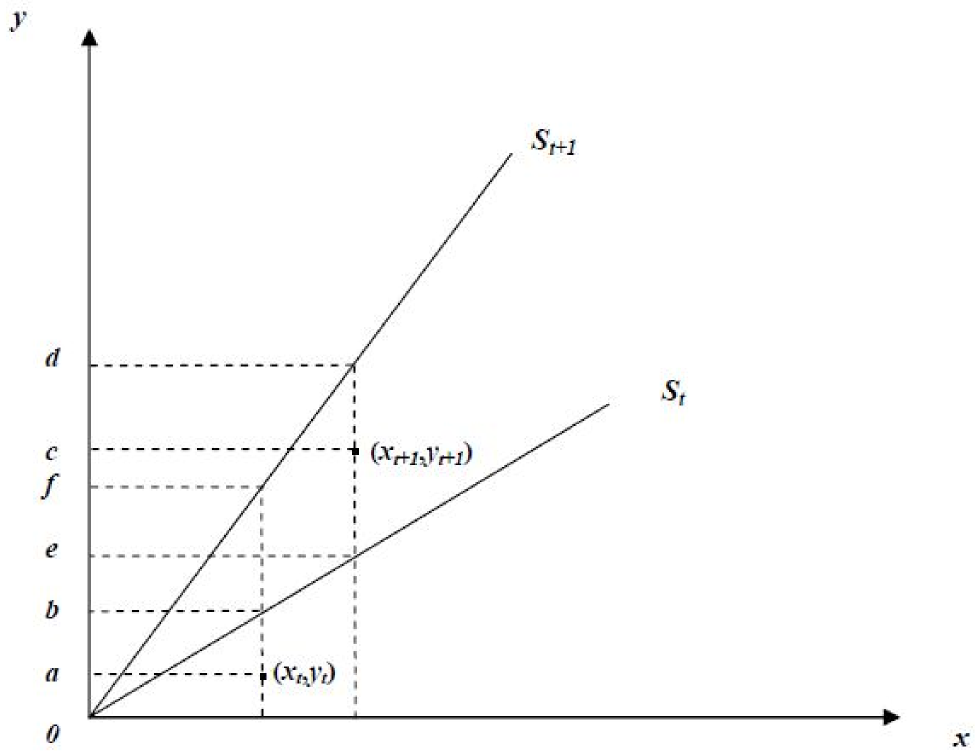

Figure 2: The Output-Orientated Malmquist TFP Index Decomposition Under Constant Returns to Scale Production Frontier

Fare et al. (1994) introduced an additional decomposition of the efficiency component of the index in malmquist index that allows identification of change in scale efficiency (a change in scale efficiency is the change in productivity resulting from a scale change that brings the economy closer to, or farther away from, the optimum scale of output as identified by a variable returns-to-scale technology). The efficiency change calculated under the assumption of constant returns-to-scale technology can be decomposed as follows:

$$\frac{D^{t+1}(x^{t+1}, y^{t+1})_{CRS}}{D^{t}(x^{t}, y^{t})_{CRS}} = \frac{D^{t+1}(x^{t+1}, y^{t+1})_{VRS}}{D^{t}(x^{t}, y^{t})_{VRS}} \left[\frac{D^{t}(x^{t}, y^{t})_{VRS}}{D^{t}(x^{t}, y^{t})_{CRS}} \; \frac{D^{t+1}(x^{t+1}, y^{t+1})_{CRS}}{D^{t+1}(x^{t+1}, y^{t+1})_{VRS}} \right]$$

CRS efficiency change = Pure efficiency change × Scale efficiency change where CRS (VRS) indicates a distance measured under the assumption of constant (variable) returns-to-scale. The pure efficiency change (the first term on the right) measures change in technical efficiency under the assumption of a variable returns-to-scale technology [Fulginiti and Perrin, 1997].

Given that suitable panel data are available, we must calculate four distance functions to measure the TFP change between two periods, t and $t+1$ for the i[th] country. This requires the solving of four linear programming problems, i.e. $D^t(x^t, y^t)$, $D^{t+1}(x^{t+1}, y^{t+1})$, $D^t(x^{t+1}, y^{t+1})$ and $D^{t+1}(x^t, y^t)$. The value of the distance function $\left[D^t(x^t, y^t)\right]^{-1}$ at time t is calculated as the solution of the following linear programming problem for each country $i = 1, \ldots, I$.

$$\begin{aligned}
&\left[D^t(x_i^t, y_i^t)\right]^{-1} = \max_{\theta,\lambda} \theta, \\
&st \qquad \theta y_{i,t} \leq \lambda_t Y_t \\
&\qquad\quad \lambda_t X_t \leq x_{i,t} \\
&\qquad\qquad \lambda \geq 0
\end{aligned}$$

and the required linear programming problem for the distance function $D^t(x_i^{t+1}, y_i^{t+1})$ referred to information from two different points in time takes the following form

$$\begin{aligned}
&\left[D^t(x_i^{t+1}, y_i^{t+1})\right]^{-1} = \max_{\theta,\lambda} \theta, \\
&st \qquad \theta y_{i,t+1} \leq \lambda_t Y_t \\
&\qquad\quad \lambda_t X_t \leq x_{i,t+1} \\
&\qquad\qquad \lambda \geq 0
\end{aligned}$$

Other required linear programming problems needed to solve for the distance functions $D^{t+1}(x_i^{t+1}, y_i^{t+1})$ and $D^{t+1}(x_i^t, y_i^t)$ are mixed-period problem.

They can be calculated respectively by interchanging subscript t and $t+1$ [Rungsuriyawiboon and Lissitsa].

3.1.3. Education Index:

Education Index is based on the adult literacy rate and the combined gross enrolment ratio for primary, secondary and tertiary schools.

Education index measures a country's relative achievement in both adult literacy and combined primary, secondary and tertiary gross enrolment. First, an index for adult literacy and one for combined gross enrolment are calculated. Then these two indices are combined to create the education index, with two-thirds weight given to adult literacy and one-third weight to combined gross enrolment. For Brazil, with an adult literacy rate of 88.6% in 2004 and a combined gross enrolment ratio of 86% in 2004, the education index is 0.876 and is calculated as follows [Human Development Report 2006]:

$$Adult\ literacy\ index = \frac{88.6-0}{100-0} = 0.886$$

$$Gross\ enrolment\ index = \frac{86-0}{100-0} = 0.857$$

$$Education\ index = \frac{2}{3}(Adult\ literacy\ index) + \frac{1}{3}(gross\ enrolment\ index)$$

$$= \tfrac{2}{3}(0.886) + \tfrac{1}{3}(0.857) = 0.876$$

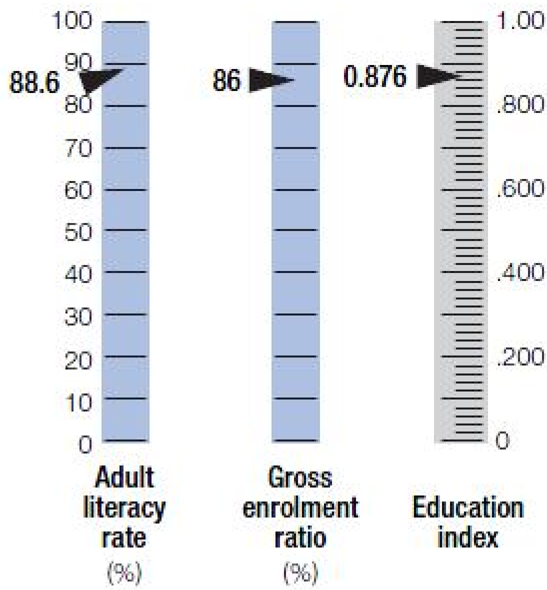

Figure 3: Example of Calculation of Education Index for Brazil [Human Development Report 2006]

3.1.4. Multiple Linear Regression

Regression analysis is a statistical tool for the investigation of relationships between variables. For a simple linear regression example, the hypothesized relationship between education and earnings may be written

$$I = \alpha + \beta E + \varepsilon$$

where

α = a constant amount (what one earns with zero education);

β = the effect in dollars of an additional year of schooling on income, hypothesized to be positive; and

ε = the "noise" term reflecting other factors that influence earnings.

The variable I is termed the "dependent" or "endogenous" variable; E is termed the "independent," "explanatory," or "exogenous" variable; α is the "constant term" and β the "coefficient" of the variable E.

Plainly, earnings are affected by a variety of factors in addition to years of schooling, factors that were aggregated into the noise term in the simple regression model above. "Multiple regressions" is a technique that allows additional factors to enter the analysis separately so that the effect of each can be estimated. It is valuable for quantifying the impact of various simultaneous influences upon a single dependent variable. Further, because of omitted variables bias with simple regression, multiple regression is often essential even when the investigator is only interested in the effects of one of the independent variables. For purposes of illustration, consider the introduction into the earnings analysis of a second independent variable called "experience".

