THE PRODUCTIVITY OF TURKEY'S AGRICULTURAL PRODUCTION ON PROVINCIAL BASIS

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Approval of the Institute of Social Sciences

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Sciences.

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ABSTRACT

THE PRODUCTIVITY OF TURKEY'S AGRICULTURAL PRODUCTION ON PROVINCIAL BASIS

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Given the geographical location, seasonal features and historical-cultural features, agriculture has always been extremely important in Turkey. In this study, using the data from 81 provinces in Turkey between 2007 and 2015, it was analyzed whether agricultural production is efficient or not. As the methodology, the Data Envelopment Analysis based Malmquist Productivity Index is used. The input set has been determined as number of tractors used in plant production, number of laborers in agricultural sector, the cultivated area used in agriculture and the amount of fertilizer used in agriculture, while the output set has been determined as the amount of income generated by the agricultural production activities of 81 provinces between 2007 and 2015 in the gross domestic product (GDP) of that province. In the given period, the province with the greatest increase in agricultural productivity was Hakkari, while the province with the greatest decrease in agricultural productivity was Karaman. In total, an overall increase in agricultural productivity was observed in Turkey.

Keywords: Agricultural Economics, Productivity, Data Envelopment Analysis, Malmquist Efficiency Index

ÖZET

TÜRKİYE'NİN TARIMSAL ÜRETİM VERİMLİLİĞİNİN İLLER BAZINDA İNCELENMESİ

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Yüksek Lisans, İktisat Bölümü

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Tarım, coğrafi konumu, mevsimsel özellikleri ve tarihi-kültürel özellikleri göz önüne alındığında, Türkiye için her zaman son derece önemli olmuştur. Bu çalışmada 2007-2015 yılları arasında 81 ilin verilerinden yararlanılarak tarımsal üretimin verimli olup olmadığı incelenmiştir. Metodoloji olarak Veri Zarflama Analizi tabanlı Malmquist Verimlilik İndeksi kullanılmıştır. Girdi seti, bitki üretiminde kullanılan traktör sayısı, tarım sektöründeki işçi sayısı, tarımda kullanılan ekili alan ve tarımda kullanılan gübre miktarı olarak belirlenirken, çıktı seti, 81 ilin 2007 ile 2015 yılları arasındaki tarımsal üretim faaliyetleri sonucu elde edilen gelirin, o ilin gayri safi yurt içi hasılası (GSYİH) içindeki miktarı olarak belirlenmiştir. Belirtilen dönemde tarımsal üretimindeki verimliliği en fazla artan il Hakkari iken, tarımsal üretimdeki verimliliğin en fazla azaldığı il ise Karaman olmuştur. Toplamda, Türkiye'de tarımsal verimliliğin genel bir artış yöneliminde olduğu gözlemlenmiştir.

Anahtar Sözcükler: Tarım Ekonomisi, Verimlilik, Veri Zarflama Analizi, Malmquist Verimlilik Endeksi

To my family

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LIST OF ABBREVIATIONS

BCC	Banker-Charnes-Cooper
CCR	Charnes-Cooper-Rhodes
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DİKA	Dicle Kalkınma Ajansı
DMU	Decision Making Unit
DPT	Devlet Planlama Teşkilatı
EAP	Eastern Anatolia Project
EFFCH	Technical Efficiency Change (Catch-Up Effect)
EU	European Union
GDP	Gross Domestic Product
IMF	International Money Fund
MI	Malmquist Index
PE	Pure Efficiency
PECH	Pure Efficiency Change
PPF	Production Possibility Frontier
PTE	Pure Technical Efficiency
SE	Scale Efficiency
SECH	Scale Efficiency Change
TECHCH	Technical Change (Frontier-Shift Effect / Technological Change)

TFP	Total Factor Productivity
TFPCH	Total Factor Productivity Change
TTE	Total Technical Efficiency
TURKSTAT	Turkish Statistical Institute
VRS	Variable Returns to Scale
WB	World Bank
WTO	World Trade Organization

CHAPTER 1

INTRODUCTION

Agriculture is the economic activity that people use and process nature's resources to meet their basic needs (TÇVY, 1997, p. 15). Agriculture in Turkey has always been a very important sector in terms of the share in the GDP and providing resources to industrial sector. Considering that the climate diversity, soil diversity and abundance of water resources, it has always been a matter of debate whether agricultural production is efficient in Turkey. In a country where there is so much diversity of land and climate, and where irrigation resources are abundant, agricultural sector is expected to be highly developed and efficient. Therefore, it is extremely important to identify the current situation of agricultural efficiency in Turkey and to make suggestions accordingly so as to further increase the efficiency. The lack of coherent growth in the agricultural sector and its diminishing share in the GDP despite the increasing GDP make the analysis of Turkey's agricultural performance necessary.

The share of agriculture in total GDP has been declining steadily, especially after 2010. It decreased by 7.52%, 9.03% and 6.83% in 2007, 2010, and 2015, respectively. Therefore, it is crucial to investigate whether the production is efficient in Turkish agricultural sector while its share in GDP is declining. This sector is one of the main sectors of the Turkish economy. In 2000, 35% of the population lived in the countryside, while in 2009; this rate went down to 24% after the improvements in urbanization. The main reason for this decline is the migration from rural areas to the urban areas due to the steadily decreasing share of agriculture in the national income, imbalances in income distribution and differences in socio-economic development between rural and urban areas (Gülçubuk, 2005, p. 68). The increase in agricultural input prices, the fragmentation of land by inheritance, the difficulty of agricultural activities for new core families due to labor shortages, and the desire to work in non-agricultural sectors have increased immigration to cities (Gülçubuk, 2005, p. 73). As a result, employment in the agricultural sector, which is the primary source of economic activity in the rural areas, has decreased from 36% to 25% since 2000 (DPT, 2011).

The aim of this study is to investigate the question of whether the current production is efficient or not. As the population increase in the world and in Turkey, the demand for food increases accordingly. The predictions indicate that by 2050 the agricultural production needs to be increased by 70% only for feeding the world's population. For developing countries, this ratio in the agricultural production must be around 100% (FAO, 2009). For this reason, analyzing the productivity of agricultural production, determining the problems and recommending solutions according to the analysis results, have a vital importance. However, the number of studies examining the productivity of agriculture in Turkey is inadequate. In addition, most of them is broad regional. This study will contribute to the literature on agricultural economics that it continuous the most recent data and is carried out on the 81 provinces of Turkey. Moreover, this study is significant since it reveals the problems of Turkey's agricultural sector and makes suggestions to overcome these problems.

In this study, the method in the analysis, is determined as Data Envelopment Analysis (DEA) based Malmquist Total Factor Productivity (TFP) indices. These indices were introduced by Caves et al. (1982). The innovation of Färe et al. (1994) was showing that this index could be estimated by using a nonparametric approach (Shahabinejad & Akbari, 2010). The DEA and Malmquist TFP indices were computed using the DEAP 2.1 computer program written by Coelli (1996).

The data set consists of four inputs, which are land, labor, tractor and fertilizer, and one output, which is the amount of income generated by the agricultural production activities of 81 provinces between 2007 and 2015 in the Gross Domestic Product (GDP) of that province. With these inputs, it was examined whether the agricultural production is efficient or not in Turkey. In the study, the producers, who are Decision Making Units (DMU), were identified as the 81 provinces of Turkey and the time period has been determined between 2007 and 2015.

The study consists of seven chapters. In the following chapter, the nexus of agriculture and economics is investigated. Before doing analytical analysis, it is necessary to talk about the developments made in this field, and to emphasize the importance of the subject. A short summary of Turkey's agricultural policy history is given, and after that the aim and importance of this study is discussed.

In the third chapter, literature review has been done. Detailed information on each work has been given including methodologies used in the studies, input and output sets, the time period of the study, the regions where the study involves, and analysis results. At the end of this chapter, studies done in the world and studies done in Turkey are compared.

In the fourth chapter, detailed information about methodology, computer program and data used in this study has been given. The historical background of the DEA based Malmquist Productivity Index, the strengths and weaknesses of this methodology, the detailed information about the models that arise in applying this method and the mathematical representations of these models can be found. The chapter also discusses how the data set in the analysis was and what problems were encountered during data collection.

In the fifth chapter, the analysis results have been examined in two different ways. Firstly, the mean analysis results for each province between 2007 and 2015 were presented (See Table 2). Secondly, the mean analysis results of all provinces in total for each period were provided (See Table 3). In other words, for each year, the level of productivity in agricultural production has been explained in detail.

In the sixth chapter, the most important problems in Turkish agriculture, which are obstacles to the development of this sector, have been identified. After identifying these and many other issues, it is of utmost importance to do what is required for the solution.

Finally, the seventh chapter summarizes the key empirical and theoretical findings. An overview of the analysis results, problems of Turkish agriculture and the proposed solution for these problems are presented. In addition, the problems encountered in this study and suggestions for future studies are included.

CHAPTER 2

AGRICULTURE AND ECONOMICS NEXUS

Looking at the developments of the economy in recent years, it can be seen that the share of the agricultural sector, both in the national income contribution and in the total labor force, tends to decrease. The share of agriculture in national income was over 30% in 1960s. This ratio fluctuated between 25-30% in the 1970s and 20-25% in the 1980s. In the 1990s, it dropped below 20%, after which it gained a rather "stable" level around 12.5-15% (Kepenek & Yentürk, 1994). The reason is that more emphasis is placed on the development of industrial and service sectors (Özçam, 2012).

Until the early 1970s, the agricultural sector was protected and supported by every government through various policies. It is because the share of agriculture in GDP was so high that it made a significant contribution to economic growth in these years. Moreover, agricultural export revenues were very high. Therefore, the agricultural sector grew regularly, yield increased, and agricultural technology developed (Kazgan, 2013).

At the beginning of the 1980s, a stagnation in this sector started to take place with the removal of agriculture from state protection. Agricultural technology was depressed. The rate of growth in agriculture remained lower than the rate of population growth. In this period, the import level exceeded the export level in agricultural sector. Although there were various attempts tp overcome the stagnation problem of agricultural sector, these attepmts were failed. (Kazgan, 2013).

The crises that took place in the 2000s caused that agricultural sector remained in the background. In this period, policies corresponding to the needs of the country could not become effective. Due to the debts borrowed from international financial institutions; such as, the International Money Fund (IMF), World Bank (WB), World Trade Organization (WTO) and the European Union (EU), the conditions imposed by them were given priority. The greatest aim of imposing these conditions was that large countries could gain a decisive role in the agricultural markets. Due to the binding reasons, these conditions had to be adhered to and the agricultural sector regressed in Turkey (Kazgan, 2013).

At this point, it is necessary to talk about what kind of agreements are made with the aforementioned organizations. In the *Stand by* Agreement signed with the IMF in December 1999, and in the letters of intention written in this framework, many agriculture-related commitments have been made. The binding force of these commitments arises when the period of 1999-2008 is evaluated with the uninterrupted IMF coexistence. In this context, the commitments made to the IMF regarding agriculture in the letters of intention may be grouped as follows (Özkaya, Günaydın, Bozoğlu, Olhan, & Sayın, 2010).

- The elimination of the existing support system and the implementation of direct income support instead,
- Termination of the Ziraat Bank's subsidized agricultural credit system.
- Determination of the support purchase prices according to world stock market prices.
- Restructuration of the agricultural Sales Cooperatives Unions.
- Privatization of Turkey Sugar Factories Inc. (TŞFAŞ), Turkey's State-run Tea Company (ÇAYKUR), and Turkish Tobacco and Alcoholic Beverages Company (TEKEL).
- Enactment of the Tobacco and Sugar Laws.

Under the IMF program, Turkey experienced two major crises in November 2000 and February 2001, with a contraction up to 12% in the economy. The embodied IMF commitments were also supported by World Bank projects.

31 of the 163 loan agreements signed with the World Bank in the 1950-2000 period are related to the agricultural sector (Güler, 1995). Turkey and WB signed the Economic Reform Loan Agreement in 2000 and the Agricultural Reform Implementation Project (ARIP) in 2001 (Özkaya, Günaydın, Bozoğlu, Olhan, & Sayın, 2010).

It was only after 2010 that Turkey could change its approach to agricultural sector. In this period, it is aimed to create an organized and competitive agricultural structure taking into consideration the sustainable use of natural resources and the provision of food safety and security (DPT, 2006, p. 78). Looking at the basic agricultural policies foreseen in the Ninth Development Plan, it seems that the focus is on the implementation of policy instruments to direct production according to demand, and on increasing the production of agricultural products with high production value, which will contribute to competition power. At the same time, it was decided to expand the land consolidation investments in order to overcome the problem of land fragmentation in agricultural enterprises. In order to increase competition power in agricultural export, it was emphasized that export subsidies subject to foreign trade and direct to branded products. On the other hand, it seems that agriculture-industry integration has been encouraged by the EU Pre-Accession Financial Assistance to provide modernization of agriculture and food businesses. Another point emphasized is the improvement of the information infrastructure and administrative structure regarding the elimination of quality and quantity problems related to agricultural statistics and the execution of agricultural policies (DPT, 2006). In addition, it was aimed to regulate agricultural supports in order to increase efficiency, productivity and quality in production. It was emphasized that financial subsidies to the agriculture sector will be diversified by providing credit subsidies and subsidy payments to the producers from various channels (Günaydın, 2009; OECD, 2011).

In the light of all these developments, the importance of agriculture and agricultural productivity cannot be denied. Whatever happens in a country, the supply of food is a necessity that will never end. This is because the demand for food is increasing with the increasing population. However, the reflection of this importance to the economy is inversely proportional to the level of development of the country. That is, in developed countries, the share of agriculture in GDP is around 2-5%, while it is 6-20% in developing countries. In the undeveloped countries, this rate can reach up to 80-90%. This is due to the slower increase in agricultural income relative to other sector revenues. As each sector grows in different proportions, the composition of national income changes constantly (Kazgan, 2013, p. 229). For this reason, the agricultural sector should not be compared with other sectors, but should be developed in parallel with other sectors. Which means, technological developments should take place in this sector, and policies should always be followed to increase productivity.

At this point it is extremely important to do this study. Whether or not agricultural production has been carried out efficiently in Turkey should be investigated, existing problems should be determined and solutions for these problems should be proposed. However, before all these stages, we define the concept of productivity, and it is useful to look at what is done in this regard, in the world.

In this study, the concept of Malmquist TFP was used in the analysis of productivity. The concept and components of TFP deal with many issues in terms of conceptual and measurability. TFP, which is used as a basic indicator in evaluating countries' growth-development efforts, is a very important concept in terms of determining the reasons for the differences in growth between countries and also determining which production factor is used more effectively in production as a driving force for growth in the process of decomposing resources (Vergil & Abasız, 2008).

In agricultural point of view, the TFP means sum of the efficiencies for all the production factors, which are included in the production process (Avcı & Kaya, 2008). The TFP growth index is decomposed into technical efficiency change and technical change indices. If technical efficiency change index is greater than one, then there is an improvement in efficiency or catching-up effect the best-practice frontier. On the other hand, if it is less than one then there is a deterioration in production performance of the DMU (Deliktaş & Candemir, 2007).

The countries' aim of a higher level of prosperity is to explore the possibilities of using the resources they have for the right purposes and in the right way. This aim is the common side of these countries' growth efforts. In the countries that show a great effort in growth, the increase in revenues and consumption as well as population, searching the new resources and using existing resources in the most efficient way become compulsory (Vergil & Abasız, 2008).

In our world entering a new century, concerns about the future have risen more intensely. The rapid growth of the world's population led many researches to question whether we can produce enough nutrients to feed this population in the future. In Turkey, agricultural production is highly dependent on nature. Hence, the growth in agriculture follows a fluctuating course due to the events that have a negative effect on production; such as, drought. Therefore, Turkish agriculture has grown by an annual average of 4.14 percent in the 2005-2011 period (Eruygur, Kıymaz, & Küçüker, 2016). Whether or not these growth rates are sufficient to meet the country's needs should be examined, and studies on this area should be intensified.

According to the results of the research conducted by TUBITAK (The Scientific and Technological Research Council Of Turkey) with Metro Wholesaler Market, 25-40% of the

49 million tons of fruits and vegetables produced in Turkey are either lost in production, distribution or consumption chain. This corresponds to approximately 4 times the annual fresh fruit and vegetables export (Lojistik Global Haber, 2017). For this reason, the aim of this study is very important. Between 2007 and 2015, it has been examined whether the agricultural production of each province is efficient. One of the possible contributions of this study is the calculation of agricultural TFP of 81 NUTS-3 (The Nomenclature of Territorial Units for Statistics) regions between 2007 and 2015.

CHAPTER 3

LITERATURE SURVEY

In the literature of agricultural economics, there are numerous studies on the agricultural productivity. These studies mainly covers comparisons between countries, or comparisons between the provinces or counties within a particular country. They were listed below in chronological order. Thus, this list makes it possible to observe whether there is a change between methods, inputs and outputs benefitted by the scholars over time (See table 1).

One of the earliest studies known in agricultural productivity was conducted by Bhattacharjee in 1955. In this study, the aim is to examine the efficiency of resources used in the worldwide agricultural production. The study asserted that the use of resources are relatively efficient. The method is the adaption of the Cobb-Douglas production function to the agricultural input-output data in selected countries of the world. The inputs are active population in agriculture, arable land equivalent, conversion ratio of pasture of arable land, productive livestock, work stock, fertilizer consumption, and number of tractors in agriculture. The output is net agricultural output of each country. At the end of the analysis, it is found that the world's agriculture is on the stage of diminishing returns.

