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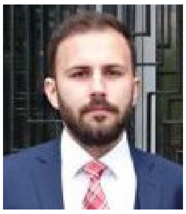

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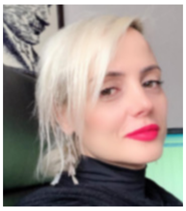

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MEASURING THE AGRICULTURAL TOTAL FACTOR PRODUCTIVITY OF PROVINCES IN TURKEY USING MALMQUIST INDEX

HABİBE YAMAN[1*] & ONUR SUNGUR[2] & MURAT ALİ DULUPÇU[3]

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Ethıcal Statement :This study is derived from the first author's doctoral thesis titled "A Review on the Development of Innovation and Productivity in the Agricultural Sector at the Provincial Level in Turkey".

ABSTRACT

This study aims to reveal the total factor productivity levels in the agricultural sector in 81 provinces of Turkey by using the Malmquist index method over the period 2009-2019. The results extracted from the Malmquist index findings show that index value changed between 1.186 and 0.952, agricultural productivity increased in 75 provinces and decreased in 6 provinces. In addition, our findings confirm technological change affects the change in agricultural productivity levels in all provinces in Turkey, and that technology is a determining factor in agricultural productivity in all provinces. From a policy perspective, the results suggest that authorities in Turkey should develop and implement technologies that will make the sector productive, to encourage and support infrastructure, research and publication studies on technology. In addition, this research claims that the regional incentive system can be revised and, it can build an incentive system based on performance and efficiency in which provinces or businesses operating in this field are classified according to their productivity.

Anahtar Kelimeler: Total Factor Productivity (TFP), Agricultural Sector, Malmquist TFP Index, Turkey

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TÜRKİYE'DE İLLERİN TARIMSAL TOPLAM FAKTÖR VERİMLİLİĞİNİN MALMQUIST ENDEKSİ İLE ÖLÇÜMÜ

ÖZ

Bu çalışma, 2009-2019 dönemi için Türkiye'nin 81 ilinde tarım sektöründeki toplam faktör verimlilik düzeylerini Malmquist indeks yöntemi kullanılarak ortaya koymayı amaçlamaktadır. Malmquist indeks bulgularından elde edilen sonuçlar, endeks değerinin 1.186 ile 0.952 arasında değiştiğini, tarımsal verimliliğin 75 ilde arttığını, 6 ilde azaldığını göstermektedir. Ayrıca bulgularımız, teknolojik değişimin Türkiye'deki tüm illerde tarımsal verimlilik düzeylerindeki değişimi etkilediğini ve teknolojinin tüm illerde tarımsal verimlilikte belirleyici bir faktör olduğunu doğrulamaktadır. Politika açısından, sonuçlar Türkiye'deki yetkililerin sektörü verimli kılacak teknolojiler geliştirmesi ve uygulaması, teknolojiye ilişkin altyapı, araştırma ve yayın çalışmalarını teşvik etmesi ve desteklemesi gerektiğini göstermektedir. Ek olarak, bu araştırma, bölgesel teşvik sisteminin revize edilebileceğini ve bu alanda faaliyet gösteren illerin veya işletmelerin verimliliklerine göre sınıflandırıldığı, performans ve verimliliğe dayalı bir teşvik sistemi kurulabileceğini iddia etmektedir.

Keywords: Toplam Faktör Verimliliği (TFV), Tarım Sektörü, Malmquist TFV Endeksi, Türkiye

INTRODUCTION

The discovery of the sources of productivity growth and productivity differences among countries and regions is a subject studied by development economics and agricultural economists. Productivity growth in the agricultural sector is necessary if the agricultural sector output is to grow at a fast rate to meet the demands for raw materials and food arising out of steady population growth (Coelli and Rao, 2005). Today, the limitation of production growth against excessive population growth and the reduction of natural resources increases the importance of productivity level measurement. This concept, which is important for all sectors, needs to be addressed for the agricultural sector as well.

Productivity growth is vital to economic well-being or economic growth, as it makes a positive contribution to living standards and quality of life. Productivity growth improves economic efficiency and thus economic efficiency leads to increase in income that can be used for improvements in social conditions and additional consumption (Link and Siegel, 2003). In this context, it is widely accepted that the development of the agricultural sector, which is an important source of economic growth, is an effective tool in reducing poverty. In addition, the more developed agricultural sector is also important in terms of ensuring food security (FAO, 2010), and the increase in food demand in terms of both quantity and quality increases the need for the intensification and industrialization of the agricultural sector (Tzounis et al., 2017). Failure to achieve rapid growth in agricultural productivity may lead to the withdrawal of foreign exchange or shifts to non-agricultural industries (Hayami and Ruttan, 1970), and the development of the sector cannot gain momentum. Therefore, agricultural practices need to be performed in a more efficient way from the point of view of countries.