Holding constant the level of education, we would expect someone who has been working for a longer time to earn more. Let X denote years of experience in the labor force and, as in the case of education, we will assume that it has a linear effect upon earnings that is stable across individuals. The modified model may be written:

$$I = \alpha + \beta E + \gamma X + \varepsilon$$

where γ is expected to be positive.

The task of estimating the parameters α, β, and γ is conceptually identical to the earlier task of estimating only α and β. The difference is that we can no longer think of regression as choosing a line in a two-dimensional diagram—with two explanatory variables we need three dimensions, and instead of estimating a line we are estimating a plane. Multiple regression analysis will select a plane so that the sum of squared errors—the error here being the vertical distance between the actual value of I and the estimated plane—is at a minimum. The intercept of that plane with the I-axis (where E and X are zero) implies the constant term α, its slope in the education dimension implies the coefficient β, and its slope in the experience dimension implies the coefficient γ [Sykes].

3.1.5. Panel Data Analysis

Panel data (also known as longitudinal or cross-sectional time-series data) is a dataset in which the behavior of entities is observed across time. These entities could be states, companies, individuals, countries, etc. Panel data example is given in Table 2.

Table 2: Panel Data Example

country	year	Y	X1	X2	X3
1	2000	5.9	6.4	5.8	3.7
1	2001	4.3	5.9	1.3	2.8
1	2002	2.5	0.9	2.3	5.2
2	2000	4.6	1.4	2.2	4.0
2	2001	5.0	3.9	2.1	2.5
2	2002	4.9	2.9	2.6	3.1
3	2000	3.7	6.7	4.3	5.1
3	2001	3.4	6.4	5.3	4.2
3	2002	4.0	3.3	4.5	3.6

Panel data allows us to control for variables we cannot observe or measure like cultural factors or difference in business practices across companies; or variables that change over time but not across entities (i.e. national policies, federal regulations, international agreements, etc.). This is, it accounts for individual heterogeneity. With panel data, variables at different levels of analysis (i.e. students, schools, districts, states) suitable for multilevel or hierarchical modeling can be included. Some drawbacks are data collection issues (i.e. sampling design, coverage), non-response in the case of micro panels or cross-country dependency in the case of macro panels (i.e. correlation between countries).

Panel Data Analysis has mostly utilized three techniques:

– Fixed effects (FE)

– Random effects (RE)

– Pooled Data Analysis.

Use fixed-effects (FE) whenever you are only interested in analyzing the impact of variables that vary over time. FE explores the relationship between predictor and outcome variables within an entity (country, person, company, etc.). Each entity has its own individual characteristics that may or may not influence the predictor variables (for example being a male or female could influence the opinion toward certain issue or the political system of a particular country could have some effect on trade or GDP or the business practices of a company may influence its stock price).

The rationale behind random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. An advantage of random effects is that time invariant variables can be included. In the fixed effects model these variables are absorbed by the intercept. Random effects assume that the entity's error term is not correlated with the predictors which allows for time-invariant variables to play a role as explanatory variables.

To decide between fixed or random effects a Hausman test is used which is a statistical test in econometrics named after Jerry A. Hausman. The test evaluates the significance of an estimator versus an alternative estimator. It helps one evaluate if a statistical model corresponds to the data. That is, the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects. It basically tests whether the unique errors are correlated with the regressors, the null hypothesis is they are not [Torres-Reyna].

3.2. Data and Variables

By combining with DEA and regression models, we search that the relationship and affects of governance terms on Agricultural Productivity, i.e. Total Factor Productivity, of selected world countries. Our country selection process depends on data availability in World Bank. Table 3 provides a list of countries in an alphabetical order. Data on 64 countries over the time period of 2002 through 2008 are used in the empirical analysis.

Table 3: Countries

Algeria	Greece	Portugal
Armenia	Hungary	Romania
Austria	Indonesia	Russian Federation
Azerbaijan	Ireland	Senegal
Bangladesh	Italy	Slovak Republic
Bhutan	Japan	South Africa
Brazil	Kazakhstan	Spain
Bulgaria	Korea, Rep.	Sri Lanka
Canada	Kyrgyz Republic	Suriname
Chile	Latvia	Sweden
China	Lithuania	Switzerland
Croatia	Luxembourg	Syrian Arab Republic
Cuba	Macedonia, FYR	Tajikistan
Cyprus	Madagascar	Tanzania
Czech Republic	Malta	Thailand
Denmark	Moldova	Trinidad and Tobago
Egypt, Arab Rep.	Netherlands	Turkey
Estonia	Norway	Ukraine
Finland	Pakistan	United States
France	Paraguay	Uruguay
Georgia	Philippines	
Germany	Poland	

In this study, the first objective is to measure the total factor productivity change $(TFPC)$ of the countries by Malmquist index which determined the movements of countries efficiencies within time i.e. efficiency scores of the countries as an average in years 2002-2008. To do this, we used DEA model (output-oriented CCR primal model) assuming that constant returns to scale (CRS) technology.

The variables in the data set consist of

Output:

- Value added: Produced add value in agricultural area as USD currency,

Inputs:

- Agricultural land (land): It is estimated by the arable land used for farming, forestry, and production activities. It is measured in km^2.
- Fertilizers (fertility): It refers to the sum of pure weight of nitrogen, phosphate, potash, and complex fertilizers which were used for agriculture. It is measured in tons.
- Machinery (tractors): It is considered as capital input for the agricultural production activities such as plowing, irrigation, draining, harvesting, farm product processing, etc. It is measured in one unit of tractor.
- Labour (labour): Participants in the economically active population in agriculture, i.e. employment in agriculture as a percentage of total employment.

To explore the impacts of the "good governance" on agricultural productivity, in the second stage we constructed the following linear regression model:

$$Efficiency_t = \beta_0 + \beta_1 ConCor_{t-1} + \beta_2 RegQua_{t-1} + \beta_3 Educ_{t-1} + \beta_4 ConCor_{t-2}$$
$$+\beta_5 RegQua_{t-2} + \beta_6 Educ_{t-2} + \beta_7 Countrytype$$

In this regression the dependent variable is

$Efficiency_t$: agricultural productivity of the countries at time t,

and independent variables can be defined as follows:

$ConCor_{t-1}$: Control of Corruption for year $t-1$,

$ConCor_{t-2}$: Control of Corruption for year $t-2$,

$RegQua_{t-1}$: Regulatory Quality for year $t-1$

$RegQua_{t-2}$: Regulatory Quality for year $t-2$

$Educ_{t-1}$: Education index for year $t-1$

$Educ_{t-2}$: Education index for year $t-2$

$Countrytype$: Developing or developed country.

We chose only two governance indicators (control of corruption and regulatory quality) from the six WGI to remove the autocorrelation and multicollinearity problems. We already know the six governance indicators are highly interrelated from Table 1. Countrytype index which indicates that the country is developing or developed and education index are included as independent variables.

3.3. Results and Analysis

In this section, models are executed and analyzed. In the first stage DEA models are executed in DEA-Solver Professional Version 5.0 computer package program.

The Malmquist total factor productivity change (Malmquist Index-TFPC), the technical efficiency change (The Catch-up Table) and technologic change (Frontier-Shift Table) for the 64 countries over the period 2002 to 2008 are given in Appendix A-B-C, respectively.

The results in Appendix A show Azerbaijan and Ukraine as the two countries with the highest total factor productivity growth. Azerbaijan has the highest total factor productivity growth rate of 27.4 percent, followed by Ukraine, Algeria, Armenia, United States, Austria, Hungary, Netherlands, Tajikistan, Indonesia, Romania, Sweden, Philippines, Canada, Slovak Republic, Lithuania, Finland, Uruguay, Norway, Pakistan, Germany, Georgia, France, Thailand, Latvia, Italy, Czech Republic, Brazil, Spain, Chile, Syrian Arab Republic, Russian Federation, Cuba, Japan, Switzerland, Bangladesh, Egypt, Arab Rep., United Kingdom, Croatia. These countries' TFPC values are over 1. Azerbaijan shows a 27.4 percent average growth in total factor productivity growth, which is due to 26.3 percent growth in technical efficiency change (from Appendix B). Bulgaria has a negative growth rate of 14.8 percent in total factor productivity change. Ireland, China, Bulgaria exhibit the lowest total factor productivity growth.

Appendix A shows a 2.77 percent overall growth in total factor productivity growth over the period 2002-2008. These results also show that over the whole period there has been no technological recession. This means advances in technology which may be represented by an upward shift in the production frontier.

In our analysis, 10 countries – Bhutan, Kazakhstan, Madagascar, Malta, Paraguay, Senegal, South Africa, Suriname, Tanzania, Trinidad and Tobago – are efficient all years.

15 countries – Korea Rep., Turkey, Denmark, Slovenia, Greece, Moldova, Poland, Estonia, Iceland, Macedonia FYR, Portugal, Kyrgyz

Republic, Ireland, China, Bulgaria – are below 1, in some years even if they reached or get over to 1, in average they are below 1.