In the paper of Hayami and Ruttan (1970) differences among the agricultural productivity of countries were studied. The approach used in this study involves the estimation of a cross-country production function of the Cobb-Douglas type for thirty-eight developed and underdeveloped countries. The inputs are land, labor, livestock, fertilizer, machinery, education, and technical manpower; and the output is agricultural production. The authors group all the countries and make comparisons one by one to reach the evaluation results. And, they use different input combinations during this process.

Mao and Koo (1996) focused on the TFP, efficiency and technology of Chinese agricultural production covering the years from 1984 to 1993. Their sample set consists of 29 provinces in China. These provinces are classified into two groups as having advanced-technology and low technology. The method of this study is DEA based Malmquist efficiency index; and their inputs are land, labor, machinery, fertilizers, and draft animals. And their output is sum of the total value of production from farming, forestry, animal husbandry, fishing, and sideline activities. The findings of the study suggest that TFP rose in most provinces in both categories.

Fulginiti and Perrin (1997) examine the changes in agricultural productivity in 18 developing countries covering the period of 1961-1985. Their method is nonparametric output-oriented Malmquist index. In this study, the inputs are land, labor, fertilizer, machinery, and livestock while the output is quantity of agricultural production in millions of 1979-1981 international dollars. As a result of this study, they figure out that the results confirm previous findings, indicating that at least half of these countries have experienced productivity declines in agriculture.

Aldaz and Millan (2003) analyze the agricultural productivity of 17 Spanish regions. Their former study conducted in 1998 uses nonparametric Malmquist efficiency index while the latter study employs the method of DEA applied to panel data. The data used for both studies belongs to the period between 1977 and 1988. Their inputs are land, labor, machinery and materials and their outputs are crop and animal production. According to the results of both studies, a technical change increases the productivity about a mean annual rate of 2.9% in Spain between 1977 and 1988, but with very great regional variation.

Nin et al. (2002) carried out a study on the agricultural productivity growth of 20 developing countries by using the method of nonparametric Malmquist efficiency index. Their inputs are land, labor, tractors, fertilizers, livestock; and outputs are crops and livestock production covering the period from 1961 to 1994 for these 20 countries. The study shows that the measured agricultural productivity in developing countries increases in general.

Nghiem and Coelli (2002) studied the productivity growth of Vietnamese rice production by using the data covering the period from 1976 to 1997. Their method is Malmquist DEA. The inputs are seed, chemical fertilizers, human labor, pesticide, and animal services, while the output is rice production. With the fastest growth observed in the period after the first agricultural incentive reform in Vietnam, a strong TFP increase of between 3.3 and 3.5 per cent per annum is noted as a result of this study.

Thirtle et al. (2003) estimated the multilateral, multifactor productivity indices for agriculture in 18 regions and the business sector in Botswana from 1981 to 1996. The method of this study is sequential Malmquist index. Their inputs are land, labor, draft power, seed and herds while their outputs are crop and livestock production. In the end, the Malmquist factor productivity indices prove that the agricultural productivity rates increase by 1.7% on average, per annum.

Coelli and Rao (2003) examined the levels and trends in agricultural output and productivity in 93 developed and developing countries, covering the period of 1980-2000. They use the DEA method to derive Malmquist productivity indices. Their inputs are land, tractors, labor, fertilizer, and livestock; and their outputs are crops and livestock production. The results show an annual growth in TFP of 2.1%, with efficiency change contributing 0.9% per year and technical change providing the other 1.2%.

Ball et al. (2005) demonstrated how productivity growth can be amended to account for nontraditional outputs, such as positive or negative externalities or other social outputs by using the Malmquist cost productivity index method. This study was conducted in 46 states of the US. The inputs are capital, land, labor, and materials and the outputs are crops and livestock production. The most important aspect of this study is to measure the increase in productivity within the "cost" framework. At that point, they build up the study around three basic facts. Firstly, they mention about the responsibility of the production of good and bad outputs simultaneously. Secondly, they claim that today's technology shows that the production of bad outputs cannot decline without reducing the production of good outputs. Although the bad outputs can be reduced without reducing the good outputs' production, this causes a serious increase in the costs of the producer. Lastly, they assume that there cannot be any production of good outputs without harming the environment and producing bad outputs. They show that measures of productivity growth that ignored bad outputs are biased upward when the production of negative externalities (or bads) increases. Conversely, when the environmental risks which were associated with production decreases, this same measure understates the social benefits of production and, hence, productivity growth.

Tonini and Jongeneel (2006) investigated the TFP growth in agriculture. Their sample set consists of the ten Central and East European countries, which are Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. The common point of these 10 countries is that they all began formal negotiations for EU accession in September 1998. Their method is Malmquist index of TFP covering the data of the years from 1993 to 2002. They choose the input set as fertilizer, labor, livestock, and machinery; and their output is the net agricultural production valued at 1999-2001 'international dollar' prices. According to the estimation results, there are big differences in technical efficiency of these countries.

Zhengfei and Lansink (2006) explained the differences between family farms and company firms by expanding the capital structure study to the situation in agriculture. They use the Malmquist productivity growth index and model return on equity (ROE) as the method of this study. Their inputs are land, labor, fertilizer, pesticides; and miscellaneous inputs; while their output is total revenue from all products, deflated to 1990 values using an index of prices received for farm outputs. Empirical results show that the long-term debt increases the productivity growth.

In the article of Chen and Ding (2007), they studied that whether it is possible to create a framework for assessing the trend of China's agricultural infrastructure and to measure its effect on TFP. They use the Malmquist index to evaluate the sources of TFP in Chinese agriculture. The inputs used in the study are per capita agriculture electricity consumption, the ratio of irrigation areas to sown areas, the reservoir capacity per sown area, number of motor vehicles per 100 rural households, the ratio of teachers to students in rural primary and secondary schools, and the ratio of villages, having small hospitals to total number of villages. Their output is TFP. At the end of this study, they reach the result that enhancing the potential of power production is the key factor for increasing Chinese agricultural TFP.

Lissitsa, et al. (2007) measured TFP growth in the agriculture of transition countries after the breakdown of socialism, and compared their TFP growth with that of other European countries. They use a panel data set on the agricultural sectors of forty-four countries between 1992 and 2002. In this study, a nonparametric distance-function approach, Malmquist TFP index, is used as the method. The inputs are land, labor, tractor, fertilizer, and livestock; and the outputs are crop and livestock production. At the end of this study, a remarkably better performance in terms of the efficiency and productivity growth of new EU members is observed, especially between 2000 and 2002.

Latruffe et al. (2008) study the usefulness of applying bootstrap procedures to TFP by using Malmquist indices, derived with DEA. They analyze 250 Polish farms during 1996-2000.

Their inputs are land, labor, capital, and intermediate consumption; and their outputs are crop, livestock and other nonagricultural production. They show that a cluster analysis based on bootstrap confidence intervals revealed that important policy conclusions could be drawn regarding productivity enhancement.

Luh et al. (2008) analyze the agricultural growth of eight East Asian economies to describe their sources. They use the Malmquist productivity growth index as the method. Their inputs are land, labor, and fertilizer; and their output is crop production. At the end of this study they found that the domestic R&D is an important matter of the growth of the agricultural sector, while international R&D spillovers can promote growth only through advances in education levels for most East Asian economies.

Wu et al. (2008) approach the geographical and physical condition of Chinese agricultural productivity growth between 1980 and 1995, which is the post-reform period. They use the nonparametric Malmquist productivity indices for this study. Their inputs are farm machinery power (plows, cultivators, irrigators, tractors, etc.), irrigation, manure fertilizer, area sown for all crops, chemical fertilizer, and labor force, while the output is gross value of agricultural production in constant 1980 prices. At the end of the study, an increase in productivity is observed in most of the cases, although a productivity decline is observed in some of the cases.

Chen et al. (2008) investigated the agricultural productivity growth of China's 29 provinces for the period between 1990 and 2003. They compute the output-oriented Malmquist productivity indices and their decomposition by using a sequential DEA approach. They use labor, land, machinery, and draft animals as inputs; and gross value-added of farming, forestry, animal husbandry, and fishery production at 1990 constant prices as outputs. The results indicate that the major source of productivity growth is technical progress and that the regional disparities in productivity growth get worse over time.

Nin-Pratt et al. (2009) make a comparison between China and Indıa with respect to productivity, technical changes, and agricultural TFP growth. They also test whether there is a structural break in the development of TFP on policy milestones. They use the Malmquist efficiency index as the method. Their inputs are land, labor, tractors, fertilizers, feed, and animal stock, while their outputs are crop and livestock production. The result of this study is that in Chine, agricultural TFP growth accelerated after 1979; in Indıa this happened after 1974. However, China’s agricultural sector clearly outperformed India’s agricultural sector.

Yao and Li (2010) study on the agricultural productivity change, which is induced by the Sloping Land Conversion Program (SLCP), with the data collected from Wuqi County. Their method is Malmquist productivity index. Their inputs are cultivated land, labor for farming and animal husbandry, fertilizers, manure, crop coversheets and improved seeds combined, feedstock and fodder combined, while their outputs are crop production and livestock production. The study concludes that in Wuqi County, it is possible to conserve the environment and increase the agricultural productivity at the same time, although a cropland reduction and production mode alternation is occurred.

Swinnen and Vranken (2010) investigate the changes in the agricultural performances of the Central and Eastern European and the Former Soviet republics between 1989 and 2005. Their method is DEA. Their inputs are land, labor, capital, fertilizer, and livestock; and their output is the value of physical production valued at fixed prices. The results show that the productivity changes are related to the duration of the pre-reform irregularities, basic resource bequests and usage of the technology and the reform administration in all these countries.

Shahabinedjad and Akbari (2010) examine the agricultural productivity of eight developing countries, which are Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey covering the years from 1993 to 2007. They use DEA based on Malmquist TFP indices as the method. Their inputs are agricultural land, animal stock, labor, fertilizer consumption, and agricultural machinery (number of tractors) while their outputs are crops and livestock production. In the conclusion of this study, it is found that the TFP had risen up during 15 years.

Fuglie and Schimmelpfennig (2010) focus on the agricultural productivity change in the global economy, with particular attention to large agricultural producers outside the Organization for Economic Co-operation and Development (OECD) countries, namely, China, India, Indonesia, and collectively the transition economies of the former Soviet Union and Eastern Europe. Tornqvist-Thiel index is used as the method of this study. The inputs are animals, machinery, seed, feed and fertilizer; and the outputs are growth in the agricultural labor force and growth in the output per worker. This study conclude that the institutional and policy reforms in these countries raised productivity growth by creating incentives for farmers to allocate resources more efficiently and exploiting their sectoral comparative advantage.

Li and Zhang (2013) conduct a study analyzing the productivity growth in China's agriculture covering a 25-year period from 1985 to 2010. They use the production function which is established based on the method proposed by Griliches (1963), and the Log-linear form of the Cobb-Douglas function as the method of this study. Their inputs are land, labor, fertilizer, and mechanicals. Their output is the gross output of agriculture, forestry, livestock and fishery (100 million Chinese Yuan '¥'). According to the results of this study, the increase in agricultural inputs and TFP contributes 40.6% and 55.2% to the agricultural output growth, respectively; China's agriculture had jumped out of the pattern which output growth was mainly driven by increasing input.

In addition to all these findings, the studies carried out in Turkey will be discussed. As can be seen below, the number of studies conducted on provincial basis is very limited and these studies do not contain current data. Apart from these, other studies have been carried out at regional level or at firm level. According to the studies mentioned below, it is found that agricultural production in Turkey is generally inefficient, at both regional and firm level. However, in the work done on provincial basis, it is mentioned that the productivity has an overall increase in a similar way to the result of this study. Detailed information about these studies can be found below.

The first study carried out by Tipi and Rehber (2006). It evaluates the agricultural technical efficiency and the TFP for South Marmara Region of Turkey between 1993 and 2002. They use DEA and the DEA based Malmquist TFP index as the method. Their inputs are utilized area, fertilizer, tractors, and labor while their outputs are crops and livestock production. This study concludes that the South Marmara Region of Turkey produces only about the 88.3% of the potential production with given inputs.

Başarır et al. (2006) analyze the Turkish agricultural production by using the method of Cobb-Dougles production function on the data of the period between 1961-2001. They use the number of tractors, animals, land, labor, fertilizers, and irrigation as inputs and agricultural production as output. They analyze the technical change by separating the 40-years period into four 10-years. According to the analyses, there is a negative technical production in the first 10-years period. However, the technical change rate reaches its highest level, in the second period, compared to the other periods. In the third period, the rates become negative. Lastly, in the fourth period, the rate of technical change becomes positive again, but not as high as in the second period.

Deliktaş and Candemir (2007) examine the productivity performance of Turkish State Agricultural Enterprises using DEA approach. This study mainly focuses on the 1999-2003 period. The inputs are labor, amortization (as a capital input), amount of fertilizer (in thousands of metric tons), cultivatable land (hectares), seed (in thousands of metric tons), annual mean rainfall (in mm by district from the meteorology department), and animal feed (in real value) and livestock in the beginning of each year for 37 state agricultural enterprises. Additionally, the output is total combined annual vegetal and animal production values in real terms. The results of regression estimation indicate that irrigation rate, tractor (an indicator of existing technology), and the geographic regions of enterprises are important determinants of production efficiency.

Avcı and Kaya (2008) examine the performance of agricultural sectors of 25 transition economies including Turkey in the period of 1992-2004. The performance of agricultural sector of each country is measured through DEA and Malmquist Index. Labor, tractor, land, and fertilizer are used as inputs, and added value in terms of US Dollar at 2000 constant prices is determined as output. Regarding the findings, for the 1992-2004 period, the average technical efficiency value of the transition economies was 0.665 and average technical value of Turkey was 0.826.

In the article of Armağan et al. (2010), NUTS regions in Turkey are accepted as a DMU. The efficiency values of these regions, changes in the TFP and technology are calculated for the 10-year period covering 1994–2003. Methods of DEA and Malmquist Productivity Index are used in order to measure the crop production of NUTS-1 regions in Turkey. The number of tractors, the amount of land cultivated, the economically active population in the agricultural sector, and the amount of fertilizers with nitrogen, potash and phosphorous in 81 provinces were determined as inputs. Also, the agricultural structure, production, price and the value of the crop production in 81 provinces are determined as outputs. As a result of this study, there has been a decrease in the technical efficiency and TFP in the regions, excluding the Western Marmara, the Aegean, the Mediterranean and The Eastern Black Sea Region, within the 10-year period analyzed.

In Kaya and E. Aktan's (2011) article, the agricultural performances of 81 cities in Turkey are analyzed by using nonparametric Malmquist efficiency index and the data of 2000-2009 period. Their inputs are number of tractors per cultivated area, planting ratio of agricultural lands, the share of agriculture in public investments, and agricultural electricity use per cultivated area. Their output is total revenue acquired from plant production per cultivated area. They discover that a technological progress in the given period caused an increase in the TFP of Turkey's agricultural sector.

In the study of Yavuz and İşçi (2013) the relative efficiency of 25 firms, which ranked among the top 500 largest companies operating in the food sector in Turkey in the last three years, are measured for 2009, 2010 and 2011 by using the DEA. The inputs are resources, total assets, and labor and the outputs are crops and livestock production. According to the study, the percentage of the average activity is 77%. For the data of 2011, 10 companies are found to be effective according to the model of the CCR (Charnes, Cooper & Rhodes) while 12 companies are found to be effective according to the model of BCC (Banker, Charnes & Cooper).

Lastly, in the study of Eruygur, et al. (2016) they estimate the determinants of agricultural TFP change by using 26 NUTS-2 level regions' data between 2005 and 2014. They also, calculated the capital stock of Turkish agricultural sector on NUTS-2 level basis. Their model is stochastic frontier analysis based Cobb-Dougles log-linear agricultural production equation. The model includes 15 variables, which are agricultural gross domestic added value, agricultural employment, agricultural capital stock, total agricultural land, the share of irrigable land in total agricultural land, use of fertilizer per hectare, Thornthwaite thermal efficiency index, a dummy variable for the drought in Turkey in between 2007 and 2008, human capital per labor force, export of high technological products, volatility of exchange rate of dollar, rural development support, time trend, exchange rate of dollar and inflation rate. As a result of this study, it is conducted that human capital, technological developments, and rural development support have a significant positive impact on TFP in agriculture. In addition, changes in foreign exchange rates, increase in economic uncertainty (inflation and volatility of exchange rates) have a significant negative impact on TFP in agriculture. On the other hand, agricultural support policies except rural development support has no statistical impact on TFP in agriculture.

To sum up, the literature on agricultural productivity regarding various countries and Turkey was reviewed and the critical findings from the literature were reflected above in chronological order. There are two production functions determined for the established models. The first one is the parametric production function, namely stochastic frontier analysis which was applied in a few studies. The second and the prevalent one in non-parametric production functions, one of which is DEA.

Accordingly, the methodology, inputs and outputs used in agricultural productivity analysis are very similar. However, when only DEA is used, a region's productivity can be measured for a single year. That is, if panel data analysis is performed, the method used should be the DEA-based Malmquist productivity index. The factors such as the arable land used in agricultural production, the number of tractors, the number of laborers in agriculture, the amount of fertilizer used in agricultural production, and the number of animals in agriculture are determined as inputs, in general. The outputs are determined as agricultural and livestock production values in the most of studies that analyses the agricultural productivity. However, the results found about the efficiencies of agricultural production vary significantly according to the countries and the time intervals.

When we compare the results of the above-mentioned studies, we see: In the studies conducted in Turkey, when output is taken as monetary value, a relative increase is generally observed in agricultural productivity. When output is taken as a unit of output, a relative decrease is generally observed in agricultural productivity. However, in studies carried out abroad, there is generally an increase in the productivity of agricultural production irrespective of the method of the study or the output values.

Table 1: List of Literature Review

ARTICLE	FIELD OF STUDY	AUTHORS	METHOD	INPUTS	OUTPUTS
Türk Tarım sektörü Verimliliğinin Parametrik Olmayan Bir Yöntemle Analizi (2011)	81 cities in Turkey	Pınar Kaya Hande Erdoğan Aktan	Malmquist Efficiency Index	• Number of tractors per cultivated area (Number of tractors/cultivated area) • Planting ratio of agricultural lands • (cultivated area/total agricultural area) • Agricultural labor force • The share of agriculture in public investments (public investments made in agriculture/total public investments) • Agricultural electricity use per cultivated area (Agricultural electricity use/cultivated area)	• Total revenue acquired from plant production per cultivated area.
Regional Productivity of Spanish Agriculture in a Panel DEA Framework (2003)	17 Spanish regions	Natalia Aldaz JoaquÍn A. Millán	Malmquist Efficiency Index	• Land • Labor • Machinery • Materials	• Crop • Animal Production

An Evaluation of Turkish Agricultural Production Performance (2006)	Turkey	Aydın Başarır Bahri Karlı Abdulbaki Bilgiç	Cobb-Douglas Production Function	• Tractor • Animals • Land • Seed • Labor • Fertilizer • Irrigation	• Agricultural production
Efficiency and Total Factor Productivity of Crop Production at NUTS1 Level in Turkey: Malmquist Index Approach (2010)	Turkey	Göksel Armağan Altuğ Özden Selim Bekçioğlu	Malmquist Efficiency Index	• The number of tractors (number) • The amount of land cultivated (ha) • Population economically active in the agricultural sector (person) • Amount of fertilizers with nitrogen, potash and phosphorous (ton) in 81 provinces	• Agricultural structure • Production • Price and value • The value of the crop production in 81 provinces
Productivity Growth in China's Agriculture During 1985–2010 (2013)	China	Zhou Li Hai-Peng Zhang	Cobb-Douglas Production Function	• Land • Labor • Fertilizer • Mechanical inputs	• The gross output of agriculture, forestry, livestock and fishery (100 million CNY)
Agricultural Productivity Changes Induced by the Sloping Land Conversion Program: An Analysis of Wuqi County in the Loess Plateau Region (2010)	China-Wuqi County	Shunbo Yao Hua Li	Malmquist Productivity Index	• Cultivated land • Labor for farming and animal husbandry • Fertilizers (the sum of N, P, K, and composite fertilizers) • Manure • Crop coversheets and improved seeds combined • Feedstock and fodder combined	• Crop production • Livestock production

Agricultural Productivity Differences among Countries (1970)	38 developed and underdeveloped countries	Yujiro Hayami V. W. Ruttan	Cobb-Douglas Production Function	• Labor • Land • Livestock • Fertilizer • Machinery • Education • Technical manpower	• Agricultural production
Geçiş Ekonomileri ve Türk Tarım Sektöründe Etkinlik ve Toplam Faktör Verimliliği Analizi (1992-2004) (2008)	Armenia, Azerbaijan, Belarus, Georgia, Kazakstan, Kirghizia, Moldova, Russia Tajikistan, Turkmenistan, Ukrain, Uzbekistan, Albania, Turkey, Croatia, Macedonia, Bulgaria, Romania, Czech Republic, Esthonia, Hungary, Letonia, Lithuania, Poland, Slovenia	M. Ali Avcı A. Ayşen Kaya	Data Envelopment Analysis & Malmquist Efficiency Index	• Labor • Tractor • Land • Fertilizer	• Added value in terms of US Dollar at 2000 constant prices

Accounting for Externalities in the Measurement of Productivity Growth: The Malmquist Cost Productivity Measure (2005)	46 States of the US	E. Ball R. Färe S. Grosskopf O. Zaim	Malmquist Cost Productivity Index	• Capital • Land • Labor • Materials	• Crops • Livestock
Total Factor Productivity Growth in China's Agricultural Sector (2008)	29 provinces in China	Po-Chi CHEN Ming-Miin YU Ching-Cheng CHANG Shih-Hsun HSU	Malmquist Productivity Index	• Labor • Land • Machinery • Draft animals	• Gross value-added of • farming, • forestry, • animal husbandry and • fisheries at 1990 constant prices
Total factor productivity growth in agriculture: A Malmquist index analysis of 93 countries, 1980–2000 (2003)	93 developed and developing countries	Tim J. Coelli D. S. Prasada Rao	Malmquist Productivity Index & Data Envelopment Analysis	• Land • Tractors • Labor • Fertilizer • Livestock	• Crops • Livestock output
Introduction to the Special Issue on Agricultural Productivity Growth: A Closer Look at Large, Developing Countries (2010)	China, India, Indonesia, and collectively the transition economies of the former Soviet Union and Eastern Europe	Keith Fuglie David Schimmelpfennig	Tornqvist-Thiel Index	• Animals • Machinery • Seed • Feed • Fertilizer	• Growth in the agricultural labor force • Growth in the output per worker

Production Efficiency and Total Factor Productivity Growth in Turkish State Agricultural Enterprises (2007)	Turkey	Ertuğrul Deliktaş Mehmet Candemir	Data Envelopment Analysis	• Labor • Amortization as a capital input • Amount of fertilizer in thousands of metric tons • Cultivatable land (ha) • Seed in thousands of metric tons • Annual mean rainfall in mm by district from the meteorology department • Animal feed in real value • Livestock in the beginning of each year for 32 state agricultural enterprises	• Total combined annual vegetal and animal production values in real terms
LDC Agriculture: Nonparametric Malmquist Productivity Indexes (1997)	Argentina, Brazil, Chile, Colombia, Dominican R., Egypt, Ghana, Ivory Coast, Korea, Malaysia, Morocco, Pakistan, Philippines, Portugal, Sri Lanka, Thailand, Turkey, Zambia	Lilyan E. Fulginiti Richard K. Perrin	Malmquist Productivity Index	• Land • Livestock • Machinery • Fertilizer • Labor	• Quantity of agricultural production in millions of 1979-81 ‘international dollars’

Productivity Change in Polish Agriculture: An Illustration of a Bootstrapping Procedure Applied to Malmquist Indices. (2008)	Poland	Laure Latruffe Sophia Davidova Kelvin Balcombe	Malmquist Productivity Index	• Land • Labor • Capital • Intermediate consumption	• Crop • Livestock • Other (non-agricultural) output
How Far Are the Transition Countries from the Economic Standards of the European Union? Measuring Efficiency and Growth in Agriculture (2007)	The Central and East European countries and newly independent states of the Former Soviet Union	Alexej Lissitsa Supawat Rungsuriyawiboon Sergiy Parkhomenko	Malmquist TFP Index	• Land • Tractor • Labor • Fertilizer • Livestock	• Crop • Livestock
Efficiency Change and Productivity Growth in Agriculture: A Comparative Analysis for Selected East Asian Economies (2008)	East Asian economies	Yir-Hueih Luh Ching-Cheng Chang Fung-Mey Huang	Malmquist Productivity Growth Index	• Land • Labor • Fertilizer	• Crop production
Is the Collapse of Agricultural Output in the CEECs a Good Indicator of Economic Performance? A Total Factor Productivity Analysis (2006)	Ten Central and East European countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia	Axel Tonini Roel Jongeneel	Malmquist Index of TFP	• Fertilizer • Labor • Livestock • Machinery	• The net agricultural production valued at 1999-2001 'international dollar' prices

Productivity Growth, Technology Progress, and Efficiency Change in Chinese Agricultural Production from 1984 to 1993 (1996)	29 provinces in China	Won W. Koo Weining Mao	Data Envelopment Analysis based Malmquist efficiency index	• Land • Labor • Machinery • Fertilizers • Draft animals	• Sum of the total value of production from farming, forestry, animal husbandry, fishing, and sideline activities.
The Effect of Incentive Reforms Upon Productivity: Evidence from the Vietnamese Rice Industry (2002)	Vietnam	Hong Son Nghiem Tim Coelli	Malmquist Data Envelopment Analysis	• Seed • Chemical fertilizers • Human labor • Pesticide • Animal services	• Rice production
Is Agricultural Productivity in Developing Countries Really Shrinking? New Evidence Using a Modified Nonparametric Approach (2002)	Argentina, Ivory Coast, Egypt, Korea, Malaysia, Philippines, Uruguay, Brazil, Morocco, Sri Lanka, Turkey, Zambia, Chile, Colombia, Dominician Republic, Ghana, Pakistan, Paraguay, Portugal, Thailand	Alejandro Nin Channing Ardt Paul V. Preckel	Malmquist Efficiency Index	• Land • Labor • Tractors • Fertilizers • Animal stock	• Crops • Livestock production

Comparisons of Agricultural Productivity Growth in China and India (2009)	China and India	Alejandro Nin-Pratt Bingxin Yu Shenggen Fan	Malmquist Efficiency Index	• Land • Labor • Tractors • Fertilizers • Feed • Animal Stock	• Crop • Livestock production
Measuring Agricultural Productivity Growth in Developing Eight (2010)	D-8 Countries: Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, Turkey	V. Shahabinejad A. Akbari	Data Envelopment Analysis & Malmquist Efficiency Index	• Agricultural land • Animal stock • Labor • Fertilizer consumption • Agricultural machinery (number of tractors)	• Crops • Livestock production
Reforms and agricultural productivity in Central and Eastern Europe and the Former Soviet Republics: 1989–2005 (2010)	Central and Eastern Europe and the Forme Soviet Republics	Johan F. M. Swinnen Liesbet Vranken	Data Envelopment Analysis	• Land • Labor • Capital • Fertilizer • Animal stock	• The value of physical production valued at fixed prices
Veri Zarflama Analizi ile Türkiye'de Gıda İmalatı Yapan Firmaların Etkinliklerinin Ölçülmesi (2013)	25 companies that are among the top 500 companies in Turkey in the last three years and operate in food sector	Selahattin Yavuz Öznur İşçi	Data Envelopment Analysis	• Resources • Total Assets • Labor	• Crop production • Livestock production

Measuring Technical Efficiency and Total Factor Productivity in Agriculture: The Case of the South Marmara Region of Turkey (2006)	South Marmara Region of Turkey	Tolga Tipi Erkan Rehber	Data Envelopment Analysis	• Utilized area • Fertilizer • Tractors • Labor	• Crops • Livestock output
The Source of Productivity Growth in Dutch Agriculture: A Perspective from Finance (2006)	Germany	Guan Zhengfei Alfons Oude Lansink	Malmquist Productivity Growth Index	• Land • Labor • Fertilizer • Pesticides • Miscellaneous inputs	• Total revenue from all products, deflated to 1990 values using an index of prices received for farm outputs
Multi-factor agricultural productivity, efficiency and convergence in Botswana, 1981–1996 (2003)	Botswana	Colin Thirtle Jenifer Piesse Angela Lusigi Kecuk Suhariyanto	Multi-Literal Malmquist Efficiency Index	• Land • Labor • Draft power • Seed • Herds	• Crop • Livestock output
Total Factor Productivity in Chinese Agriculture: The Role of Infrastructure (2007)	China	Chen Weiping Ding Ying	Malmquist Efficiency Index	• Per capita agriculture electricity consumption • The ratio of irrigation areas to sown areas • The reservoir capacity per sown area • Number of motor vehicles per 100 rural households • The ratio of teachers to students in rural primary and secondary school • The ratio of villages which have small hospitals to total villages	• Total factor productivity

Productivity Growth and Its Components in Chinese Agriculture After Reforms (2008)	China	Shunxiang Wu David Walker Stephen Devadoss Yao-Chi Lu	Malmquist Productivity Index	• Farm machinery power (plows, cultivators, irrigators, tractors, etc.) • Irrigation • Manure fertilizer • Area sown for all crops • Chemical fertilizer • Labor force	• Gross value of agricultural output in constant 1980 prices
Türk Tarımında Rekabet Edebilirlik ve Toplam Faktör Verimliliği (2016)	26 NUTS-2 level regions in Turkey	Ozan Eruygur Taylan Kıymaz Mustafa Can Küçüker	Cobb-Dougles Production Function	• agricultural gross domestic added value, • agricultural employment, agricultural capital stock, • total agricultural land, the share of irrigable land in total agricultural land, • use of fertilizer per hectare, • Thornthwaite thermal efficiency index, • a dummy variable for the drought in Turkey in between 2007 and 2008, • human capital per labor force, export of high technological products, • volatility of exchange rate of dollar, • rural development support, time trend, • exchange rate of dollar and inflation rate	• Total factor productivity

Veri Zarflama Analizi İle Türkiye'de Gıda İmalatı Yapan Firmaların Etkinliklerinin Ölçülmesi (2013)	Turkey	Selahattin Yavuz Öznur İşçi	Data Envelopment Analysis	• Resources • Total Assets • Labor	• Net Sales • Profit • Export

CHAPTER 4

METHODOLOGY AND DATA

After the concept of productivity had become a concern, the question of how to make analysis about this concept became important. Productivity measurements are generally exercised at three different levels, namely economic, industrial or firm level. Studies making economic analysis are contributive in both for monitoring developments over time and carrying out international case evaluations. Productivity measurements also enable scholars to study the development of the calculated productivity values in industrial and firm level studies over time. Productivity concept and productivity measurement can be altered by considering whether they are going to be applied to macro level or micro level (Vergil & Abasız, 2008).

There are two broad paradigms to measure economic efficiency. One of them is based on an essentially nonparametric programming approach to analysis of observed outcomes, and the other one is based on an econometric approach to estimation of theory-based models of production, cost, or profit (Greene, 2008, p. 92). In econometric approaches, the most common method which is used to measure the efficiency is stochastic frontier analysis (SFA). This method was developed by Dennis Aigner, Knox Lovell, Peter Schmidt, Wim Meeusen and Julien Van Den Broeck, in 1977. According to this method, there are production borders of all the operations. This method assumes that these operations cannot make efficient production by using their resources. Statistical errors are taken into account. This method, also, identifies the minimum level of costs at a certain output level, input prices and production technology (Özbuğday & Nillesen, 2013)

In nonparametric approaches, the level of efficiency is reached through expressing the inputs and outputs with different characteristics in a single index. In order for inputs and outputs to be collected in a single index, it is crucial to establish the required weights and exhibits the share of receivables from the inputs. The Malmquist Productivity Index shows the output distance of the inputs under the condition of fixed technology at different times. That is, when the input vector is data, it means that the output vector is the maximum. In this method, which measures productivity by linear programming method for input and output without any restriction on production technology, production curve is created for each input and output, and production technology is determined. The specified technology level gives the efficiency rate (Vergil & Abasız, 2008).

In this study, DEA based Malmquist TFP indices was adopted as the method. Caves et al. (1982) introduced these indices. The new approach of Färe et al. (1994) show that this index can be estimated by using a nonparametric approach (Shahabinejad & Akbari, 2010). The DEA and Malmquist TFP indices were computed using the DEAP 2.1 computer program written by Coelli (1996). One of the most important reasons for choosing this method is that in DEA, less assumptions are made in this method. So, applying this method is relatively easy compared to applying parametric methods. On the other hand, regulating the data according to expected results is relatively probable in parametric methods (Çakmak, Akder, Levent , & Karaosmanoğlu, 2008, p. 35). Detailed explanations of the methods mentioned above can be found in the following sections.

4.1. Data Envelopment Analysis (DEA)

Production is a vital factor for a country. The efficiency of the production shows the level of development. At this point we can briefly explain efficiency as; producing maximum level of outputs with minimum level of inputs. In addition, efficiency is the ratio of the level of outputs to the level of inputs and is a measurement of how effective the resources are used (Baş & Artar, 1991). In other words, efficiency is the relation between the outputs, which are produced by a manufacture or a service system and the inputs that are used in order to create those outputs (Prokopenko, 1998, p. 3).

Measurement of efficiency is an assessment of actual outcomes in comparison to targeted outcomes. In order to make this assessment, resources utilized in a particular time and in a particular way must be specified. If the outcomes of a DMU overlap the targeted outcomes, then this unit is called an *efficient unit*. If not, it is called an *inefficient unit*. At this point, it is significant that the current measurement of efficiency reveals how close the actual outcomes and targeted outcomes are (Basmacı & Yüksek Özdemir). For different functions and application areas numerous methods of measuring performance have been established so as to find out how close the production scale to targets is. These methods are structurally divided into three groups: ratio analyses, parametric methods and non-parametric methods.