Appendix B shows that the catch-up term pertaining to the countries for years, which compares the closeness of countries in each period to that period's efficient frontier. A value of 1 for this term would mean a country has the same distance from the respective frontiers in periods t and $t+1$. A value of over 1 represents the countries become more efficient in period $t+1$ compared to period t, i.e. that have moved closer to the frontier in period $t+1$. And also the converse is true when the catch-up term has a value under 1.

The frontier shift terms pertaining to the countries for years are given in Appendix C. The frontier shift term measures the movement of the frontier between periods t and t+1 at two locations. The interpretation of the frontier shift terms in Appendix C are as follows:

- For all countries except Indonesia, Bangladesh and 10 efficient countries, boundary shift terms are over 1, i.e. a frontier shift in excess of 1 represents productivity gain by the country in that at the input-output mixes of country in periods t and t+1 efficient production uses 'on balance' lower input levels in period t+1 than in period t, controlling for output levels.
- For Indonesia and Bangladesh, frontier shift terms are under 1 which represent productivity loss by the country in that at the input-output mixes operated by country in periods t and t+1 efficient production uses 'on balance' higher input levels in period t+1 than in period t, controlling for output levels.
- For 10 countries – Bhutan, Kazakhstan, Madagascar, Malta, Paraguay, Senegal, South Africa, Suriname, Tanzania, Trinidad and Tobago–, the frontier shift terms are 1. These countries have on average registered neither productivity gains nor productivity losses between

period t and t+1. That is at the input-output mixes operated by country in periods t and t+1 efficient production uses 'on balance' the same input levels in period t+1 as in period t, controlling for output levels.

The term 'on balance' here gives expression to the geometric mean used for computing the distance between the efficient frontiers in period t and t+1 at the two input-output mixes operated by country in those periods [Thanassoulis, 2001, pp.183].

For all countries average efficiency scores, their input and output's projection values, and their difference quantities and theirs difference changes as percentage are given in Appendix D. In Table 4, these values are only given for Turkey. According to our analysis Turkey have to decrease labour at 28.49%, and to increase 2.48% value added to reach efficient frontier. The usage of land, fertilize and tractor inputs are proper.

In the second stage, we made regression analysis to find the effects of Control of corruption and regulatory quality, education and country type of a country on country's agricultural productivity. We only selected two governance indicators (Control of corruption and regulatory quality), we thought that those indicators have more influence on agriculture than the others. In our regression we tried to explain each year's efficiency in relating to the $t-1$ and $t-2$ year's data of control of corruption and regulatory quality and education index. The regression model is:

$$Efficiency_t = \beta_0 + \beta_1 ConCor_{t-1} + \beta_2 RegQua_{t-1} + \beta_3 Educ_{t-1} + \beta_4 ConCor_{t-2}$$
$$+\beta_5 RegQua_{t-2} + \beta_6 Educ_{t-2} + \beta_7 Countrytype$$

executed in Stata Computer Program and coefficients are shown in Table 6.

Table 4: CCR results for Turkey

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
60	Turkey	1,024767756			
	Land	404847,1429	404847,143	0	0,00%
	Fertilize	100,9486449	100,948645	0	0,00%
	Tractors	437,4684947	437,468495	0	0,00%
	Labour	30,31428571	22,1976925	-8,11659317	-28,49%
	Value Added	27904017038	2,8586E+10	681714371	2,48%

Table 5: Summary of CCR results

Summary of CCR				
YEAR	Mean	Std. Dev.	Freq.	
2002	.4059375	.33762173	64	
2003	.41884063	.34004764	64	
2004	.41608438	.33435361	64	
2005	.41134219	.33332271	64	
2006	.41851094	.33766898	64	
2007	.42012656	.3382576	64	
2008	.41461094	.33970914	64	
Total	.41506473	.33505206	448	
Countrytype	Mean	Std. Dev.	Freq.	No of countries
undeveloped	.3847737	.33712086	308	44
developed	.481705	.32169892	140	20
Total	.41506473	.33505206	448	64

Table 6: Regression Coefficients and Model Summary

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	*Constant*	,968	,124		7,819	,000		
	ConCor(t-2)	-,007	,135	-,021	-,049	,961	,014	69,900
	RegQua(t-2)	-,111	,144	-,309	-,774	,440	,017	57,918
	Educ(t-2)	-1,379	1,144	-,618	-1,205	,229	,010	95,463
	Countrytype	,424	,058	,595	7,272	,000	,411	2,433
	ConCor(t-1)	-,161	,134	-,522	-1,202	,231	,015	68,633
	RegQua(t-1)	,163	,142	,449	1,152	,250	,018	55,114
	Educ(t-1)	,614	1,162	,270	,529	,598	,011	95,023

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,479	,229	,210	,29402564	,598

In Table 6 Durbin-Watson result (d =0,598) shows us the regression has autocorrelation, and the VIF value (VIF>10) shows us the high multicollinearity. For this reason, we have the following modifications in our model:

$$Efficiency_t - \rho Efficiency_{t-1} = \beta_0 + \beta_1(ConCor_t - \rho ConCor_{t-1})$$
$$+\beta_2(RegQua_t - \rho RegQua_{t-1}) + \beta_3(Educ_t - \rho Educ_{t-1}) + \beta_4 ConCor_{t-2}$$
$$+ \beta_5 RegQua_{t-2} + \beta_6 Educ_{t-2} + \beta_7 Countrytype$$

where

$\rho \cong 1 - \frac{d}{2} = 0.75,$

$ConCor_t$: Control of Corruption for year t,

$ConCor_{t-1}$: Control of Corruption for year $t-1$,

$ConCor_{t-2}$: Control of Corruption for year $t-2$,

$RegQua_{t}$: Regulatory Quality for year t,

$RegQua_{t-1}$: Regulatory Quality for year $t-1$,

$RegQua_{t-2}$: Regulatory Quality for year $t-2$,

$Educ_{t}$: Education index for year t,

$Educ_{t-1}$: Education index for year $t-1$,

$Educ_{t-2}$: Education index for year $t-2$,

$Countrytype$: developed or developing country.

Fixed Effect model does not analyze the $Countrytype$. So according to Breusch and Pagan Lagrangian multiplier test, we have to use random effects model in our study since Prob>chi2=0.0000 .

Random effect models and pooled regression model's results are given in Table 7 and 8, respectively.

It can be seen that from Table 7, countrytype and education are significant variables. Countrytype has positive coefficient which shows the positive relationship between efficiency and development level of a country. On the other hand, education has negative coefficient which shows the negative relationship between efficiency and education. We can also see this negative relationship in Table 9, if we made a regression analysis in which labour from 2002 to 2008 as dependent variable and education from 2002 to 2008 as independent variable, by executing Stata Computer Programme. From Table 9 we see that Hausman test suggests to use fixed effects model. So this is evidence that there exists a negative relationship between education and labour.

Table 7: Random Effect Model Results

Breusch and Pagan Lagrangian multiplier test for random effects:

CCRdiff[countrycode,t] = Xb + u[countrycode] + e[countrycode,t]

Estimated results:

		Var	sd = sqrt(Var)
	CCRdiff	0.0104666	0.1023062
	E	0.0042579	0.0652523
	U	0.0049309	0.0702201
Test:	Var(u)=0		
chi2(1)=	158.50		
Prob>chi2=	0.0000		

random effects				
	Coef.	Std. Err.	z	P>z
Educ(t)- Educ(t-1)	0,2784251	0,3356521	0,83	0,407
RegQua(t)-RegQua(t-1)	0,0449864	0,0358694	1,25	0,21
ConCor(t)-ConCor(t-1)	-0,0327317	0,0342223	-0,96	0,339
Educ(t-2)	**-0,2458137**	0,1027129	-2,39	**0,017**
ConCor(t-2)	-0,0183172	0,0187336	-0,98	0,328
RegQua(t-2)	-0,0059072	0,0218361	-0,27	0,787
Countrytype	**0,0900751**	0,0320187	2,81	**0,005**
Constant	0,2346146	0,067364	3,48	0

Random-effects	GLS regression	Number of obs	= 320
Group variable	(i): cıuntrycode	Number of groups	= 64
R-sq: within	0,0002	Obs per group: min	= 5
Between	0,2446	avg	= 5
Overall	0,1583	max	= 5
Random effects	u_i ~ Gaussian	Wald chi2(7)	= 14,74
corr(u_i, X)	= 0 (assumed)	Prob > chi2	= 0,0395

Pooled regression model results are given in Table 8 and we see that the results are similar to the random effects model’s.