Ratio analyses are known as independent analyses which measure the performances of every single sub-system in an organization. They require making a remark between single input and single output dimensions. Similarly, parametric methods, which are also called regression analyses, are focus on average responses. Although, a single output can be correlated with multi-inputs, these methods are rather restricted to analyze the total measurements. Besides, they presuppose the existence of an analytical form in an absolute sense. On the other hand, *non-parametric methods* use the mathematical programming as a solution and they are convenient to analyze the multi-input and multi-output production environment (Atikbay, 2001, p. 88). Hence, using a non-parametric method give more reliable results for this study.

One of the most common non-parametric method is DEA. It is significant to the field of productivity analysis due to its certain properties which are as follows: (1) it does not need an analytically functional framework, (2) it is possible to make a simultaneous evaluation of multi-input and multi-output production system, (3) it separates the effective and ineffective DMUs from each other and creates reference points from the efficient units, and (4) it is possible to use this method even if inputs and outputs are expressed with different notations (Basmacı & Yüksek Özdemir). The other important feature of the DEA is that this model defines the ineffective DMUs and directs the decision makers for how these ineffective units can become effective ones (Tosun & Erdoğan Aktan, 2010). These whole features show the reason why the DEA is used for assessment of effectiveness in many different areas, such as, schools, health units, banks, armed forces, market researches, agriculture, transportation and public institutions.

4.1.1. Description of DEA

The DEA is a non-parametric method which has been developed for the purpose of measuring the efficiency of economic DMUs which are alike in terms of produced goods or services, by Charnes et al. (Kaya & Erdoğan Aktan, 2011).

The DEA can be defined as a linear programming basis method, which is used for evaluation of the DMUs who are responsible for using similar inputs to produce one or more outputs (Cooper, Seiford, & Zhu, 2011). The distinctive characteristics of the DEA is that it provides an easy way to evaluate the situations which include a large number of inputs and a large number of outputs. In other words, the DEA enables researchers to measure the effectiveness of multi-output production environment rather than the single output production environment (Yolalan, 1993).

Using the DEA also enables the researchers to take some important steps such as; identification of the factors leading to the relative inefficiency of any unit, measurement of the relative inefficiency of any unit, classification of the units in regard to their efficiency, evaluation of the managements of the units that are compared, evaluation of the efficiencies of programs or policies that are not under the control of the units, and differentiation of the program inefficiency from managerial inefficiency or vice versa. Furthermore, reassigning the resources from one unit to another for using these inputs more effectively while reaching the targeted output level, determining the efficient input-output relations and efficient units for the functions that are not directly related with the comparison among the units, examining and reviewing the current standards under the actual performance conditions for specific input-output relations, and comparing the results of previous studies are some other important stages of a study and DEA is one of the easiest methods to accomplish these steps (Golany & Roll, 1989; Atan, Karpat, & Göksel, 2002; Tepe, 2006).

According to the definition of Charnes et al. (1978), DEA is a non-parametric method that utilizes the linear programming approach and it does not need any functional form of a technological factor for determining the optimal production limit. DEA’s way of measuring the efficiency is determining the optimal DMUs, which creates the best combinations of inputs, and reaching the maximum amount of outputs by using the minimum amount of inputs. It also refers this production level as active border and evaluates how the ineffective units are far from the active border (Yolalan, 1993).

The basic measurement of efficiency of DEA is division of weighted sum of outputs to weighted sum of inputs. We can formalize this explanation follows (Cooper, Seiford, & Tone, 2000);

$$Efficiency = \frac{u_1 y_1 + u_2 y_2 + \cdots + u_n y_n}{v_1 x_1 + v_2 x_2 + \cdots + v_m x_m} \tag{4.1}$$

In this formulation n stands for number of outputs, m stands for number of inputs, u_n stands for weight of n^{th} output, y_n stands for amount of n^{th} output, v_m stands for weight of m^{th} input and x_m stands for amount of m^{th} input.

The DEA can be conducted in two ways: *input-oriented* and *output-oriented*. Input-oriented DEA means observing the changes in inputs, while output remains constant. It is used in conjunction with the ratio models to indicate that an inefficient unit is made efficient through the proportional reduction of its inputs while its outputs proportions are held constant (DEAzone, n.d.).

Output-oriented DEA means observing the changes in outputs, while input remains constant. Namely, an inefficient unit is made efficient through the proportional increase of its outputs, while the inputs proportions remain unchanged (DEAzone, n.d.). Additively, there are three models of DEA: *CCR (Charnes-Cooper-Rhodes) Model*, *BCC (Banker-Charnes-Cooper) Model*, and *Cumulative Model*. The CCR model is based on Constant Returns to Scale (CRS) assumption, which means, if output increases by that same proportional change, as all inputs change then there is CRS. On the other hand, BCC model is based on Variable Returns to Scale (VRS) assumption, which means if output increases/decreases by less/more than the proportional change in inputs, there is VRS. These two models can be solved by both input-oriented and output-oriented methods. In addition, the third one, Cumulative Model simultaneously uses both input-oriented and output-oriented methods.

DEA helps us to find out some results of measuring the performance such as; efficient and inefficient DMUs, resource surplus amounts that are used by inefficient DMUs, the output level to be produced of the inefficient DMUs by the current input level, and the units that comprise the efficient reference sets of inefficient DMUs (Depren, 2008).

4.1.2. Strengths and Weaknesses of DEA

DEA is a very important and efficient tool for the studies on agricultural productivity. There are numerous of advantages of the DEA.

Some of the most important features of the DEA are listed as follows: it has the ability of processing multi-input and multi-output production systems and it defines multiple alternative ways to raise an inefficient DMU's performance up to relatively efficient DMUs' level. Also, using the DEA provides the DMUs to know their production process and input-output relations. Another important feature of the DEA is that a researcher can generate a database, which includes necessary data and analysis results. It assumes that input and output data are not generated through random mechanism. In other words, the data is obtained from deterministic variables. The efficiency analysis is made by the border function, which is constituted by the best observations. So, the goals are determined according to the units showing the best performances. By this way, the efficiency analysis, which is made via the DEA, becomes more appropriate and more significant when compared to parametric production functions (Yaralıoğlu, 2004; Tepe, 2006).

On the other hand, DEA has some restrictions or handicaps. One of the most important weaknesses and disadvantages of DEA is that it is restricted with technical input-output efficiency, because the DEA is generally tested with physical input-output dimensions. Besides, because the DEA is a nonparametric method, it is hard to apply statistical hypothesis tests to the results. This reveals another problem such that qualitative input-output dimensions may weaken the results. If the method can reflect the production process of relevant inputs and outputs accurately, then it can give reliable results. Hence, this accuracy has a vital importance for that reason. At that point, if a critical input or output is excluded from the analysis, the results may be misleading or non-objective. Another disadvantage is that the difference between observed performance via DEA and actual best performance only gives us an information about inefficiency. The measuring errors of extreme observation plots are ignored. Additionally, the DEA models are static models which make a section analysis of only one specific period of time. However, in real life, the DMU's conversion of their inputs to outputs may last more than one period. It means that production process is a dynamic process. Therefore, it is required to use of appropriate reduction ratios for the data in different periods. Moreover, solving large scale problems with DEA may be timeconsuming in terms of calculations, since a solution of linear programming model is separately needed for each decision point. Lastly, the DEA helps us on evaluating the relative effectiveness of a DMU, as compared to other units. However, this does not mean that relatively effective DMU is surely effective when it is evaluated on its own. Therefore, the DEA efficacy results should be evaluated in the context of relativity (Yaralıoğlu, 2004; Tepe, 2006).

4.1.3. Choice of Decision Making Units

The choice of DMU is very important for the reliability of DEA analysis since, DEA is a comparative analysis. In case of choosing wrong DMUs, all analysis results are affected from that. The most important points in choosing the DMUs are as follows (Yolalan, 1993; Tepe, 2006):

- DMUs should be similar with respect to the inputs they use and outputs they produce. In addition, the production technology of these DMUs should be similar.
- Observation set should be homogenous. Homogeneity means, the DMUs that constitute the set have the same input-output dimensions and similar external factors. At that point, more DMUs mean less homogeneity but more reliability. Therefore, defining the observation set requires a great attention.
- The number of inputs and outputs must be as large as possible. By this way, the results of the analysis will give more detailed information about the efficiency of DMUs.

In DEA, there are two types of boundries that affect the definition of the DMUs. First one is organizational, physical and regional boundaries which define the units. Second, one is the periods in which the field of activities are going to be measured. It should not be forgotten that in the DEA, efficiency is measured according to the selected DMUs and the factors including inputs and outputs (Golany & Roll, 1989).

4.1.4. Determination of Inputs and Outputs

Inputs and outputs used in the DEA method form the basis of the comparison between the DMUs. Therefore, selection of the DMUs has a vital importance. Resources that are used or conditions that affect the activities constitute typical inputs. And measurable benefits that are produced, create outputs. At this point, the input-output set must contain the following features (Yaralıoğlu, 2004; Tepe, 2006):

- They must be the same factors for all the DMUs.
- They must comprise all activity levels, all performance criteria, and all the measurable physical and economical resources.

Having determined the inputs and outputs to be used in the DEA, higher quantity of outputs means an increase in the efficiency while higher quantity of inputs means a decrease in the efficiency.

4.1.5. Choice of the DEA Model

Following the determination of input-output set and observation set consisted of the DMUs, the researcher chooses the most appropriate DEA model for the current production environment. For each DMU concerning linear program is solved and by this way, the solution sets are reached (Yolalan, 1993).

There are various DEA models which can be set up according to their use and assumptions. Choosing or setting up a model is determined after the examination of the inputs and outputs. If the inputs are not controllable, then an output-oriented model should be chosen. If the outputs are not controllable, then an input-oriented model should be chosen (Yaralıoğlu, 2004).

4.1.6. Mathematical Notation of DEA

Efficiency in the DEA is defined as the ratio of weighted sum of outputs to weighted sum of inputs. DEA enables researchers to estimate the weights with maximum efficiency as much as possible one by one for all the units. Mathematically, the effectiveness of each observation is calculated as the maximum proportion of weighted outputs to weighted inputs providing that using the same weights for every ratio. By this way, efficiency measurement result is less than or equal to 1 for all comparable units (Boles, Donthu, & Lohtia, 1995).

Efficiency measurement in the DEA is implemented through two stages. In the first stage, the DMUs, which are on the efficiency border, are determined. This means that these DMUs use the minimum input combination and produce maximum output combination. In the second stage, the efficiency border is considered as the reference and the distance of the inefficient units to that border is measured radially. If there are multiple inputs and outputs in an organization, the efficiency formulation can be generated as follows (Atikbay, 2001);

$$Efficiency = \sum(Weighted\ Outputs)/\sum(Weighted\ Inputs) \tag{4.2}$$

A virtual input and a virtual output is calculated with the multiple inputs and outputs that are observed for every DMU:

$$Virtual\ Input = v_1x_1 + v_2x_2 + \cdots + v_mx_m \tag{4.3}$$

$$Virtual\ Output = u_1y_1 + u_2y_2 + \cdots + u_ny_n \tag{4.4}$$

$$\frac{Virtual\ Input}{Virtual\ Output} \tag{4.5}$$

The main purpose of solving this equation is to maximize the ratio of virtual input to virtual output. The weights which are to maximize this ratio are calculated through the use of linear programming. The optimum inputs and outputs making this ratio maximum changes from one DMU to another. The weights which are used on the calculations, are not defined in advance. They are calculated by the observed data. However, the calculations are expected to give the efficiency results between 0 and 1. To reach this result, measurement outcomes is ought to be normalized (Kale, 2009).

4.1.6.1. Charnes, Cooper & Rhodes (CCR) Method

The CCR model is based on the constant returns to scale assumption. Abraham Charnes, William Wager Cooper and Edwardo L. Rhodes (1978) developed this method to evaluate the efficiency by using the multi-input and multi-output production processes, rather than single input and single output production processes. The CCR model measures the level of total technical efficiencies of the DMUs. In order to reach reliable results, the number of DMUs, inputs and outputs has a vital importance (Tarım, 2001).

If the efficiency of k^{th} DMU is h_k, then maximizing the h_k becomes the main purpose. So, the objective function can be formalized as;

$$max h_k = \frac{\sum_{r=1}^{s} u_{rk} y_{rk}}{\sum_{i=1}^{m} v_{ik} x_{ik}} \tag{4.6}$$

And the restrictions are;

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \ (j = 1, \dots, n)$$

$$u_r \geq 0 \ (r = 1, \dots, s)$$

$$v_i \geq 0 \ (i = 1, \dots, m) \tag{4.7}$$

It would be more difficult to solve a fractional equation than to solve a linear equation. Therefore, under the input-oriented assumption, the objective function becomes;

$$max v_k = \sum_{r=1}^{s} \mu_r y_{rk} \tag{4.8}$$

And the restrictions are;

$$\sum_{i=1}^{m} \omega_i x_{ik} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} \omega_i x_{ij} \leq 0 \ (j = 1, \dots n) \tag{4.9}$$

$$\mu_r, \omega_i \geq \varepsilon > 0 \ (r = 1, \dots, s)(i = 1, \dots, m)$$

If the CCR model will be used under the output-oriented assumption, then the objective function becomes;

$$min \theta_k = \sum_{i=1}^{m} \omega_i x_{ik} \tag{4.10}$$

And the restrictions are;

$$\sum_{r=1}^{s} \mu_r y_{rk} = 1$$

$$\sum_{i=1}^{m} \omega_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0 \; (j = 1, \ldots, n) \qquad (4.11)$$

$$\mu_r, \omega_i \geq \varepsilon > 0 \; (r = 1, \ldots, s)(i = 1, \ldots, m)$$

For each DMU, the optimal solution of input-oriented CCR model equals to the inverse value of the output-oriented optimal solution. Thus, under the constant returns to scale assumption, using input-oriented or output-oriented CCR model does not matter. By using one of these models, the solution of other model can be reached as well (Gümüşoğlu & Tütek, 2008, p. 232).

It is input-oriented or output-oriented, regardless of the fact that if a decision maker tries to find out the efficiencies of DMUs by the CCR model, s/he must apply the model mentioned above to all decision points. When the model is implemented to each decision point, total technical efficiency measures is obtained for each decision point. These measures indicate effectiveness for the decision points that are equal to 1. On the other hand, they indicate ineffectiveness for the decision points that are smaller than 1.

4.1.6.2. Banker, Charnes & Cooper (BCC) Method

This model has been developed by Rajiv D. Banker, Abraham Charnes, and William Wager Cooper (1984). It has been derived through changing the assumptions of the CCR model. BCC model is based on the variable returns to scale assumption. When the model is solved for each decision point, pure technical efficiency measures will be obtained for each decision point.. By using the BCC model, the type of ‘returns to scale’ for every decision unit can be determined. The only difference between BCC model and CCR model is that in BCC model the sum of every λ is equal to 1 under the variable returns to scale assumption (Basmacı & Yüksek Özdemir).

$$\sum_{j=1}^{n} \lambda_j = 1$$

Here λ is obtained from the solutions of the linear programs that are solved for each DMU. It gives the value for constituting possible efficient input-output combinations of an inefficient decision point. Consequently, the objective function of input-oriented BCC model becomes;

$$\max v_k = \sum_{r=1}^{s} \mu_r y_{rk} - \mu_0 \tag{4.12}$$

And the restrictions are;

$$\sum_{i=1}^{m} \omega_i x_{ik} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} \omega_i x_{ij} - \mu_0 \le 0 \ (j = 1, \dots, n) \tag{4.13}$$

$$\mu_r, \omega_i \ge \varepsilon > 0 \ (r = 1, \dots, s)(i = 1, \dots, m)$$

(μ_0 can be both negative or positive)

If the BCC model is used under the output-oriented assumption, then the objective function becomes;

$$\min \theta_k = \sum_{i=1}^{m} \omega_i x_{ik} - \omega_o \tag{4.14}$$

And the restrictions are;

$$\sum_{r=1}^{s} \mu_r y_{rk} = 1$$

$$\sum_{i=1}^{m} \omega_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} - \omega_o \ge 0 \ \ (j = 1, \dots, n) \tag{4.15}$$

$$\mu_r, \omega_i \ge \varepsilon > 0 \ (r = 1, \dots, s)(i = 1, \dots, m)$$

(ω_0 can be both negative or positive)

The case in which the input-oriented model and output-oriented model have opposite results of the optimal objective functions is not valid for the BCC models. On the other hand, using the variable μ_0, it can be determined that in which type of 'returns to scale' the DMU makes its production. Accordingly, if $\mu_0 < 0$, then there are increasing returns to scale and if $\mu_0 > 0$, then there are decreasing returns to scale (Gümüşoğlu & Tütek, 2008, pp. 237-238).

As a result, the BCC model gives information about the scale in which the DMUs make their production. From this point of view, the ratio of the efficiency value, and also from CCR model to the efficiency value, which is obtained from the BCC model, is named as *scale* *efficiency* or *scale inefficiency*. So, it can be said that the scale efficiency (SE) or inefficiency can be reached through DEA method (Aydemir, 2002).

$$Scale\ Efficiency = SE = \frac{\theta^{*}CCR}{\theta^{*}BCC} = \frac{Total\ Technical\ Efficiency(TTE)}{Pure\ Technical\ Efficiency(PTE)} \quad (4.16)$$

If a DMU is 100% efficient according to both CCR and BCC models, then this DMU makes its production at the most efficient scale size. SE=1 means the DMU is on the constant returns to scale level. If a DMU has the BCC efficiency (PTE=1) and CCR inefficiency (TTE<1), then this DMU is locally efficient but globally inefficient because of the scale size. This means there is a scale inefficiency. On the other hand, if both PTE and TTE are smaller than 1 (TTE<1 and PTE<1), there is both locally and globally inefficiency for that DMU. The reason of it is again considered as the scale size (Gümüşoğlu & Tütek, 2008).

4.1.6.3. Cumulative Method

The CCR and BCC models are evaluated as input-oriented or output-oriented models. However, in cumulative method, the models, which are developed under the input-oriented and output-oriented assumptions, are integrated into one single model. This means that if a model evaluates the input-orientation and output-orientation at the same time, this model is the cumulative model. It is based on variable returns to scale assumption and has been developed by Charnes et al. (1985) (Sarıca, 2007).

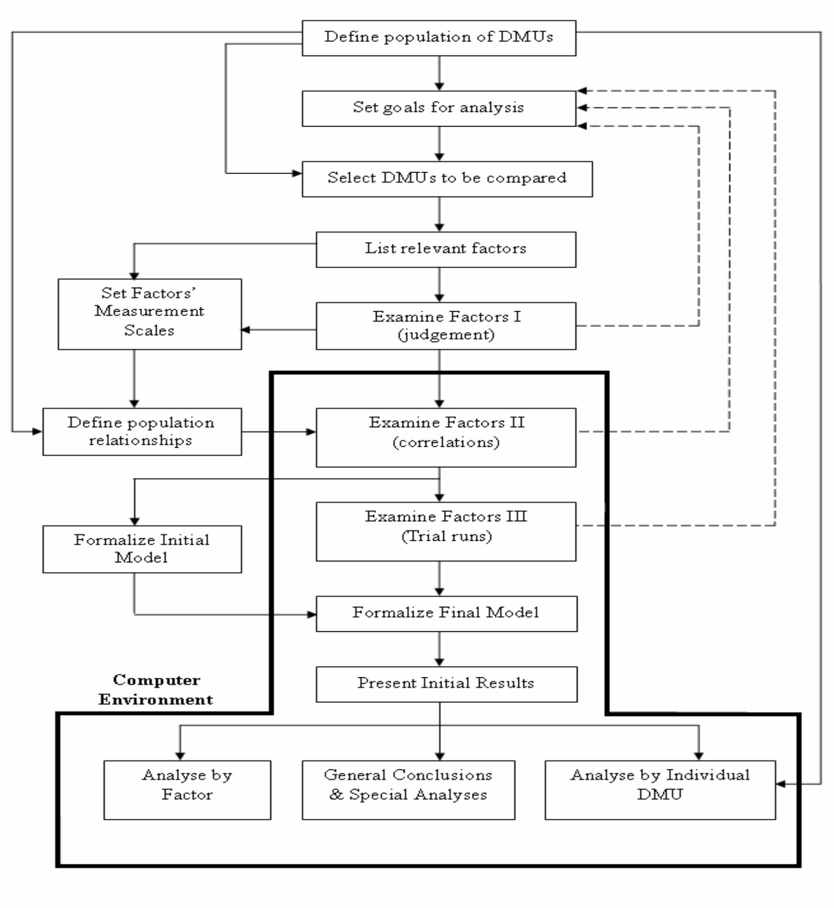


Figure 1: DEA Application Flow Chart (Golany & Roll, 1989)

4.2. Malmquist Total Factor Productivity (TFP) Index

DEA is a static analysis because it performs a cross-section analysis between DMUs in a specific period of time. This causes a very important problem, such that a DMU defined as efficient by using the DEA might be determined as inefficient if it is evaluated in further periods. Hence, this DMU might lose its ability of being a reference for efficiency evaluation. At this point, it becomes significant to evaluate the efficiencies by revealing the progress of them over time. That is why the Malmquist TFP index involving the time dimension of the analysis has been developed.

4.2.1. Description of Malmquist TFP Index

Malmquist TFP Index has been developed by Sten Malmquist (1953) to calculate the relative distance ratios according to common technology of each data point. The Malmquist TFP index measures the change in TFP considering progression or regression between the two data point. It also decomposes the components of productivity differences that develop over time under the multiple input and multiple output assumption, across decision units. A parametric distance function has been developed for this measurement.

4.2.2. Parametric Distance Function

Before using the Malmquist TFP index, a distance function must be determined. This determination is made by using the DEA. The distance function is applied to the production technologies with many inputs and many outputs, without aiming profit maximization or cost minimization (Dinçer, 2008). It can also be determined as input-oriented and output-oriented. Input-oriented distance function states the production technology, which considers the minimum proportional reduction of the input vector, while the output vector is the parameter. On the other hand, output-oriented distance function states the production technology, which considers the maximum proportional increase of output vector, while the input vector is the parameter.

4.2.3. Mathematical Notation of Malmquist TFP Index

The output set of distance function is named as S^t. This set states the vector of x, which consists from the inputs, and the vector of y, which consists from outputs. The nonparametric Malmquist index production technology can be shown as follows (Färe, Grosskopf, Norris, & Zhang, 1994):

$$t = 1, \dots, T \qquad Time$$

$$y_t = (y_1, \dots, y_M) \quad Vector\ of\ outputs$$

$$x_t = (x_1, \dots, x_K) \quad Vector\ of\ inputs$$

$$S^t = \{(x_t, y_t): x_t\ can\ produce\ y_t\} \tag{4.17}$$

For each time period $t = 1, \dots, T$ the production technology S^t designs the conversion of inputs x_t into outputs y_t (Färe, Grosskopf, Norris, & Zhang, 1994).

The distance function depending on the output set S^t in period of t, can be defined as;

$$D_0^t = (x_t, y_t) = min\{\theta: (x_t, y_t/\theta) \in S^t\} \tag{4.18}$$

In this equation, θ means the maximum output, which takes the value of 1 or greater. (θ-1) gives the proportional increase of the output, which is produced by the i^{th} country with given inputs. And $1/_\theta$ states the technical efficiency which takes the value between 0 and 1 (Avcı & Kaya, 2008).

If (x_t, y_t) is on the production border in time of t, then the distance function becomes,

$D_0^t = (x_t, y_t) = 1$. This outcome shows that the production became technically efficient from the period of t to period of $t + 1$.

If (x_t, y_t) is under the production border in time of t, then the distance function becomes,

$D_0^t = (x_t, y_t) < 1$. This outcome indicates that the production became technically inefficient from the period of t to period of $t + 1$.

Likely, the distance function in the period of $t + 1$ can be defined as;

$$D_0^t = (x_{t+1}, y_{t+1}) = min\{\theta: (x_{t+1}, y_{t+1}/\theta) \in S^t\} \tag{4.19}$$

This equation measures the proportional change in the output of the period y_{t+1} with given inputs of period x_{t+1} with the technology of time t. At this point, the proportional change in outputs of the period y_t with given inputs of period x_t with the technology of time $t + 1$ can also be measured. Starting from this point of view, by using the equations of (3.3.2) and (3.3.3) an index which measures the efficiency change between two periods can be written as;

$$\sqrt{MI = \left[\left(\frac{D_0^{t+1}(x_{t+1,}y_{t+1})}{D_0^t(x_t,y_t)}\right)\left(\frac{D_0^t(x_{t+1,}y_{t+1})}{D_0^{t+1}(x_t,y_t)}\right)\right]} \quad (4.20)$$

This equation which is also called Malmquist Index (MI) is the geometric average of the indices of the periods t and $t+1$. Here, t shows the base year and $t+1$ shows the following year (Kök & Deliktaş, 2003). $D_0^t(x_t, y_t)$ represents the distance from the observation of period t to the technology of period t. And $D_0^{t+1}(x_t, y_t)$ represents the distance from the observation of period t to the technology of period $t+1$, which means that in this equation, the only change occurs in technology (Färe, Grosskopf, Norris, & Zhang, 1994). We can also rewrite the equation of (3.3.4) as follows;

$$MI = \frac{D_0^{t+1}(x_{t+1,}y_{t+1})}{D_0^t(x_{t+1,}y_{t+1})} \times \sqrt{\frac{D_0^t(x_{t+1,}y_{t+1})}{D_0^{t+1}(x_t,y_t)} \times \frac{D_0^t(x_{t+1,}y_{t+1})}{D_0^{t+1}(x_t,y_t)}} \quad (4.21)$$

The Malmquist TFP index derived above must be evaluated in two sub-groups, which are the change in technical efficiency (i.e. catch-up effect) (ΔTE) and the change in technology (ΔT) (i.e. technical change or frontier-shift effect). The first part of the right-hand side of (4.21) shows the change in technical efficiency and the second part of the (4.21), the expression in the square root, shows the change in technology. In this way, the contribution of these two effects to TFP can be easily observed.

4.2.3.1. Technical Efficiency Change (Catch-Up Effect)

$$\Delta TE = \frac{D_0^{t+1}(x_{t+1,}y_{t+1})}{D_0^t(x_{t+1,}y_{t+1})} \quad (4.22)$$

The ratio given above measures the change in technical efficiency between the periods of t and $t+1$. The change in the technical efficiency is the ratio of technical efficiency in the period $t+1$ to the technical efficiency in the period t. At this point, technical efficiency change means the measurement of the degree to which it is possible to achieve the best production possibility frontier for each observation between the two periods, under the constant variable returns assumption. In other words, technical efficiency is the case where the maximum amount of output is obtained with the existing resources; that is, the production is made with the least opportunity cost. If the catch-up effect is greater than 1($\Delta TE > 1$), then there is an increase in technical efficiency of the DMU from period t to period $t+1$. If the catch-up effect is equal to 1 ($\Delta TE = 1$), then there is no change in technical efficiency of the DMU from period t to period $t+1$. If the catch-up effect is smaller than 1 ($\Delta TE < 1$) then there is a decrease in technical efficiency of the DMU from period t to period $t+1$ (Tone, 2004).

4.2.3.2. Technical Change (Frontier-Shift Effect)

$$\Delta T = \sqrt{\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)} \times \frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)}} \tag{4.23}$$

The ratio given above measures the technological change between the period t and the period $t+1$. The frontier-shift effect gives the degree of progression or regression that occurs from the technological innovations between the two periods. That is why a change in technology causes to shift the production possibility frontier (PPF), which also gives the maximum production border with given technology. Therefore, technical change or a change in technology is also called as frontier-shift effect. If the frontier-shift effect is greater than one ($\Delta T > 1$), then there is a progression in the frontier technology of the DMU from period t to $t+1$. If the frontier-shift effect is equal to 1 ($\Delta T = 1$), then there is no change in the frontier technology of the DMU from period t to $t+1$. If frontier-shift effect is smaller than 1 ($\Delta T < 1$), then there is a regression in the frontier technology of the DMU from period t to $t+1$ (Tone, 2004).

4.2.3.3. Malmquist Index

$$MI = \Delta TE \times \Delta T$$

The product of catch-up effect (ΔTE) and frontier-shift effect (ΔT) gives the TFP change of a DMU between the periods t and $t+1$. This formulization is also called as Malmquist TFP index. If Malmquist TFP index value is greater than 1 ($MI > 1$), then there is an increase in the efficiency of the DMU from the period t to period $t+1$. If Malmquist TFP index value is equal to 1 ($MI = 1$), then there is no change in the efficiency of the DMU from the period t to period $t+1$. If Malmquist TFP index is smaller than 1 ($MI < 1$), then there is a decrease in the efficiency of the DMU from the period t to period $t+1$ (Tone, 2004).

4.5. Data

In this study, the data set consists of 4 inputs, which are land, labor, tractor and fertilizer, and 1 output which is the gross domestic product (GDP) of 81 provinces as agricultural production activity. With these inputs, it is going to be examined whether the agricultural production is efficient or not in Turkey. The producers, which can also be named as DMUs, have been identified as the 81 provinces of Turkey and the time period has been determined between 2007 and 2015.

While collecting the data, some problems were encountered with respect to the number of laborers in agricultural sector. It forced the study to calculate the approximate values for this input data. In this study, the data regarding the 81 provinces of Turkey has been collected. Nonetheless, Turkish Statistical Institute (TURKSTAT) does not include the number of laborers in agricultural sector between the years 2007 and 2015 for each province, separately. They have the survey results of General Agricultural Census (2001). According to this census, the total number of settlements, total number of households, total number of households engaged in agricultural activity, and total number of households not engaged in agricultural activity can be found for 81 provinces of Turkey (TURKSTAT, 2004). On the other hand, the number of laborers in agricultural sector between the years of 2007 and 2015 can also be found in The Nomenclature of Territorial Units for Statistics II (NUTS II) level, which TURKSTAT grouped, the 81 provinces of Turkey in 26 regions according to their population, geographical position, regional development plans, basic statistical indicators and socio-economic development rankings of provinces. Thus, in order to reach the specific data including the number of agricultural laborers between the years of 2007 and 2015 for 81 provinces, the General Agricultural Census results were rearranged according to the NUTS II regions. Then, the proportion of agricultural laborers in all provinces and the number of agricultural laborers in NUTS II regions in the year of 2001 have been converted to the data mentioned above as the number of laborers in agricultural sector in NUTS II level between the years of 2007 and 2015. In this way, the most approximate data for this input is expected to be reached.

The input set has been determined as number of tractors used in plant production, number of laborers in agricultural sector, the cultivated area used in agriculture and the amount of fertilizer used in agriculture, while the output set has been determined as the gross domestic product (GDP) of 81 provinces as agricultural production activity between the years of 2007 and 2015. At the end of this study, it can be easily seen whether the plant production of each province is efficient or not.

CHAPTER 5

ANALYSIS RESULTS

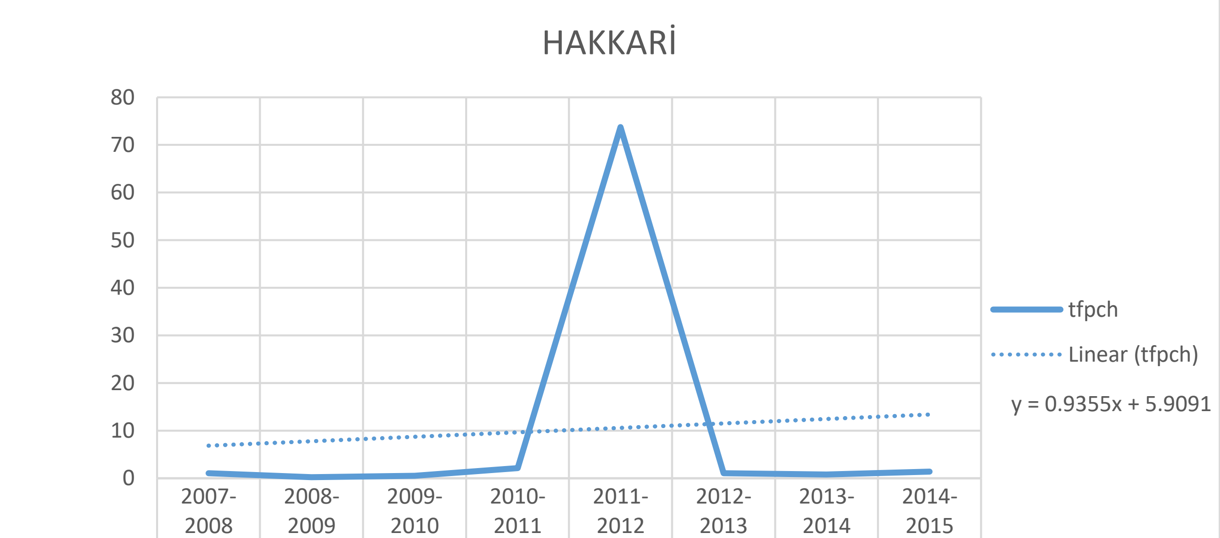
According to the data, composed of 4 inputs and 1 output, the analysis of agricultural efficiency is conducted for 81 provinces of Turkey between 2007 and 2015. In the study, the DEAP 2.1 program is benefitted. The analysis has been carried out constant returns to scale assumption by using output-oriented model. It is possible to observe whether the TFP change (TFPCH) results from the catch-up effect or from the frontier-shift effect by the technical efficiency change (EFFCH) and technical change (TECHCH) values found on the table. If these values are above 1, it will show the increase in TFP; if they are below 1, it will show the decrease in TFP. In summary, if TFPCH is less than 1, then one of the EFFCH or TECHCH values is necessarily less than 1. Likewise, if the TFPCH value is greater than 1, then one of the EFFCH or TECHCH values is necessarily greater than 1. If TFPCH value equals to 1, then neither EFFCH nor TECHCH is observed between those years. Besides, the SE and pure efficiency (PE) can be calculated by this software.

The analysis results are presented under 2 different headings. Accordingly, the results are examined as the Total Factor Productivity Over Provinces and the Total Factor Productivity Over Years (See Table 2 and Table 3).

5.1. Examination of Total Factor Productivity Over Provinces

While the first five provinces with the highest TFPCH value are Hakkari, Istanbul, Kocaeli, Bursa, and Ankara, the first five provinces with the lowest TFPCH values are Karaman, Ordu, Yozgat, Kilis and Bayburt between 2007 and 2015, respectively (See Table 2).