Table 8: Pooled Regression Model Results

pooled reg				
	Coef.	Std. Err.	t	P>t
Educ(t)- Educ(t-1)	0,6391359	0,433279	1,48	0,141
RegQua(t)-RegQua(t-1)	0,0697204	0,046136	1,51	0,132
ConCor(t)-ConCor(t-1)	-0,0674836	0,043488	-1,55	0,122
Educ(t-2)	**-0,3762074**	0,108426	-3,47	**0,001**
ConCor(t-2)	-0,0248434	0,015764	-1,58	0,116
RegQua(t-2)	-0,0001827	0,017841	-0,01	0,992
Countrytype	**0,107988**	0,018406	5,87	**0,000**
Constant	0,2624197	0,039655	6,62	0,000

Source	SS	df	MS			
				Number of obs	=	320
Model	0,543837623	7	0,0776911	F(7, 312)	=	8,67
Residual	2,79499584	312	0,0089583	Prob > F	=	0
Total	3,33883346	319	0,0104666	R-squared	=	0,1629
				Adj R-squared	=	0,1441
				Root MSE	=	0,09465

Table 9: Results of the Regression which Shows the Relationship Between Education and Labour

Fixed-effects (within) regression

labour	Coef.	Std. Err.	t	P>t
educ	**-29.8777**	6.198689	-4.82	**0.00000**
Constant	46.21847	5.419732	8.53	0.00000
F(1,383)	=		23.23	
Prob > F	=		0	
R-sq: within	= 0.0572			
Between	= 0.3897			
Overall	= 0.3839			
Number of obs	=		448	
Number of groups	=		64	

Hausman test results to compare fixed and random effects.

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	random	Difference	S.E.
educ	-29.8777	-39.4781	9.600398	2.443119

b = consistent under Ho and Ha; obtained from xtreg

B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 15.44

Prob>chi2 = 0.0001

CONCLUSION

This thesis combines with DEA and regression models examining the influences of governance on agricultural productivity in 64 countries over the period 2002 to 2008.

This study includes two stages. In the first stage, we used DEA model to measure TFPC by Malmquist index which determines the movements of countries efficiencies within time. Model's inputs are land, fertility, tractors and labour and the output is produced add value as USD currency. By 2.77 percent overall growth, the Malmquist index indicates that there has been technological progression over the whole period.

In the second stage we made regression analysis to find the effects of two governance indicators (control of corruption and regulatory quality), education and country type of a country on country's agricultural productivity. Panel Data analysis indicates that countrytype and education are significant variables. Countrytype has positive coefficient which shows the positive relationship between efficiency and development level of a country. This explains that in developed countries agricultural productivity is of importance and is supported by Research and Development studies and uses technological agriculture, whereas old-type agricultural activities is commonly used in others.

On the other hand, education has negative coefficient which shows the negative relationship between efficiency and education. The result can be interpretated as when the education level becomes high, educated people focus on their own fields and to be away from agricultural activities.

We expected that the control of corruption indicator has a negative effect on agricultural productivity as Lio and Liu's claim (Lio and Liu, 2008). But we could not found such relationship.

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APPENDICES

Appendix A: Malmquist Index (TFPC)

Malmquist	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Average
Algeria	1,778234	0,444909	1,945337	0,679595	1,011521	1,622668	1,247044
Armenia	1,211506	0,963427	1,351134	0,853404	1,856916	0,873534	1,184987
Austria	0,984587	1,572848	0,949487	1,02822	1,258715	1,097184	1,148507
Azerbaijan	1,308391	0,782201	3,401986	1	0,351011	0,802197	**1,274298**
Bangladesh	1,10668	1,316484	0,715607	0,873262	1,049726	0,992938	1,009116
Bhutan	1	1	1	1	1	1	1
Brazil	0,945189	1,010259	1,087046	1,034977	0,922123	1,13093	1,021754
Bulgaria	1	1	0,205867	0,930949	0,75553	1,217558	**0,851651**
Canada	1,10382	1,106642	1,007956	0,972797	0,984713	1,076537	1,042078
Chile	0,944531	1,101043	1,052875	1,005963	0,983126	1,01982	1,017893
China	0,939486	1,049207	0,854489	0,936482	0,876271	0,773833	0,904961
Croatia	0,919563	1,117742	0,958463	1,068084	0,986128	0,963093	1,002179
Cuba	1,460208	0,881288	0,780777	0,86577	1,142106	0,953507	1,013943
Czech Republic	1,064842	1,099904	1,134701	0,859263	0,896703	1,078493	1,022318
Denmark	1,016075	1,007482	0,958454	0,949288	1,008184	0,987205	0,987781
Egypt, Arab Rep.	0,970297	1,0552	0,979666	1,0935	0,992613	0,940069	1,005224
Estonia	0,866817	0,880008	1,189033	0,892066	0,883703	1,075567	0,964532
Finland	0,977113	0,982767	1,045619	1,01552	1,127466	1,05689	1,034229
France	0,788803	1,227519	1,003579	0,998008	0,996834	1,150339	1,027514
Georgia	1,848304	0,526077	0,856952	0,832735	1,050156	1,056239	1,028411
Germany	0,978371	1,361475	0,872535	1,002053	0,995805	0,968567	1,029801
Greece	0,782884	1,348604	0,861676	0,933851	0,933503	1,030001	0,981753
Hungary	1,022914	1,492632	0,965078	0,933612	0,791093	1,531247	1,122763
Iceland	0,936114	0,812616	1,364575	0,677346	1,018601	0,94956	0,959802
Indonesia	0,951866	1,034945	1,086768	1,274981	0,989325	1,092821	1,071784
Ireland	1,015767	1,038701	0,695159	0,891774	1,026846	0,985647	0,942316
Italy	0,944985	1,125126	0,992159	0,974529	0,97149	1,127035	1,022554
Japan	0,93659	0,82658	1,075142	0,990945	1,036349	1,196297	1,010317
Kazakhstan	1	1	1	1	1	1	1
Korea, Rep.	0,92534	1,061067	0,985007	0,980606	1,011	1,008204	0,995204
Kyrgyz Republic	0,502703	1,083698	0,910267	1,052756	1,008598	1,114153	0,945362
Latvia	0,984255	1,001502	1,13163	1,000491	1,031423	0,99344	1,02379
Lithuania	0,990283	0,988284	1,194244	0,872694	1,14097	1,030373	1,036141
Macedonia, FYR	0,989228	0,662398	0,867468	1,162067	0,835381	1,241584	0,959688
Madagascar	1	1	1	1	1	1	1

Malmquist	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Average
Malta	1	1	1	1	1	1	1
Moldova	0,948586	1,083633	0,958497	1,022901	0,567126	1,279723	0,976744
Netherlands	1,034393	1,295322	0,98082	1,119601	1,152629	1,132378	1,11919
Norway	1,011264	1,123569	0,959686	1,001256	1,036271	1,058024	1,031678
Pakistan	1,030924	0,993464	1,021305	1,048227	1,060052	1,031432	1,030901
Paraguay	1	1	1	1	1	1	1
Philippines	0,985352	1,054761	1,054421	1,100836	1,005736	1,063655	1,044127
Poland	0,986942	1,068248	0,876125	0,974644	0,929717	0,969018	0,967449
Portugal	0,94159	1,010945	0,858187	1,005648	0,896194	0,98176	0,949054
Romania	1,013952	1,184153	0,961267	1,122762	1,030165	1,078182	1,06508
Russian Federation	1,169476	0,998432	0,927114	1,047787	0,937856	1,009266	1,014989
Senegal	1	1	1	1	1	1	1
Slovak Republic	1,067194	0,988423	0,975894	1,110752	1,125825	0,981409	1,041583
Slovenia	0,792905	1,149182	0,958793	0,99003	1,005764	0,99596	0,982106
South Africa	1	1	1	1	1	1	1
Spain	0,962533	1,000739	0,973123	1,054419	1,028753	1,109697	1,021544
Suriname	1	1	1	1	1	1	1
Sweden	1,012376	1,083669	0,983323	1,116199	1,052028	1,023923	1,045253
Switzerland	0,910071	1,112424	0,981753	0,966913	1,067243	1,018184	1,009431
Syrian Arab Republic	0,923173	0,997158	1,037294	1,097756	0,988153	1,052816	1,016058
Tajikistan	1,046845	1,070129	1,002587	1,214055	1,076128	1,066601	1,079391
Tanzania	1	1	1	1	1	1	1
Thailand	1,043246	1,019845	1,051196	1,033632	0,95586	1,051613	1,025899
Trinidad and Tobago	1	1	1	1	1	1	1
Turkey	0,810519	1,000946	1,060303	1,017523	0,974278	1,078798	0,990395
Ukraine	0,904979	1,18139	2,488553	1	1	1	1,262487
United Kingdom	1,050529	0,998934	1,077089	0,999549	0,894908	0,997575	1,003097
United States	1,725538	0,960264	1,197629	0,963104	0,893089	1,320229	1,176642
Uruguay	0,962196	1,068147	1,035639	1,056577	0,94373	1,138757	1,034174
Average	1,023911	1,0376	1,060958	0,99534	0,992897	1,055883	**1,027765**
Max	1,848304	1,572848	3,401986	1,274981	1,856916	1,622668	1,274298
Min	0,502703	0,444909	0,205867	0,677346	0,351011	0,773833	0,851651
SD	0,208633	0,177814	0,400437	0,099786	0,167176	0,132613	0,075097

Appendix B: Catch-up table (Technical Efficiency Change)

Catch-up	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Average
Algeria	1,645466	0,421032	1,837586	0,723516	1,098651	1,417178	1,190572
Armenia	1,276612	1,043645	1,300907	0,842801	1,831803	0,670691	1,161077
Austria	1,039962	1,723828	0,903083	1,005235	1,262007	0,821485	1,125933
Azerbaijan	1,394295	0,786979	3,353333	1	0,351569	0,694022	**1,263366**
Bangladesh	1,055613	1,073624	0,950861	0,980744	1,02229	0,952274	1,005901
Bhutan	1	1	1	1	1	1	1
Brazil	0,902039	0,91884	1,078678	1,048339	0,972052	1,108871	1,004803
Bulgaria	1	1	0,207896	0,895059	0,74869	1,16598	0,836271
Canada	1,073508	1,032201	0,947003	0,977911	1,010233	0,985874	1,004455
Chile	1,049938	0,962754	1,074497	0,991046	0,979166	0,983983	1,006897
China	0,908874	0,955779	0,834544	0,934693	0,895065	0,729128	0,876347
Croatia	0,971361	1,198202	0,921238	1,085542	0,935465	0,896667	1,001412
Cuba	1,535352	0,905783	0,757198	0,85311	1,122067	0,844739	1,003042
Czech Republic	1,163579	1,033282	1,134972	0,857551	0,879334	1,027039	1,01596
Denmark	1,088042	1,018038	0,936248	0,954229	0,970791	0,92859	0,982656
Egypt, Arab Rep.	1,043627	1,039626	0,963068	1,005024	0,967299	0,980315	0,999826
Estonia	0,917197	0,939028	1,142254	0,896538	0,838119	1,004358	0,956249
Finland	1,0447	1,018399	1,016143	1,01867	1,078719	0,992691	1,02822
France	0,867738	0,978212	1,04208	0,994558	0,994358	1,055712	0,988776
Georgia	1,951487	0,565197	0,832131	0,822247	1,035842	0,810925	1,002971
Germany	1,108617	1,175539	0,878654	1,013058	0,952661	0,918603	1,007855
Greece	0,833115	1,385045	0,836835	0,931232	0,895763	0,927768	0,968293
Hungary	1,165616	1,328697	0,984215	0,923468	0,781501	1,470445	1,10899
Iceland	0,999836	0,856235	1,319154	0,668938	1,021581	0,751881	0,936271
Indonesia	0,89204	0,998428	1,247283	1,527313	0,952867	1,203607	1,136923
Ireland	1,077824	1,076251	0,672473	0,899631	0,979574	0,92093	0,93778
Italy	0,995392	1,198165	0,949667	0,962123	0,949956	0,939127	0,999072
Japan	0,973651	0,817436	1,049311	0,975178	1,002513	0,993143	0,968539
Kazakhstan	1	1	1	1	1	1	1
Korea, Rep.	0,966145	1,124114	0,947764	0,991436	0,95817	0,937537	0,987528
Kyrgyz Republic	0,526432	1,087623	0,883273	1,031828	1,011839	0,963474	0,917411
Latvia	1,035414	1,069459	1,096547	0,996615	0,982093	0,941218	1,020225
Lithuania	1,035928	1,021682	1,165189	0,86601	1,085236	0,951444	1,020915
Macedonia, FYR	1,055969	0,747242	0,824877	1,135883	0,837553	0,935648	0,922862
Madagascar	1	1	1	1	1	1	1
Malta	1	1	1	1	1	1	1
Moldova	1,01317	1,127955	0,927076	1,010638	0,568817	1,012668	0,943387

Catch-up	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Average
Netherlands	1,090787	1,377063	0,941872	1,131964	1,095162	1,055966	1,115469
Norway	1,068227	1,204448	0,922413	1,017622	0,983032	0,985049	1,030132
Pakistan	1,040017	0,963915	1,032639	0,99722	1,056848	0,960334	1,008496
Paraguay	1	1	1	1	1	1	1
Philippines	0,988621	0,961169	1,101487	1,048673	0,976854	0,960335	1,00619
Poland	1,036613	1,129514	0,854518	0,97041	0,914247	0,869876	0,962529
Portugal	0,999966	1,050232	0,831515	0,998659	0,856866	0,922388	0,943271
Romania	1,111234	1,20101	0,948074	1,103032	1,017262	0,968246	1,058143
Russian Federation	1,130685	0,962781	0,84084	1,065149	0,964176	0,944512	0,98469
Senegal	1	1	1	1	1	1	1
Slovak Republic	1,16461	0,940692	0,980042	1,0638	1,1085	0,942987	1,033439
Slovenia	0,837568	1,231905	0,921554	1,006213	0,954093	0,927267	0,979767
South Africa	1	1	1	1	1	1	1
Spain	1,093123	0,87568	0,958324	1,042495	1,035647	0,962974	0,994707
Suriname	1	1	1	1	1	1	1
Sweden	1,088818	1,091717	0,961415	1,124448	1,009434	0,959724	1,039259
Switzerland	0,961334	1,192501	0,943623	0,982718	1,012413	0,947958	1,006758
Syrian Arab Republic	0,947338	0,97244	1,044843	1,079888	0,999071	0,952725	0,999384
Tajikistan	1,107537	1,132317	0,979403	1,203793	1,053412	0,936528	1,068832
Tanzania	1	1	1	1	1	1	1
Thailand	1,06796	0,975712	1,050318	1,022891	0,955358	0,940448	1,002114
Trinidad and Tobago	1	1	1	1	1	1	1
Turkey	0,841291	1,010459	1,047272	0,997522	0,957693	0,980242	0,972413
Ukraine	0,842418	1,117177	2,398817	1	1	1	1,226402
United Kingdom	1,046373	1,03481	1,00701	1,003734	0,85478	0,905107	0,975302
United States	1,681943	0,829171	1,114167	1,001075	0,901925	1,150945	1,113204
Uruguay	1,057727	0,90216	1,057274	1,035495	0,934073	1,089646	1,012729
Average	1,059574	1,027894	1,046148	0,995578	0,978351	0,973457	1,0135
Max	1,951487	1,723828	3,353333	1,527313	1,831803	1,470445	1,263366
Min	0,526432	0,421032	0,207896	0,668938	0,351569	0,670691	0,836271
SD	0,206278	0,180447	0,388561	0,110403	0,163972	0,127096	0,072935

Appendix C: Frontier-Shift Table (Technologic Change)

Frontier	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Average
Algeria	1,080687	1,05671	1,058637	0,939295	0,920693	1,145	1,033504
Armenia	0,949001	0,923136	1,038609	1,012581	1,013709	1,302438	1,039913
Austria	0,946753	0,912416	1,051385	1,022865	0,997391	1,33561	1,044403
Azerbaijan	0,938389	0,993929	1,014509	1	0,998413	1,155867	1,016851
Bangladesh	1,048376	1,226206	0,752588	0,890408	1,026838	1,042702	0,997853
Bhutan	1	1	1	1	1	1	1
Brazil	1,047837	1,099494	1,007758	0,987254	0,948635	1,019894	1,018479
Bulgaria	1	1	0,990243	1,040098	1,009136	1,044235	1,013952
Canada	1,028236	1,072119	1,064364	0,994771	0,974739	1,091962	1,037699
Chile	0,899606	1,143639	0,979878	1,015051	1,004044	1,036421	1,013106
China	1,033681	1,097751	1,023899	1,001913	0,979003	1,061313	1,032927
Croatia	0,946675	0,93285	1,040408	0,983917	1,054158	1,074082	1,005348
Cuba	0,951058	0,972956	1,031139	1,014841	1,017859	1,128759	1,019435
Czech Republic	0,915144	1,064477	0,999761	1,001996	1,019752	1,050099	1,008538
Denmark	0,933857	0,989631	1,023718	0,994823	1,038518	1,063122	1,007278
Egypt, Arab Rep.	0,929736	1,014981	1,017235	1,088033	1,02617	0,958946	1,00585
Estonia	0,945072	0,937148	1,040953	0,995011	1,054388	1,070899	1,007245
Finland	0,935304	0,965012	1,029008	0,996908	1,045189	1,064672	1,006016
France	0,909033	1,25486	0,963054	1,003469	1,002491	1,089633	1,03709
Georgia	0,947126	0,930785	1,029828	1,012755	1,013819	1,302513	1,039471
Germany	0,882515	1,158171	0,993035	0,989137	1,045289	1,054391	1,020423
Greece	0,939707	0,97369	1,029685	1,002813	1,042132	1,110192	1,01637
Hungary	0,877574	1,123381	0,980556	1,010984	1,012274	1,041349	1,007686
Iceland	0,936267	0,949057	1,034432	1,012569	0,997083	1,262914	1,032054
Indonesia	1,067067	1,036574	0,871308	0,834787	1,038261	0,907955	0,959325
Ireland	0,942424	0,96511	1,033736	0,991266	1,048258	1,070274	1,008511
Italy	0,949359	0,93904	1,044744	1,012895	1,022669	1,200088	1,028133
Japan	0,961936	1,011186	1,024618	1,016168	1,03375	1,204557	1,042036
Kazakhstan	1	1	1	1	1	1	1
Korea, Rep.	0,957765	0,943914	1,039295	0,989077	1,055136	1,075375	1,010094
Kyrgyz Republic	0,954926	0,996391	1,030562	1,020282	0,996797	1,156392	1,025891
Latvia	0,950591	0,936457	1,031995	1,003888	1,050229	1,055484	1,004774
Lithuania	0,955938	0,967311	1,024935	1,007718	1,051356	1,082957	1,015036
Macedonia, FYR	0,936797	0,886457	1,051633	1,023052	0,997407	1,326978	1,037054
Madagascar	1	1	1	1	1	1	1
Malta	1	1	1	1	1	1	1
Moldova	0,936255	0,960706	1,033893	1,012133	0,997028	1,263714	1,033955
Netherlands	0,948299	0,940641	1,041352	0,989078	1,052474	1,072362	1,007368
Norway	0,946675	0,93285	1,040408	0,983917	1,054158	1,074082	1,005348