Hakkari has been the province with the highest productivity in the years indicated earlier. According to the analysis results, the most important reason for the decrease or increase in productivity in Hakkari is the change in the frontier-shift effect. In the formation of this effect there may be technological improvements in the province, subsidies made by the state, and so on. In other words, the situations that shift the production possibility frontier (PPF) are called as the frontier-shift effect. Considering Hakkari's agricultural sector, 70 percent of the population earns their income from agriculture (T.C. Hakkari Valiliği, 2014, p. 17). An average of 20-25 percent of the province's economy also comes from agricultural activities. However, due to the rugged terrain, farming in the field is possible in certain areas. The major agricultural crops produced in the province are feed crops, wheat, walnuts, apples, tomatoes, and grapes (T.C. Hakkari Valiliği, 2014, p. 18). A significant increase was observed in the monetary value of agricultural production, due to the increasing incentives and supports, along with the peace process affecting the province. Between 2006 and 2013, the grants, which were provided by the Ministry of Food, Agriculture and Livestock to Hakkari Province as part of the Rural Development Investment Support Program was 12,824,284.41 TL, while the grant support in 2014 was 22,808,759.84 TL (T.C. Hakkari Valiliği, 2014, p. 5). Within this framework, agriculture is of utmost importance for Hakkari economy. As such projects and supports increase, the productivity of Hakkari in agricultural sector undoubtedly increases.



	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
tfpch	1.057	0.234	0.501	2.127	73.749	1.079	0.816	1.388

Figure 2: Total Factor Productivity Change of Hakkari

The second province, which have the most productive agricultural production, is İstanbul. Figure 3 shows the TFP changes of İstanbul. According to the analysis results, İstanbul also has the higher frontier-shift effect. This effect causes an increase in productivity. The most important reason for this is İstanbul is the center of industrial production of Turkey. By this way, the producers in İstanbul can easily reach the most technological production functions. Modern agricultural production technologies are relatively too much and easy to reach. In addition, thanks to the fertile soil resources, the production variety and yield provide agricultural abundance. In addition, due to the fact that Istanbul is also close to the secondary production factors, the loss experienced by the farmers is decreasing and their revenues are increasing, since agricultural products can be easily ruined. Therefore, being close to the market is also a great advantage in agriculture.

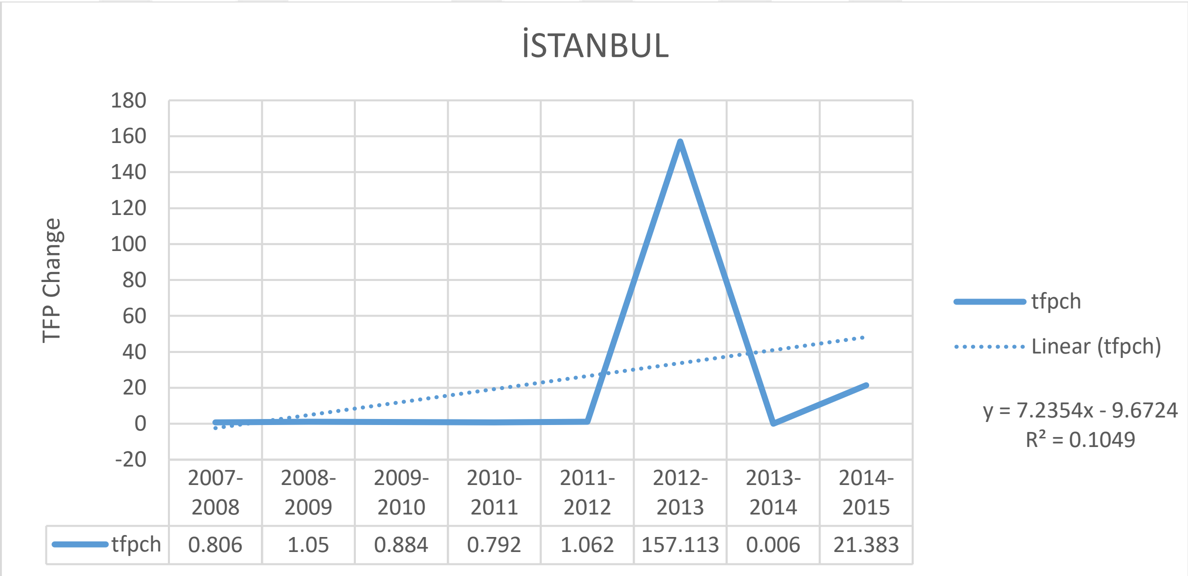


Figure 3: Total Factor Productivity Change of İstanbul

Another province that makes the most efficient agricultural production is Kocaeli. Here, frontier-shift effect is the main reason of TFP increase. Figure 4 shows the TFP changes of Kocaeli. The similar reasons with İstanbul are effective in Kocaeli, too. Because, their geographical locations are very close and this causes the similar climate characteristics, soil structure, irrigation possibilities, closeness to the market and availability of technological developments. In addition, some important precautions are taken for one of the most important problems in agriculture, in Kocaeli. This problem is fragmented land issue. Because of Turkey's inheritance law, the most productive agricultural lands are in danger.

The agricultural areas are getting smaller and smaller from generation to generation. This causes the larger farms are also getting smaller. This is a huge problem, because small farms are not able to make a profitable production. This also leads these farmers' lose their price setter power. In this direction, Kocaeli Directorate of Provincial Food Agriculture and Livestock started a project, which aims to consolidate 14,600 hectare cultivable land. By this way, a more economical and more profitable production is possible (Kocaeli Directorate of Provincial Food, Agriculture, and Livestock, 2016).

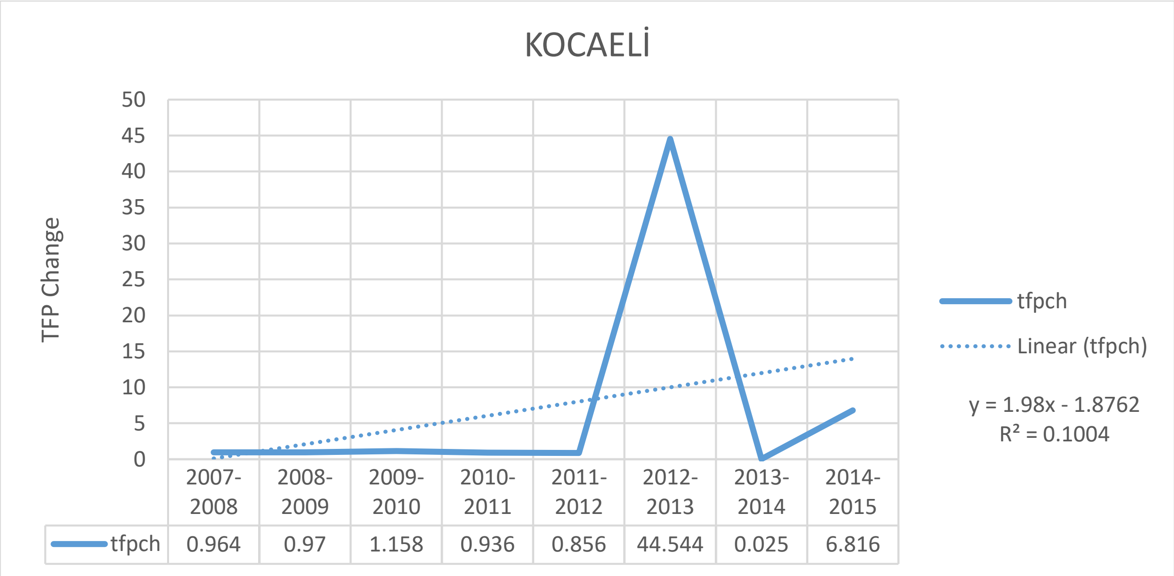


Figure 4: Total Factor Productivity Change of Kocaeli

On the other hand, the lowest level of agricultural productivity was realized in Karaman between 2007 and 2015. The average TFPCH is at the lowest level in this province, even though Figure 5 shows an overall increase. Of the low level of productivity is the catch-up effect. Here, the catch-up effect shows whether an optimal output can be achieved through existing inputs or not. When Karaman's agricultural sector is viewed, it is possible to assert we can say that approximately 40 percent of the population earns their income from this sector (Yıldırım, Sezer, Aydın, & Ateş Sönmezoğlu, 2014, p. 13). The share of agriculture in the total GDP of the province is about 50 percent. The main crops produced in this province can be listed as field crops; such as, wheat, barley, dried beans, chickpeas, potatoes, sugar beet, and grain corn; fruits; such as, apple, sweet cherry, walnut, almond, and grape; and in vegetables; such as, onion, spinach, and cabbage. In addition to these, field crops; such as tomatoes and lettuce became widespread in recent years (Değerli, 2011).

In Karaman, while agriculture has such a big potential, irrigation problems can be seen as the main reason behind the inefficient agricultural production. Although the province has large lowlands, irrigation cannot be performed as it is needed in agricultural areas because of the shortage of rivers (Yıldırım, Sezer, Aydın, & Ateş Sönmezoğlu, 2014). This, as can be predicted, has a very negative effect on productivity. With the projects, investments and incentives to be carried out on irrigation, the problem of inefficiency encountered in this area can be largely eliminated.

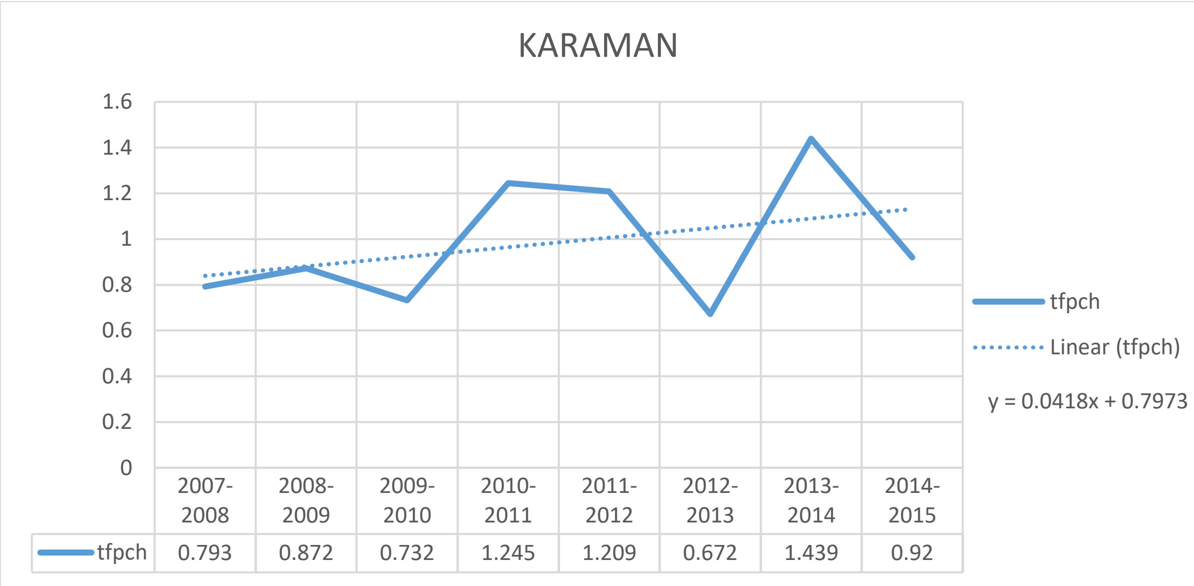


Figure 5: Total Factor Productivity Change of Karaman

The second province that has the least productive agricultural production is Ordu. Even if the frontier-shift effect is greater, the catch-up effect is more effective on TFP change. Therefore, lower catch-up effect is the reason of lower TFP. Figure 6 shows the fluctuations in the TFP of Ordu. Because of the rugged terrain and climate characteristics, which is usually cloudy and rainy, the production of variable agricultural products cannot be possible. Hazelnut is the main source of agricultural income in this area. Other varieties are generally produced not for the commercial purposes, but for the fulfillment of the needs. The geographical features of this area causes the agricultural sector to grow less.

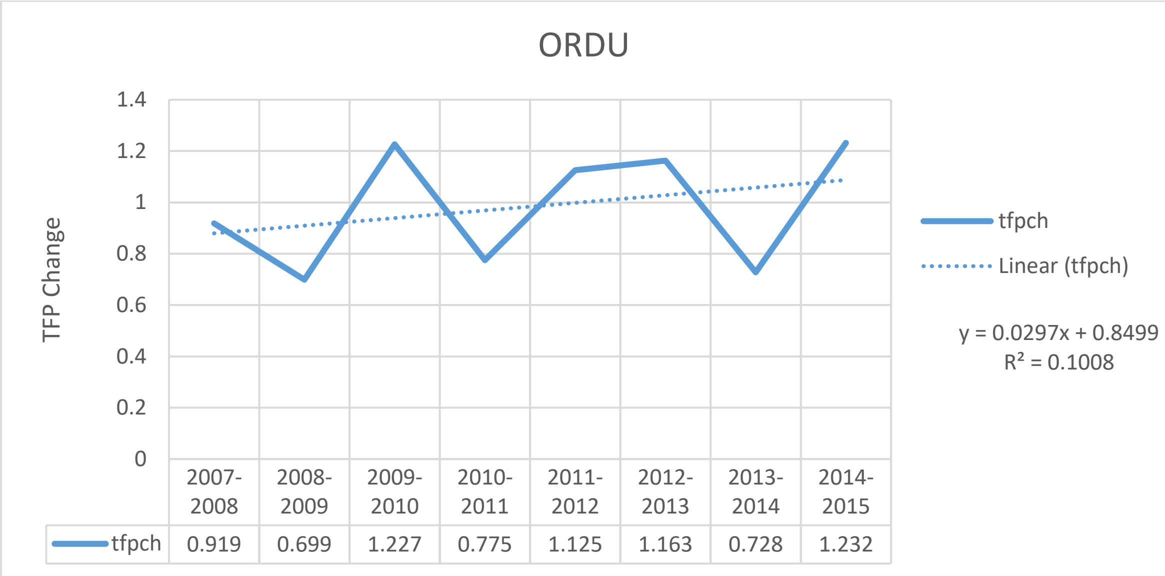


Figure 6: Total Factor Productivity Change of Ordu

Lastly, Yozgat has become one of the provinces that has the least TFP change. Figure 7 shows the TFP fluctuations of Yozgat. Just like in Ordu, Yozgat has also greater frontier shift effect. However, lower catch-up effect caused the TFP change to decrease. When we look at the features of agricultural sector of Yozgat, we see that, rough climate characteristics, irrigation problems and lack of storage facilities does not let the farmers to produce the high added-value products. Grain types are the main agricultural income resources of Yozgat. Even if the geographical formations are appropriate for agriculture in province-wide, the problems that are mentioned above caused the agricultural production to be less productive.

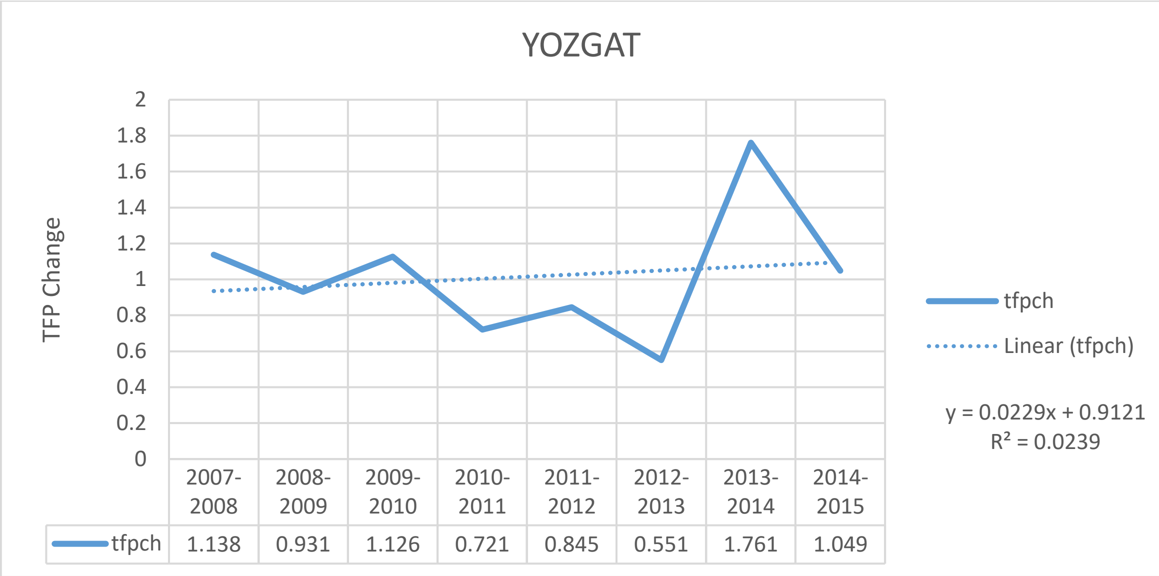


Figure 7: Totatl Factor Productivity Change of Yozgat

Table 2 gives the mean results of each province between 2007 and 2015. For each province, the average of the catch-up effect (EFFCH), frontier-shift effect (TECHCH), pure efficiency change (PECH), scale efficiency change (SECH) and TFP change (TFPCH) values can be seen in the table. The increase and the decrease on agricultural productivity for each province can also be observed between the years of 2007 and 2015.

Table 2: Malmquist Index Summary of Provincial Means

plate code	Name of the province	Avg effch	Avg techch	Avg pech	Avg sech	Avg tfpch	Min tfpch	Max tfpch
1	Adana	0.735	1.4	0.852	0.862	1.029	0.392	2.857
2	Adıyaman	0.801	1.311	0.803	0.998	1.05	0.482	2.106
3	Afyonkarahisar	0.788	1.256	0.824	0.956	0.99	0.741	1.332
4	Ağrı	0.915	1.152	0.878	1.041	1.054	0.476	2.118
5	Amasya	0.842	1.318	0.831	1.014	1.11	0.938	1.408
6	Ankara	0.848	1.322	0.901	0.94	1.12	0.091	14.862
7	Antalya	0.82	1.258	0.871	0.942	1.031	0.515	1.65
8	Artvin	0.804	1.223	0.826	0.973	0.983	0.72	1.335
9	Aydın	0.797	1.246	0.824	0.967	0.993	0.868	1.149
10	Balıkesir	0.854	1.266	0.888	0.961	1.081	0.688	1.538
11	Bilecik	0.888	1.233	0.882	1.007	1.095	0.19	4.639
12	Bingöl	0.95	1.102	0.908	1.047	1.047	0.68	1.351
13	Bitlis	0.805	1.239	0.798	1.009	0.998	0.547	1.493

14	Bolu	0.836	1.182	0.832	1.004	0.988	0.452	2.54
15	Burdur	0.853	1.236	0.846	1.008	1.054	0.941	1.296
16	Bursa	0.879	1.278	0.906	0.97	1.123	0.142	7.734
17	Çanakkale	0.824	1.284	0.826	0.998	1.058	0.825	1.42
18	Çankırı	0.813	1.252	0.814	0.998	1.018	0.819	1.207
19	Çorum	0.832	1.28	0.846	0.983	1.066	0.889	1.529
20	Denizli	0.831	1.232	0.849	0.979	1.024	0.441	2.193
21	Diyarbakır	0.708	1.408	0.777	0.912	0.998	0.515	1.744
22	Edirne	0.765	1.329	0.758	1.009	1.017	0.865	1.199
23	Elazığ	0.856	1.229	0.85	1.007	1.052	0.439	1.736
24	Erzincan	0.858	1.199	0.86	0.998	1.028	0.455	1.436
25	Erzurum	0.868	1.172	0.829	1.048	1.018	0.763	1.204
26	Eskişehir	0.82	1.313	0.811	1.01	1.076	0.272	4.057
27	Gaziantep	0.832	1.328	0.833	0.999	1.105	0.13	6.69
28	Giresun	0.82	1.248	0.803	1.02	1.023	0.489	1.901
29	Gümüşhane	0.928	1.104	0.947	0.98	1.025	0.509	1.798
30	Hakkari	1	1.486	1	1	1.486	0.234	73.749
31	Hatay	0.746	1.375	0.817	0.913	1.026	0.369	2.399
32	Isparta	0.852	1.203	0.835	1.02	1.025	0.793	1.303
33	Mersin	0.796	1.265	0.842	0.946	1.008	0.728	1.409
34	İstanbul	1	1.373	1	1	1.373	0.006	157.113
35	İzmir	0.839	1.294	0.915	0.917	1.085	0.156	6.597
36	Kars	0.855	1.204	0.828	1.032	1.03	0.368	1.924
37	Kastamonu	0.874	1.184	0.851	1.026	1.034	0.89	1.229
38	Kayseri	0.783	1.291	0.835	0.938	1.01	0.226	4.057
39	Kırklareli	0.778	1.342	0.759	1.025	1.043	0.331	2.711
40	Kırşehir	0.747	1.359	0.764	0.977	1.015	0.757	1.382
41	Kocaeli	1.057	1.198	1.055	1.002	1.266	0.025	44.544
42	Konya	0.763	1.381	0.886	0.861	1.055	0.872	1.366
43	Kütahya	0.858	1.187	0.836	1.026	1.019	0.393	2.477
44	Malatya	0.832	1.222	0.826	1.008	1.017	0.292	1.963
45	Manisa	0.824	1.247	0.88	0.937	1.028	0.645	1.494
46	Kahramanmaraş	0.772	1.371	0.819	0.943	1.059	0.338	3.232
47	Mardin	0.752	1.376	0.762	0.987	1.035	0.719	1.263
48	Muğla	0.863	1.167	0.848	1.018	1.008	0.821	1.162
49	Muş	0.859	1.179	0.867	0.99	1.012	0.546	1.411
50	Nevşehir	0.779	1.314	0.771	1.011	1.024	0.661	1.466
51	Niğde	0.769	1.335	0.746	1.031	1.027	0.689	1.47
52	Ordu	0.761	1.261	0.742	1.026	0.959	0.699	1.232
53	Rize	1	1.041	1	1	1.041	0.599	1.932
54	Sakarya	0.781	1.321	0.806	0.969	1.032	0.242	4.039
55	Samsun	0.851	1.26	0.879	0.968	1.072	0.671	1.618
56	Siirt	0.819	1.326	0.947	0.865	1.086	0.583	1.753

57	Sinop	0.911	1.153	0.882	1.033	1.05	0.649	1.216
58	Sivas	0.787	1.245	0.801	0.982	0.979	0.738	1.297
59	Tekirdağ	0.831	1.33	0.821	1.013	1.105	0.11	7.701
60	Tokat	0.852	1.234	0.832	1.024	1.051	0.543	1.498
61	Trabzon	0.876	1.14	0.905	0.968	0.999	0.332	2.646
62	Tunceli	0.908	1.122	1	0.908	1.018	0.855	1.231
63	Şanlıurfa	0.693	1.432	0.816	0.85	0.993	0.638	1.351
64	Uşak	0.834	1.264	0.833	1.001	1.054	0.372	2.499
65	Van	0.972	1.074	0.935	1.04	1.044	0.441	1.653
66	Yozgat	0.757	1.272	0.785	0.964	0.963	0.551	1.761
67	Zonguldak	0.954	1.166	0.919	1.038	1.112	0.164	6.116
68	Aksaray	0.755	1.346	0.758	0.996	1.016	0.789	1.435
69	Bayburt	0.824	1.181	0.842	0.979	0.973	0.261	3.008
70	Karaman	0.73	1.305	0.732	0.997	0.952	0.732	1.439
71	Kırıkkale	0.81	1.341	0.854	0.948	1.086	0.299	3.066
72	Batman	0.776	1.389	0.883	0.879	1.078	0.334	2.683
73	Şırnak	0.739	1.394	0.954	0.774	1.03	0.361	1.729
74	Bartın	0.952	1.154	0.931	1.022	1.098	0.458	1.943
75	Ardahan	0.969	1.114	0.926	1.046	1.079	0.254	2.533
76	Iğdır	0.876	1.153	0.854	1.025	1.01	0.293	2.976
77	Yalova	0.938	1.127	1	0.938	1.057	0.107	7.105
78	Karabük	1.012	1.089	0.984	1.028	1.102	0.116	6.498
79	Kilis	0.707	1.372	1	0.707	0.97	0.59	1.572
80	Osmaniye	0.805	1.358	0.845	0.952	1.093	0.556	2.271
81	Düzce	0.838	1.249	0.838	1	1.047	0.292	3.354
	mean	0.835	1.255	0.856	0.976	1.048	0.503	5.857

5.2. Examination of Total Factor Productivity Over Years

When the TFP changes experienced in 2008 are examined in comparison with the previous year, the first five provinces, which achieved the highest increase in agricultural productivity, were Kırıkkale, Nevşehir, Muş, Uşak, and Aksaray. The increase in the productivity of these provinces was caused by an increase in the catch-up effect. On the other hand the first five provinces, which realized the biggest decline in productivity, were Kilis, Diyarbakır, Şırnak, Bayburt, and Batman, respectively. The cause of the decline in the productivity of these provinces was observed as a decrease in the catch-up effect.

Kırıkkale with the highest increase in TFP produced 19 kinds of fruits, 23 kinds of vegetables, and 21 kinds of field plants in 2007. In 2008, the number of varieties produced increased to 20 kinds of fruits, 32 kinds of vegetables, and 22 kinds of field plants, causing positive effect in productivity. 23 kinds of fruits, 26 kinds of vegetables, and 15 kinds of field crops were produced in 2007 in Kilis, which showed the highest decrease in TFP value. In 2008, number of fruit and vegetable varieties were constant, while field crop varieties decreased to 14.

Considering change in the agricultural productivity in 2009 compared to the previous year, the top five provinces with the highest TFP value were Siirt, Şırnak, Kilis, Batman, and Diyarbakir. The increase in productivity of these provinces was caused by the increase in the catch-up effect. The first five provinces where TFP value most decreased were Hakkari, Nevşehir, Ordu, and Giresun, and Kütahya. While the decrease in the productivity of Hakkari and Kütahya was determined by the frontier-shift effect, the cause of the decrease in Nevşehir, Ordu and Giresun was the catch-up effect.

In Siirt, which met 14 percent of Turkey's pistachio production in 2009, the production of high value-added products was given priority and it became the province maximizing its productivity in agriculture (DİKA, 2011). In Hakkari there was an increase in input data in 2009, except for the decrease in arable land area compared to 2008. On the other side, there was a significant decrease in the output data. Despite the increase in input data, the decrease in output data caused the greatest decrease in TFP value in Hakkari. This means that Hakkari could not meet the optimal agricultural production with given inputs.

When the agricultural productivity of 2010 is compared with the year 2009, the following results were reached. (1) The first five provinces with the highest TFP values were Ağrı, Kars, Samsun, Çorum, and Trabzon respectively. While the cause of the increase in productivity in Ağrı and Kars was the catch-up effect, the frontier-shift effect was effective in Samsun, Çorum and Trabzon. (2) The first five provinces with the lowest TFP value are Hakkari, Ankara, Karaman, Karabük, and Kahramanmaraş, respectively. The reason for this decrease in the productivity of Hakkari and Ankara is the frontier-shift effect, while in Karaman, Karabük and Kahramanmaraş the reason of this decrease is the catch-up effect.

Among the reasons of the increase in Ağrı's agricultural productivity, the grants made within the framework of the Eastern Anatolia Project (EAP), which was first implemented in 2010, can be mentioned. Such projects clearly have a positive impact on agricultural productivity. At this point Hakkari became the province with the most decrease in productivity, as it was in the previous period. In addition to the reasons mentioned in the previous period, there was also a decline in the diversity of the crops produced in this period. For example, in 2009, 24 varieties of field crops, 24 varieties of vegetables, and 24 varieties of fruits were produced in Hakkari. In 2010, 16 varieties of field crops, 20 varieties of vegetables, and 25 varieties of fruits were produced in Hakkari. Apparently, crops with high added value are not preferred in plant production. In other words, diversity in field crops and vegetable production diminished compared to the previous year. In fruit production on the other hand, only one kind of crop (dried seedless grape) began to be produced. Only 4 tonnes of this newly added variety of fruit was produced, and no significant contribution was made to the revenue generated in agriculture. The release of other products (rye, whole oat, vetch, dry alfalfa, dry sainfoin, dry clover, alfalfa seed, and sainfoin seed) caused a decline in income attained from agriculture. This can be viewed as one of the reasons that adversely affect productivity in Hakkari.

When the agricultural productivity change of 2011 is examined in comparison with the previous year, it is observed that Hakkari, Ardahan, Yalova, Malatya, and Şırnak were the top five provinces with the highest TFP value. It is also reached that while the catch-up effect was influential in Şırnak and Malatya's productivity increase was effective, it was observed that the frontier-shift effect was effective in Hakkari, Ardahan, and Yalova. On the other side, the first five provinces with the smallest TFP value in this period were Kilis, Yozgat, Sivas, Kayseri, and Trabzon, respectively. Here, while the cause of the productivity decrease in Trabzon was the frontier-shift effect, the cause of productivity decrease in the other four provinces was the catch-up effect.

Unlike the previous year, Hakkari was the province with the highest TFP value in 2011. The effect of the diesel support, fertilizer support, and agriculture support of 14.5 million TL in 2011 was significant. At the same time, the grant of 418.000 TL transferred within the scope of EAP also plays a very important role in developing agricultural productivity (T.C. Gıda Tarım ve Hayvancılık Bakanlığı, 2011). On the other hand, in Kilis, where the TFP value was the lowest, a change was observed in the variety of agricultural crop production. Whereas 23 kinds of fruits, 25 kinds of vegetables, and 13 field crop plants were produced in 2010, 25 kinds of fruits, 17 kinds of vegetables, and 15 kinds of field plants were produced in 2011. At this point, it is possible to assert that even if the variety of fruit and field crops increases, agricultural productivity decreases because products with high added value are not produced.

When we look at the agricultural productivity of 2012, the five provinces with the highest TFP value were Hakkari, Manisa, Bayburt, Kırklareli, and Mardin, respectively, while the first five provinces with the lowest TFP value were Nevşehir, Antalya, Bolu, Ankara, and Muğla, respectively.

It was observed that in Hakkari and Mardin, the frontier-shift effect was the reason of this rise, while the catch-up effect was the reason in the other three provinces. On the other hand, the productivity decline in Muğla and Nevşehir was caused by the catch-up effect, while it was caused by the frontier-shift effect in the other three provinces.

By maintaining the activities and incentives of the previous year, the productivity reached the maximum level in Hakkari. It can be considered as the most productive province of the country in this way. In Nevşehir, which is the most inefficient province in this period, there is a serious decrease in the monetary value of the agricultural production even if the number of crop varieties increases. In 2011, 77 varieties of agricultural products were produced and the revenue was 978,992 TL. In contrast, in 2012, 91 varieties of agricultural products were produced, but 813,878 TL income was obtained. This was a sign of inefficient production.

Looking at the changes in agricultural productivity in 2013 compared to 2012, the top five TFP values were in İstanbul, Kocaeli, Ankara, Bursa, and Tekirdağ. The five provinces with the lowest TFP were Ardahan, Bayburt, Iğdır, Kars, and Ağrı. All positive or negative changes observed in agricultural productivity during this year were the result of the frontier-shift effect.

Considering at Istanbul, which is the province where productivity increased most, there was a high increase in the share of agricultural production in GDP even though total amount of agricultural production decreased. This might be caused by the production of high added value crops in Istanbul. On the other hand, Ardahan, which is the province with the lowest agricultural productivity, experienced the opposite. In other words, in addition to the decline in the amount of production, there is also a large decline in the share of agricultural goods in GDP. The production of non-value added agricultural products might be the reason of the reduction in agricultural productivity in Ardahan.

In 2014, the five provinces with the highest increase in agricultural productivity were Bayburt, Iğdır, Ardahan, Kars, and, Yozgat respectively. The five provinces with the lowest agricultural productivity were Istanbul, Kocaeli, Ankara, Yalova, and Tekirdağ. While the catch-up effect is the cause of the increase in agricultural productivity, the frontier-shift effect is the cause of the decrease in productivity. In Bayburt, the province with the highest TFPCH value, there was a significant increase in both quantity and monetary value of agricultural production, although there was a decrease in agricultural land and in the amount of fertilizer used in agriculture. This shows that there is an increase in agricultural productivity in this province. On the other hand, contrary to the previous year, Istanbul showed the lowest productivity in 2014. Despite the increase in agricultural crop diversity, both the amount of production and the share of agriculture in GDP declined significantly. While Istanbul is the most productive province of the previous year, it has been the most unproductive province of the year. The reasons for this situation should be investigated.

Finally, when we examine the agricultural productivity of the year 2015 compared to the previous year, the first five provinces with the highest increase in TFPCH were İstanbul, Kocaeli, Karabük, Ankara, and Yalova, respectively. On the other hand, the top five provinces with the lowest TFPCH value were Bayburt, Iğdır, Muş, Konya, and Karaman. Here, the frontier-shift effect was the reason for the increase in agricultural productivity, while the catch-up effect was the reason for the decrease in agricultural productivity.

The results of this year conflict with of the results of the previous year. In other words, İstanbul is the most productive province and Bayburt is the most unproductive province. The reasons for the exact reversal of the situation need to be investigated. However, according to the TURKSTAT data, it should be noted that, although there is a noticeable decrease in the crop variety and the amount of production, a huge increase in monetary value of production has been observed in İstanbul. At this point, it is possible to conclude that, unlike the previous year, products with high added value were produced in İstanbul in 2015. Taking Bayburt into consideration, even if a slight increase in the amount of agricultural production the monetary value of agricultural production declined.

Table 3 shows the mean TFPCH values of all the provinces for each period, and Figure 8 shows the TFP change of Turkey between 2007 and 2015. The level of agricultural productivity in Turkey can be followed annually in this table. For example, between 2014 and 2015, there were only nine provinces of which agricultural sector is unproductive. In other words, 72 provinces have realized agricultural productivity. A high frontier-shift effect was observed throughout Turkey. On the other hand, between 2013 and 2014, while 60 provinces failed to achieve agricultural productivity, only 21 provinces realized agricultural productivity. Here, although a very high catch-up effect is observed, the overall agricultural productivity is low due to the low frontier-shift effect. In summary, it is possible to propound that some structural changes are required to obtain a high yield in Turkish agriculture. The factors; such as, technological developments and government incentives are affecting productivity to a large extent.