Frontier	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	Average
Pakistan	0,991256	1,030655	0,989024	1,05115	1,003032	1,074035	1,023192
Paraguay	1	1	1	1	1	1	1
Philippines	0,996693	1,097373	0,95727	1,049742	1,029566	1,107588	1,039705
Poland	0,952083	0,945759	1,025287	1,004364	1,016921	1,113973	1,009731
Portugal	0,941622	0,962592	1,032076	1,006998	1,045898	1,064368	1,008926
Romania	0,912456	0,985965	1,013916	1,017887	1,012684	1,113542	1,009408
Russian Federation	1,034307	1,03703	1,102605	0,9837	0,972702	1,068559	1,033151
Senegal	1	1	1	1	1	1	1
Slovak Republic	0,916353	1,05074	0,995767	1,044136	1,015629	1,040744	1,010562
Slovenia	0,946675	0,93285	1,040408	0,983917	1,054158	1,074082	1,005348
South Africa	1	1	1	1	1	1	1
Spain	0,880535	1,142813	1,015442	1,011438	0,993343	1,152365	1,032656
Suriname	1	1	1	1	1	1	1
Sweden	0,929794	0,992628	1,022787	0,992664	1,042195	1,066894	1,007827
Switzerland	0,946675	0,93285	1,040408	0,983917	1,054158	1,074082	1,005348
Syrian Arab Republic	0,974491	1,025419	0,992774	1,016547	0,989072	1,105058	1,017227
Tajikistan	0,9452	0,945079	1,023672	1,008524	1,021564	1,138889	1,013821
Tanzania	1	1	1	1	1	1	1
Thailand	0,976859	1,045231	1,000836	1,010501	1,000526	1,118204	1,02536
Trinidad and Tobago	1	1	1	1	1	1	1
Turkey	0,963422	0,990586	1,012443	1,02005	1,017318	1,100543	1,017394
Ukraine	1,074264	1,057477	1,037408	1	1	1	1,028192
United Kingdom	1,003972	0,96533	1,069591	0,995831	1,046945	1,102163	1,030639
United States	1,025919	1,158101	1,07491	0,96207	0,990204	1,147082	1,059714
Uruguay	0,909683	1,183988	0,979537	1,02036	1,010339	1,04507	1,02483
Average	0,966436	1,012367	1,013896	1,000931	1,01493	1,089132	1,016282
Max	1,080687	1,25486	1,102605	1,088033	1,055136	1,33561	1,059714
Min	0,877574	0,886457	0,752588	0,834787	0,920693	0,907955	0,959325
SD	0,046599	0,078309	0,046401	0,032807	0,027174	0,087905	0,016242