Table 3: Malmquist Index Summary of Annual Means

year	Avg effch	Avg techch	Avg pech	Avg sech	Avg tfpch	Min tfpch	Max tfpch	Number of provinces tfpch≥1	Number of provinces tfpch<1
2007-2008	1.067	0.949	1.063	1.004	1.012	0.59	1.478	45	36
2008-2009	1.045	0.923	0.987	1.059	0.964	0.234	1.753	31	50
2009-2010	0.987	1.157	0.959	1.03	1.142	0.501	2.118	62	19
2010-2011	1.003	0.989	1.05	0.955	0.993	0.673	2.127	38	43
2011-2012	1.035	1.004	1.057	0.979	1.04	0.764	73.749	34	47
2012-2013	0.039	43.127	0.059	0.661	1.684	0.254	157.113	57	24
2013-2014	27.356	0.02	16.874	1.621	0.536	0.006	3.008	21	60
2014-2015	0.193	7.259	0.258	0.748	1.4	0.794	21.383	72	9
mean	0.835	1.255	0.856	0.976	1.048	0.477	32.841	-	-

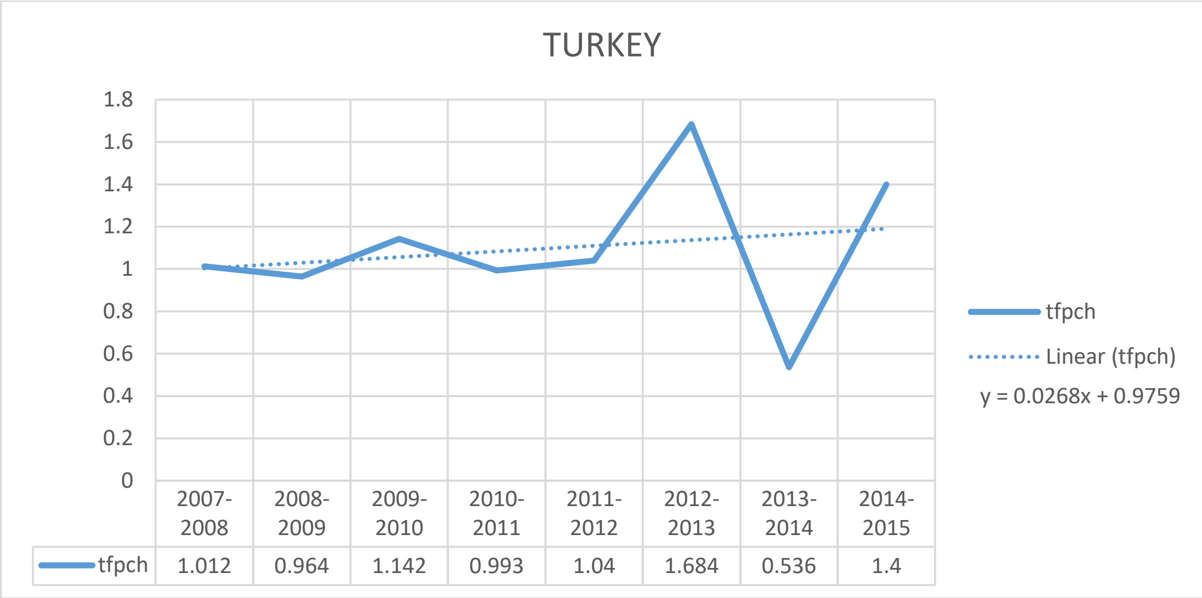


Figure 8: Total Factor Productivity Change of Turkey

CHAPTER 6

IDENTIFICATION OF PROBLEMS AND RECOMMENDATION FOR SOLUTIONS

Even if the prominence of agriculture in the Turkish economy diminishes relatively, it still holds a great importance in terms of the domestic food requirement, input to the industrial sector, export and employment opportunities (Yavuz F. , 2005). While the share of agricultural sector in GDP was 42.8% 1920s, it decreased to 36.0% in 1970s, 25% in 1980, 16% in 1990, 13.5% in 2000, and 12.6% in 2003. The gradual decrease in the share of the agricultural sector in the GDP is a result of more emphasis on the industrial and service sectors. Hence, Turkey’s agricultural sector remained in the background. Nevertheless, demand for food is expected to increase as the population increases and thus, investments, incentives and projects on agricultural activity must be continuously developed in synchronism with other sectors. The decrease in the share of agricultural sector in GDP should not prevent policy-makers from supporting agricultural sector. Agricultural sector should benefit from technological developments so that agriculture-related population do not have to tend towards other sectors.

Today, one of the most important problems faced in Turkish agriculture sector is that the new generation living in rural areas no longer attaches importance to agriculture. They move to the cities and seek for new job opportunities in the service or industry sectors. At the point where agricultural production stops, emphasis will be given to imported products, and a significant share of the national income will be allocated to this area. However, it is expected that agriculture must be an extremely efficient sector in Turkey, where climate diversity, soil diversity and water resources are so rich.

Considering the results of this study, even though the results of provinces vary within themselves, an increased efficiency in monetary terms has emerged throughout Turkey, while productivity decrease in terms of quantity was observed. The increase in productivity is hopeful for the future. At this point, it is possible to put forward that the increase in agricultural product prices led to the productivity increase in monetary terms. However, the problems, which lead to productivity decrease in terms of quantity, expressed by Turkish farmers for many years, must be identified, and people working in this sector should be supported to stay in this sector. Otherwise, it is not possible to avoid Turkey from becoming a country that consumes without producing and also cannot benefit from its potential.

Considering Turkey's problems in the agricultural sector, it is possible to assert that the main problem is the input costs. The costs of Turkish farmers rise considerably because the main inputs used in agricultural production; such as, diesel, electricity, fertilizer, seed, and medicine are well above the international market prices. If this situation continues, Turkish farmers became disadvantaged in the international competition on agricultural markets. In order to overcome this problem, government intervention is required. For example, fuel support, fertilizer support, tax reduction, subsidies, etc. might contribute to the solution of the problems of farmers.

The second problem is that the agricultural land is very fragmented and small. Due to the provisions of Turkish inheritance law, in case of a landowner's death, the agricultural lands are divided and transferred to the inheritors. As a result, agricultural lands shrink and become fragmented which means increasing cost of production, difficulty in the application of the modern agricultural techniques, difficulty in the construction of a transportation network, and decrease in the earnings of the farmers. Farmers in this situation are not able to go beyond producing in small gardens and being small merchants. For the solution of this problem, "Land Consolidation and Borderless Product, Village Project" studies which was started by the Ministry of Agriculture, Food and Livestock, and has been carried out since 1961, should be accelerated.

Another problem is the inadequacy of farmer education and practices provided by the government. To increase the awareness of producers on new technologies, production systems, marketing systems, incentives and legislation, encouragement of the young population on agricultural production has a vital importance. At the same time, farmers are ought to be educated about environmental problems. Moreover, more economical methods of using water resources and the use of renewable energy sources should be encouraged and made widespread among the farmers.

With respect to Turkish agricultural economy and production factors, it is possible to conclude that the productivity is low since the labor is unqualified, the capital is limited and inadequate, and the land is fragmented and undersized. It should also be emphasized that in the presence of these shortcomings, technology plays an important role in bringing the capital to the desired levels. In addition, there must be an efficient and educated labor force in the sector, and the correct amount of production (business size) must be achieved. (Çakmak, Akder, Levent , & Karaosmanoğlu, 2008)

Another important problem is that agricultural loans given by the banks are very difficult to follow-up. The primary purpose of agricultural loans is to ensure procurement of the required technologies for production and to increase the agricultural productivity. Even though the use of agricultural credits has increased with a rising trend, the increase in productivity is not at the same level with credits. It is even hard to say that there is a correlation between them (See Figure 9 and Figure 10). The reason is that the loans received by the farmers may sometimes be used to meet other needs, which are not related with agricultural production. Unless the control and follow-up of these loans and credits are provided, their effectiveness will possibly remain low.

In addition, the agricultural areas in the provinces should be clearly specified and that should not be allowed to be transformed into construction sites. Thus, the sustainability of agricultural production should be ensured and the laborers, who live in these areas and sustain their life in agriculture, should be encouraged to stay in this sector.

Furthermore, farmers should avoid being a community that goes from home to fields, comes home from fields, and cannot express their complaints or cannot raise their voices. Organizations should be established and farmers should be able to voice their problems in these organizations, effectively. Through these organizations, deficiencies in the agricultural production process should also be determined and eliminated. Organized farmers become able to increase their price-setter power in the market. All intermediaries who increase the market price must be subjected to a tighter control. If possible, the intermediaries must be removed and the producers should be able to get direct access to the consumers and obtain more share from the profit. This will prevent the gap between the market price and the field price, which affect both producers and consumers in a positive way.

Finally, problems regarding the registration and statistics of the agricultural activities must be overcome. These data should be open to everyone and easy to be accessed so that more qualified studies on agriculture could be carried out. The universities, trade associations and the Ministry of Food, Agriculture and Livestock should always cooperate with each other. The studies carried out in this area should be taken into account and precautions should be taken for the problems in the light of those studies.

Considering these problems, it turns out that Turkey's agricultural sector has not yet reached the desired level of development. After identifying the problems and many other issues, it is of utmost importance to do what is required for the solution. It is clear that food demand is a demand that never ends. However, problems arising in the supply of food might put the country economy in trouble. Therefore, rational and long-term agricultural production and marketing programs should be prepared and applied in Turkey for the food safety and sustainable agricultural environment in Turkey.

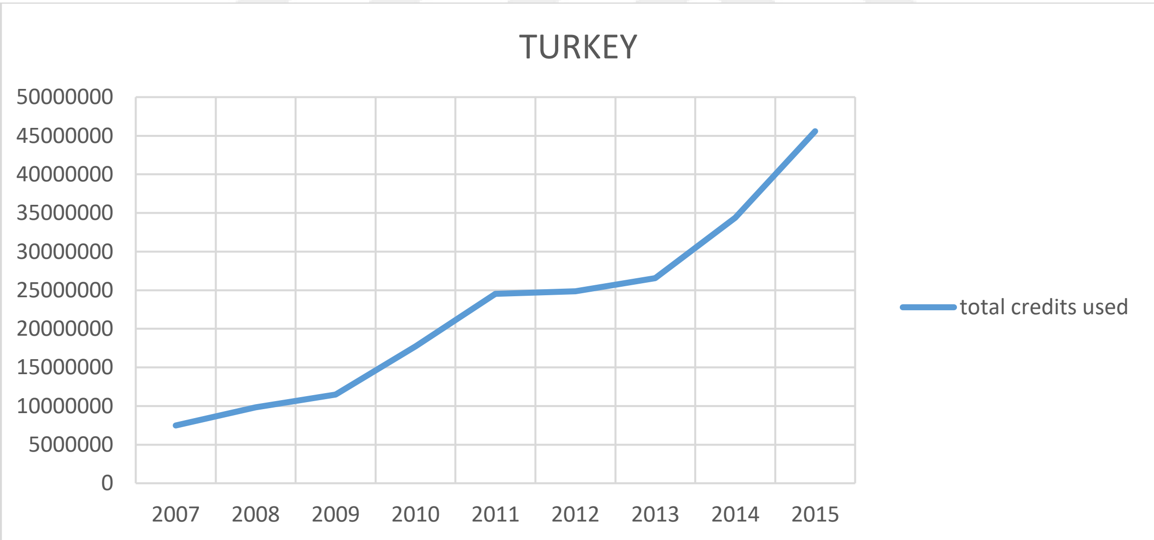


Figure 9: Agricultural Credits Used in Turkey

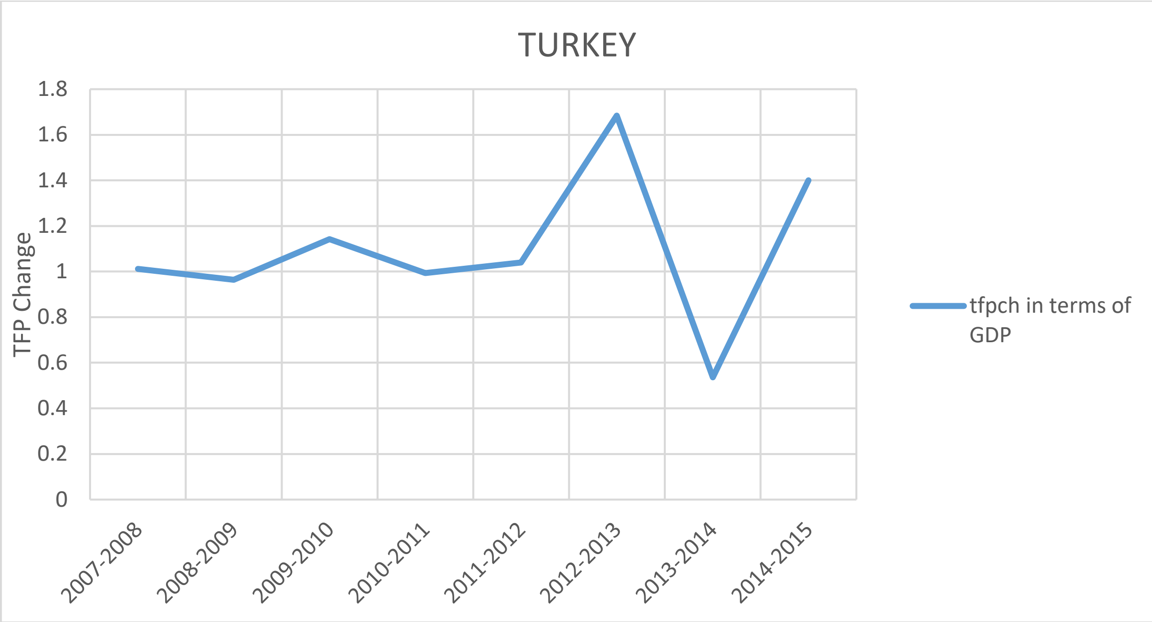


Figure 10: TFP Changes in Terms of the share of agriculture in GDP

CHAPTER 7

CONCLUSION

In this study, the agricultural productivity of 81 provinces of Turkey was measured for the 2007-2015 period. The agricultural productivity performances of these provinces, namely, catch-up effect (technical efficiency/efficiency change/EFFCH), frontier-shift effect (technological change/TECHCH) and total factor productivity change (TFPCH) values were calculated by using DEA based Malmquist productivity index and DEAP 2.1 computer program. The data used in this study, consists of four inputs, including land, labor, tractor and fertilizer and one output, which is the amount of income generated by the agricultural production activities of 81 provinces in the Gross Domestic Product (GDP) of each province between 2007 and 2015.

The analysis results were evaluated in two different ways. Firstly, when the average of nine years is taken, Hakkari and Karaman were identified as the most efficient and the least efficient provinces respectively for the productivity of agricultural production in Turkey. According to this, in the general average, there are 14 provinces in which agricultural sectors are unproductive, whereas there are 67 provinces in which agricultural sectors are productive. Various assumptions were made in the analysis results chapter about the reasons for this situation.

Secondly, whether the agricultural production of each provinces is efficient or not was examined. This analysis was carried out for each year in the 2007-2015 period. As a result of this analysis, provinces, which have the most efficient and inefficient agricultural production annually, were tried to be revealed. According to this, Kırıkkale, which increases the productivity of agricultural production most in 2007-2008, while Kilis is the province with the least increase in productivity. Between 2008 and 2009, Siirt is the most productive province and Hakkari is the most unproductive province. The province with the most productivity increase in 2009-2010 is Ağrı, and the province with the most decrease in productivity is Hakkari as in the previous year. The province with the greatest productivity increase between the years of 2010 and 2011 is Hakkari, contrary to the previous year, the province with the most productivity decrease is Kilis. Between 2011 and 2012, the highest productivity is in Hakkari and the lowest in Nevşehir. Between 2012 and 2013, the highest agricultural productivity was in İstanbul and the lowest agricultural productivity was in Ardahan. Between 2013 and 2014, agricultural the highest productivity is in Bayburt while it is the lowest in İstanbul. And lastly, between 2014 and 2015, on the contrary to the previous year, the productivity of agricultural production is the highest in Istanbul while it was the lowest in Bayburt. The reasons for these situations have been examined in detail in the chapter of analysis results.

The analysis results indicate some policy recommendations. Clearly, the following conclusion can be reached: Turkey's agriculture is a sector, which must be developed, has significant deficiencies and has a very high potential. In this study, some problems that can be detected are mentioned, and solution proposals are presented. However, there are many other problems that need to be addressed. These issues need to be identified and overcome by competent authorities.

In terms of suggestions for future studies, it is useful to refer to the data collection issue. In Turkey the agricultural sector has many shortcomings in terms of registration and statistics. Thus, the significance of the data obtained will always be an ambiguous issue. The importance given to the elimination of these deficiencies will give results that are more meaningful. In this regard, with the cooperation of the universities, trade associations and Ministry of Food, Agriculture and Livestock, the agricultural sector is expected to develop, which is vital for Turkey.

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TEZ FOTOKOPİSİ İZİN FORMU

<u>ENSTİTÜ</u>

Fen Bilimleri Enstitüsü [ ]

Sosyal Bilimler Enstitüsü [**X**]

<u>YAZARIN</u>

Soyadı : Köse

Adı : Elif Gül

Bölümü : İktisat

<u>TEZİN ADI</u> (İngilizce): The Productivity of Turkey's Agricultural Production on Provincial Basis

<u>TEZİN TÜRÜ</u>: Yüksek Lisans [**X**] Doktora [ ]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [**X**]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
3. Tezimden bir (1) yıl süreyle fotokopi alınamaz. [ ]

<u>TEZİN KÜTÜPHANEYE TESLİM TARİHİ</u>: …/07/2017