Appendix D: CCR Results for 64 Countries

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
1	Algeria	1,64109905			
	Land	408369,5714	408369,571	0	0,00%
	Fertilize	11,88991386	11,8899139	0	0,00%
	Tractors	134,127527	18,6044297	-115,523097	-86,17%
	Labour	20,56666667	1,0993257	-19,467341	-94,67%
	Value Added	6397197442	1,0492E+10	4095143782	64,11%
2	Armenia	9,243585838			
	Land	16000,88571	16000,8857	0	0,00%
	Fertilize	24,72774546	24,7277455	0	0,00%
	Tractors	319,6120479	283,604711	-36,0073369	-11,11%
	Labour	46,32	0,73410162	-45,5858984	-98,40%
	Value Added	649383304,9	5793372093	5143988788	785,91%
3	Austria	10,14711508			
	Land	32752,85714	32752,8571	0	0,00%
	Fertilize	163,5799443	155,537586	-8,0423585	-2,81%
	Tractors	2390,248929	1832,64311	-557,605816	-23,39%
	Labour	5,5	2,79057135	-2,70942865	-49,53%
	Value Added	3411032429	3,4229E+10	3,0818E+10	816,97%
4	Azerbaijan	3,279136421			
	Land	47546	47546	0	0,00%
	Fertilize	12,62142417	12,6214242	0	0,00%
	Tractors	122,1291088	93,9872425	-28,1418663	-20,07%
	Labour	39,31809524	1,3066274	-38,0114678	-96,70%
	Value Added	1165453679	3834395454	2668941775	227,91%
5	Bangladesh	1			
	Land	90635,71429	90635,7143	0	0,00%
	Fertilize	184,9243356	184,924336	0	0,00%
	Tractors	2,3788179	2,3788179	0	0,00%
	Labour	49,18	49,18	0	0,00%
	Value Added	13326648489	1,3327E+10	0	0,00%
6	Bhutan	6,417917779			
	Land	5598,571429	5598,57143	0	0,00%
	Fertilize	9,169648903	9,1696489	0	0,00%
	Tractors	9,941329443	9,94132944	0	0,00%
	Labour	43,6	2,21702066	-41,3829793	-94,92%
	Value Added	135387663,9	870177145	734789481	541,79%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
7	Brazil	2,428406139			
	Land	2642714,286	2642714,29	0	0,00%
	Fertilize	155,6489353	155,648935	0	0,00%
	Tractors	129,921406	127,948778	-1,97262779	-1,54%
	Labour	20,14	14,9238644	-5,21613557	-26,05%
	Value Added	39527199769	9,5872E+10	5,6345E+10	142,84%
8	Bulgaria	5,261649672			
	Land	52422,85714	52422,8571	0	0,00%
	Fertilize	94,82395992	94,8239599	0	0,00%
	Tractors	122,0333611	122,033361	0	0,00%
	Labour	9,101904762	9,10190476	0	0,00%
	Value Added	1470510124	7569824406	6099314282	426,17%
9	Canada	1,710198718			
	Land	675658,5714	675658,571	0	0,00%
	Fertilize	64,39546194	61,4307423	-2,96471967	-3,33%
	Tractors	161,9433561	161,943356	0	0,00%
	Labour	2,653333333	2,65333333	0	0,00%
	Value Added	15546125733	2,657E+10	1,1024E+10	71,02%
10	Chile	3,753075142			
	Land	157261,4286	157261,429	0	0,00%
	Fertilize	450,3259178	259,317616	-191,008301	-40,83%
	Tractors	382,4581182	382,458118	0	0,00%
	Labour	12,74380952	12,7438095	0	0,00%
	Value Added	5645958499	2,1158E+10	1,5512E+10	275,31%
11	China	1			
	Land	5285925,143	5285925,14	0	0,00%
	Fertilize	408,8477542	408,847754	0	0,00%
	Tractors	140,3407594	140,340759	0	0,00%
	Labour	44,1	44,1	0	0,00%
	Value Added	2,19005E+11	2,19E+11	0	0,00%
12	Croatia	16,18027746			
	Land	12120	12120	0	0,00%
	Fertilize	307,3979792	85,8657134	-221,532266	-71,64%
	Tractors	4242	1131,63297	-3110,36703	-73,33%
	Labour	15,18	1,13490294	-14,0450971	-92,45%
	Value Added	1274470909	2,0589E+10	1,9314E+10	999,90%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
13	Cuba	3,304971941			
	Land	66152,85714	66152,8571	0	0,00%
	Fertilize	28,03985124	28,0398512	0	0,00%
	Tractors	204,0669341	200,869262	-3,19767227	-1,57%
	Labour	20,28190476	2,41641833	-17,8654864	-87,97%
	Value Added	2129938134	6992657957	4862719823	230,50%
14	Czech Republic	4,41664376			
	Land	42594,28571	42594,2857	0	0,00%
	Fertilize	138,6372346	98,1049826	-40,532252	-28,43%
	Tractors	287,3147836	287,314784	0	0,00%
	Labour	4,042857143	4,04285714	0	0,00%
	Value Added	2110582840	9244690246	7134107406	341,67%
15	Denmark	3,40552745			
	Land	26738,57143	26738,5714	0	0,00%
	Fertilize	129,6618686	87,8574943	-41,8043743	-31,51%
	Tractors	490,7196413	490,719641	0	0,00%
	Labour	3,071428571	3,07142857	0	0,00%
	Value Added	3326729314	1,1276E+10	7949240010	240,55%
16	Egypt, Arab Rep.	1			
	Land	34924,28571	34924,2857	0	0,00%
	Fertilize	554,9382807	554,938281	0	0,00%
	Tractors	343,4846987	343,484699	0	0,00%
	Labour	31,1	31,1	0	0,00%
	Value Added	18381572515	1,8382E+10	0	0,00%
17	Estonia	52,52990288			
	Land	7884,285714	7884,28571	0	0,00%
	Fertilize	73,34725745	63,7398001	-9,60745739	-11,01%
	Tractors	616,6337638	616,633764	0	0,00%
	Labour	5,4	1,69383871	-3,70616129	-65,55%
	Value Added	222722875,1	1,1598E+10	1,1376E+10	999,90%
18	Finland	4,337042545			
	Land	22715,71429	22715,7143	0	0,00%
	Fertilize	130,7241548	126,326519	-4,39763546	-3,29%
	Tractors	784,943385	784,943385	0	0,00%
	Labour	4,8	4,8	0	0,00%
	Value Added	3824923004	1,6518E+10	1,2693E+10	333,70%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
19	France	1			
	Land	295095,8	295095,8	0	0,00%
	Fertilize	196,7502456	196,750246	0	0,00%
	Tractors	635,7407426	635,740743	0	0,00%
	Labour	3,714285714	3,71428571	0	0,00%
	Value Added	33086569111	3,3087E+10	0	0,00%
20	Georgia	11,64213928			
	Land	26564,28571	26564,2857	0	0,00%
	Fertilize	37,14638606	37,1463861	0	0,00%
	Tractors	403,9617202	377,76226	-26,1994598	-6,24%
	Labour	54,27619048	2,07614199	-52,2000485	-96,19%
	Value Added	710600421,4	8247497496	7536897075	894,73%
21	Germany	1,132818965			
	Land	169757,1429	169757,143	0	0,00%
	Fertilize	205,7647312	141,125236	-64,639495	-31,55%
	Tractors	704,2313319	704,231332	0	0,00%
	Labour	2,3	2,3	0	0,00%
	Value Added	21606124141	2,4363E+10	2756502191	13,28%
22	Greece	4,013222883			
	Land	51685,14286	51685,1429	0	0,00%
	Fertilize	162,8854172	162,885417	0	0,00%
	Tractors	1180,717905	1180,71791	0	0,00%
	Labour	12,95714286	11,9022743	-1,05486851	-9,17%
	Value Added	6523082017	2,5995E+10	1,9472E+10	301,32%
23	Hungary	3,498475574			
	Land	58335,71429	58335,7143	0	0,00%
	Fertilize	114,6166002	109,879039	-4,73756144	-3,94%
	Tractors	261,995272	261,995272	0	0,00%
	Labour	5,157142857	5,15714286	0	0,00%
	Value Added	3008494379	1,0182E+10	7173061688	249,85%
24	Iceland	4,001009498			
	Land	22810	22810	0	0,00%
	Fertilize	9,017849314	9,01784931	0	0,00%
	Tractors	11049,42857	103,642925	-10945,7856	-99,07%
	Labour	6,416190476	0,45029762	-5,96589286	-93,36%
	Value Added	675744148,2	2698061432	2022317284	300,10%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
25	Indonesia	1			
	Land	476284,2857	476284,286	0	0,00%
	Fertilize	150,2964485	150,296449	0	0,00%
	Tractors	2,04023704	2,04023704	0	0,00%
	Labour	43,13333333	43,1333333	0	0,00%
	Value Added	30390247024	3,039E+10	0	0,00%
26	Ireland	13,40980405			
	Land	42980,14286	42980,1429	0	0,00%
	Fertilize	518,5767484	197,093999	-321,482749	-61,95%
	Tractors	1457,962861	1457,96286	0	0,00%
	Labour	6,042857143	6,04285714	0	0,00%
	Value Added	2321426632	2,9944E+10	2,7623E+10	966,99%
27	Italy	1,66608066			
	Land	144694,2857	144694,286	0	0,00%
	Fertilize	175,0371284	175,037128	0	0,00%
	Tractors	2117,052009	2117,05201	0	0,00%
	Labour	4,3	3,90846401	-0,39153599	-9,62%
	Value Added	26343502107	4,382E+10	1,7477E+10	66,61%
28	Japan	1			
	Land	46934,28571	46934,2857	0	0,00%
	Fertilize	333,1283959	333,128396	0	0,00%
	Tractors	4383,049511	4383,04951	0	0,00%
	Labour	4,4	4,4	0	0,00%
	Value Added	79667744183	7,9668E+10	0	0,00%
29	Kazakhstan	3,507485559			
	Land	2078672,857	816337,101	-1262335,76	-60,73%
	Fertilize	5,315075302	5,3150753	0	0,00%
	Tractors	19,53998494	15,6259883	-3,91399668	-21,54%
	Labour	32,76666667	3,8841353	-28,8825314	-88,27%
	Value Added	1982897701	6836837853	4853940152	250,75%
30	Korea, Rep.	1,171096885			
	Land	18711,42857	18711,4286	0	0,00%
	Fertilize	501,4468424	166,264447	-335,182395	-66,41%
	Tractors	1406,32381	1406,32381	0	0,00%
	Labour	8,014285714	4,90752539	-3,10676032	-40,03%
	Value Added	23019256425	2,6992E+10	3972978497	17,11%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
31	Kyrgyz Republic	13,0519583			
	Land	107597	107597	0	0,00%
	Fertilize	20,24243815	20,2424381	0	0,00%
	Tractors	180,2244699	155,637232	-24,5872375	-14,54%
	Labour	38,17	1,73838338	-36,4316166	-95,62%
	Value Added	541364952,4	7085981937	6544616985	948,03%
32	Latvia	29,55194817			
	Land	17245,71429	17245,7143	0	0,00%
	Fertilize	69,55658104	69,556581	0	0,00%
	Tractors	523,838716	523,838716	0	0,00%
	Labour	11,88571429	5,56944968	-6,31626461	-47,51%
	Value Added	378562949	1,1155E+10	1,0777E+10	999,90%
33	Lithuania	21,23295477			
	Land	27180	27180	0	0,00%
	Fertilize	113,8845971	113,884597	0	0,00%
	Tractors	632,0889935	632,088993	0	0,00%
	Labour	13,71428571	11,8037421	-1,91054358	-11,48%
	Value Added	697257142,9	1,4779E+10	1,4082E+10	999,90%
34	Macedonia, FYR	34,66144784			
	Land	12157,14286	12157,1429	0	0,00%
	Fertilize	51,0199168	51,0199168	0	0,00%
	Tractors	1182,78355	668,334604	-514,448947	-44,03%
	Labour	19,63333333	0,79040511	-18,8429282	-95,94%
	Value Added	352211262,6	1,2346E+10	1,1994E+10	999,90%
35	Madagascar	1,555870277			
	Land	408432,8571	72503,8002	-335929,057	-82,25%
	Fertilize	3,151525424	3,15152542	0	0,00%
	Tractors	1,674576271	1,67457627	0	0,00%
	Labour	80,8	0,54341274	-80,2565873	-99,33%
	Value Added	1127255286	1750365459	623110173	55,59%
36	Malta	1,809520028			
	Land	98,28571429	98,2857143	0	0,00%
	Fertilize	106,9220053	0,69663221	-106,225373	-99,32%
	Tractors	1213,333333	9,17983026	-1204,1535	-99,24%
	Labour	1,785714286	0,00922107	-1,77649321	-99,48%
	Value Added	93541694,46	166970652	73428957,4	80,95%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
37	Moldova	8,419143997			
	Land	25121,42857	25121,4286	0	0,00%
	Fertilize	9,257971046	9,25797105	0	0,00%
	Tractors	210,1453892	105,527192	-104,618197	-49,27%
	Labour	38,4152381	0,49009983	-37,9251383	-98,86%
	Value Added	342537511,9	2830443313	2487905801	712,88%
38	Netherlands	2,592760446			
	Land	19317,71429	19317,7143	0	0,00%
	Fertilize	345,8438571	126,173635	-219,670223	-63,01%
	Tractors	1264,436719	1264,43672	0	0,00%
	Labour	2,942857143	2,94285714	0	0,00%
	Value Added	9306904630	2,3899E+10	1,4592E+10	159,28%
39	Norway	4,949583116			
	Land	10361,85714	10361,8571	0	0,00%
	Fertilize	215,566277	73,5461215	-142,020156	-65,86%
	Tractors	1538,205847	967,642177	-570,56367	-37,08%
	Labour	3,371428571	0,97128222	-2,40014635	-70,93%
	Value Added	3565515185	1,7588E+10	1,4023E+10	394,96%
40	Pakistan	1,215636346			
	Land	269942,8571	269942,857	0	0,00%
	Fertilize	161,5382625	161,538262	0	0,00%
	Tractors	195,8266403	195,82664	0	0,00%
	Labour	43,02952381	35,1831336	-7,84639016	-18,18%
	Value Added	19926461188	2,418E+10	4253699402	21,56%
41	Paraguay	8,262736632			
	Land	200200	200200	0	0,00%
	Fertilize	63,96470636	63,9647064	0	0,00%
	Tractors	62,69253238	62,6925324	0	0,00%
	Labour	29,34761905	16,7908145	-12,5568045	-43,05%
	Value Added	1651648089	1,3548E+10	1,1896E+10	726,27%
42	Philippines	1,023489126			
	Land	114007,1429	114007,143	0	0,00%
	Fertilize	150,2684737	150,268474	0	0,00%
	Tractors	127,56231	127,56231	0	0,00%
	Labour	36,78	34,5797462	-2,20025384	-5,99%
	Value Added	14486854592	1,4808E+10	321643453	2,35%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
43	Poland	3,738161443			
	Land	162270	162270	0	0,00%
	Fertilize	151,0298019	151,029802	0	0,00%
	Tractors	1157,485427	1157,48543	0	0,00%
	Labour	16,81809524	12,2471071	-4,57098814	-26,75%
	Value Added	8488536679	3,1651E+10	2,3162E+10	273,82%
44	Portugal	7,822439727			
	Land	36712,85714	36712,8571	0	0,00%
	Fertilize	210,4482971	210,448297	0	0,00%
	Tractors	1359,22475	1359,22475	0	0,00%
	Labour	12	12	0	0,00%
	Value Added	3678556420	2,8719E+10	2,5041E+10	682,25%
45	Romania	1,766950783			
	Land	141512,8571	141512,857	0	0,00%
	Fertilize	42,69903616	42,6990362	0	0,00%
	Tractors	192,1971805	192,19718	0	0,00%
	Labour	32,07142857	8,18003231	-23,8913963	-74,98%
	Value Added	6378648054	1,1078E+10	4698997818	76,70%
46	Russian Federation	1			
	Land	2158618,571	2158618,57	0	0,00%
	Fertilize	12,91215144	12,9121514	0	0,00%
	Tractors	40,37714983	40,3771498	0	0,00%
	Labour	10,06380952	10,0638095	0	0,00%
	Value Added	17466961298	1,7467E+10	0	0,00%
47	Senegal	3,891503788			
	Land	87821,42857	87821,4286	0	0,00%
	Fertilize	7,313681772	7,31368177	0	0,00%
	Tractors	2,194287014	2,19428701	0	0,00%
	Labour	33,7	1,75825171	-31,9417483	-94,78%
	Value Added	769485930,3	2924947498	2155461568	289,15%
48	Slovak Republic	3,260194729			
	Land	20220	20220	0	0,00%
	Fertilize	92,30218123	79,5848739	-12,7173074	-10,71%
	Tractors	157,8939071	157,893907	0	0,00%
	Labour	4,914285714	4,91428571	0	0,00%
	Value Added	1683806625	5465325615	3781518991	226,02%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
49	Slovenia	14,85735929			
	Land	5017,142857	5017,14286	0	0,00%
	Fertilize	344,7059118	35,5965886	-309,109323	-89,57%
	Tractors	104041,8476	468,519822	-103573,328	-99,55%
	Labour	9,459047619	0,47024995	-8,98879767	-95,00%
	Value Added	575190190	8519504099	7944313908	999,90%
50	South Africa	7,822300491			
	Land	995100	980820,039	-14279,9612	-1,43%
	Fertilize	51,6471582	51,6471582	0	0,00%
	Tractors	41,50262224	39,1490329	-2,35358939	-5,47%
	Labour	9,132380952	5,31966854	-3,81271241	-40,59%
	Value Added	4205269021	3,2787E+10	2,8582E+10	682,23%
51	Spain	1,395666777			
	Land	287605,7143	287605,714	0	0,00%
	Fertilize	148,6977102	148,69771	0	0,00%
	Tractors	768,2047194	768,204719	0	0,00%
	Labour	5,157142857	4,98137391	-0,17576895	-4,09%
	Value Added	22027008093	3,0702E+10	8674736009	39,57%
52	Suriname	12,56427807			
	Land	750,5714286	750,571429	0	0,00%
	Fertilize	188,5171576	5,32511766	-183,19204	-96,10%
	Tractors	182,8245214	70,1020533	-112,722468	-61,27%
	Labour	8	0,07041186	-7,92958814	-99,12%
	Value Added	101542839,5	1273992308	1172449468	999,90%
53	Sweden	2,478496062			
	Land	31608,57143	31608,5714	0	0,00%
	Fertilize	106,3167728	78,7272389	-27,5895339	-24,01%
	Tractors	595,5647924	595,564792	0	0,00%
	Labour	2,084761905	2,0847619	0	0,00%
	Value Added	5322209799	1,3101E+10	7779238037	147,85%
54	Switzerland	7,621027538			
	Land	15621,28571	15621,2857	0	0,00%
	Fertilize	217,6866623	110,853237	-106,833425	-48,91%
	Tractors	2619,456127	1458,7432	-1160,71293	-44,31%
	Labour	3,88952381	1,4639696	-2,42555421	-62,35%
	Value Added	3483500488	2,6517E+10	2,3034E+10	662,10%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
55	Syrian Arab Republic	2,431166906			
	Land	138537,1429	138537,143	0	0,00%
	Fertilize	79,35786301	77,7583028	-1,59956016	-1,82%
	Tractors	227,2154431	227,215443	0	0,00%
	Labour	18,6	9,21564997	-9,38435003	-41,70%
	Value Added	5798464124	1,406E+10	8261266061	143,12%
56	Tajikistan	21,83111681			
	Land	46685,71429	46685,7143	0	0,00%
	Fertilize	31,17579958	31,1757996	0	0,00%
	Tractors	250,5362736	250,536274	0	0,00%
	Labour	55,5	2,99327145	-52,5067286	-94,61%
	Value Added	337647079,5	7232723754	6895076675	999,90%
57	Tanzania	1,606772991			
	Land	347315,7143	347315,714	0	0,00%
	Fertilize	5,84178112	5,84178112	0	0,00%
	Tractors	23,3043956	14,3666017	-8,9377939	-38,35%
	Labour	74,6	0,9031256	-73,6968744	-98,79%
	Value Added	4005274367	6478788189	2473513822	60,68%
58	Thailand	1,774904803			
	Land	196140	196140	0	0,00%
	Fertilize	127,2322955	127,232296	0	0,00%
	Tractors	453,5421405	453,54214	0	0,00%
	Labour	42,85333333	15,8472368	-27,0060965	-63,30%
	Value Added	12798036361	2,2705E+10	9906767180	77,49%
59	Trinidad and Tobago	11,90809284			
	Land	558,5714286	558,571429	0	0,00%
	Fertilize	679,4920879	3,96334435	-675,528744	-97,57%
	Tractors	2063,589744	52,1724259	-2011,41732	-97,41%
	Labour	4,06	0,05242148	-4,00757852	-98,35%
	Value Added	83899219,77	948840023	864940803	934,43%
60	Turkey	1,024767756			
	Land	404847,1429	404847,143	0	0,00%
	Fertilize	100,9486449	100,948645	0	0,00%
	Tractors	437,4684947	437,468495	0	0,00%
	Labour	30,31428571	22,1976925	-8,11659317	-28,49%
	Value Added	27904017038	2,8586E+10	681714371	2,48%

		Average			
No.	DMU	1/Score			
	I/O	Data	Projection	Difference	%
61	Ukraine	2,656346683			
	Land	413215,7143	413215,714	0	0,00%
	Fertilize	21,04537617	21,0453762	0	0,00%
	Tractors	111,4850278	57,1673937	-54,3176341	-48,60%
	Labour	18,66380952	1,56822132	-17,0955882	-91,36%
	Value Added	5402641789	1,4402E+10	8998871093	165,64%
62	United Kingdom	2,086425717			
	Land	173011,4286	173011,429	0	0,00%
	Fertilize	278,0539988	101,303179	-176,75082	-62,82%
	Tractors	444633,3333	1287,91568	-443345,418	-99,71%
	Labour	1,342857143	1,34285714	0	0,00%
	Value Added	13343275041	2,7822E+10	1,4479E+10	108,64%
63	United States	1			
	Land	4134112,857	4134112,86	0	0,00%
	Fertilize	113,8304715	113,830471	0	0,00%
	Tractors	258,8835444	258,883544	0	0,00%
	Labour	1,62952381	1,62952381	0	0,00%
	Value Added	1,17666E+11	1,1767E+11	0	0,00%
64	Uruguay	10,65850841			
	Land	147565,7143	147565,714	0	0,00%
	Fertilize	132,9876434	127,801766	-5,18587774	-3,92%
	Tractors	269,2269649	269,226965	0	0,00%
	Labour	11,07619048	11,0761905	0	0,00%
	Value Added	1547473653	1,6485E+10	1,4937E+10	960,26%