The conceptual development of agriculture has been affected by various factors, such as land productivity, labour productivity, the environment, and economics. These factors play a significant role in the directing of agricultural development (Allafi, 2014). In addition, capital (in terms of purchase, development, and reclamation of land), irrigation purpose, drainage, feeds, seeds, livestock, agricultural implements, machineries, and crop production chemicals are being given priority as a factor for enhancing agricultural productivity (Dharmasiri, 2012). Crop output per land area is a cited productivity measure for agriculture. Higher efficiency may be an indicator of improved fertilization practices, quality lands allocated to the product, a well-trained workforce and/or more effective use of capital. However, it may also explain by fundamental factors beyond the control of farmers, such as soil conditions and weather (FAO, 2017). Production factors, which can be determined as material inputs such as capital, labour and land, affect the production increase in the agricultural sector. However, residual factors also impact on this process. Agricultural productivity is under the influence of various factors such as transportation, storage, marketing opportunities, prices, firm size, climate, terrain, organization, taxes, subsidies, social structure, education and research potential, mechanization, natural disaster (Çelik, 2000). Various factors influence agricultural productivity, especially physical, socio-economic and technological factors, but today dynamic factors such as technology and socio-economic factors stand out rather than natural factors. However, because people have minimal control over the physical environment, there is no single goal that can set in terms of the highest efficiency for all situations. There are attempts to control some physical factors using technology. Improving soil quality with chemical fertilizers, agriculture with irrigable water, pest control with chemicals and increasing production with high-yielding varieties are some achievements in question (Dharmasiri, 2012).

Generally, agriculture, forestry, and fishing sector have lower value added (in terms of % of GDP) in high-income economies, while it has higher values in low-income countries. For example, according to the data got from the World Bank (2022), this value is less than 0.05% in high-income economies such as Bahrain, Luxembourg, China, Singapore, Qatar, and over 38% in low-income countries such as Sierra Leone, Chad, Liberia, Niger. On the other hand, Turkey's agriculture, forestry, and fishing sector value added is 10.03% in 2000 and 6.68% in 2020, the recent data available. This value is relatively low in Turkey when compared to other countries in the middle-high income group.

This research aims to explore the total factor productivity levels of the provinces by using a comprehensive data set for 81 provinces in Turkey. There are several reasons for choosing Turkey's agricultural sector in the study. First, although there are many studies focused on productivity of the agricultural sector in Turkey, studies conducted with a comprehensive data set containing 81 provinces are limited. Most of the studies conducted at the provincial or regional level do not cover all provinces, or productivity measurement is made with output variables based on product and production (see Özok, 2006; Tipi and Rehber, 2006; Armagan and Ozden, 2007; Karaman, 2008; Kaya and Aktan, 2011; Guvercin, 2018). Second, agriculture is one of the three priority development areas (along with Defence and Tourism) under the title of "Competitive Production and Productivity" in the annual programs (Presidency of the Republic of Turkey Presidency of Strategy and Budget, 2022), and agricultural productivity growth remains a top priority for Turkey. Although there are various advantages in Turkey's agricultural sector, the level of productivity in the sector is not at the desired level. For example, considering the milk yield values measured as the amount of milk produced per animal in the world, it is seen that countries such as USA (10,189 kg), Denmark (9,895 kg), Estonia (9,144 kg), Finland (8,834 kg), Sweden (8,817 kg), Japan (8,464 kg), England (8,139 kg), Germany (7,990 kg), Luxembourg (7,393 kg), Canada (7,358 kg) come first in this value for 2018. Turkey, on the other hand, is quite behind the mentioned countries in this value (722 kg) (Ritchie et al., 2019). In addition, Iceland (131.730,9), Canada (116.095,4), Norway (109.962,4), USA (91.464,1) and Sweden (84.161,3) are in the top five in terms of agricultural added value per worker (constant, 2015 US dollars) for 2019 and Turkey (12.638,4) is in the 49th place in this value (FAOSTAT, 2022). Consequently, improving productivity in agriculture is important and this study also aims to devoting proposals to increase the productivity of the provinces.

In this context, the main research question of this study is to what extent the productivity levels of the provinces in Turkey have changed in the agricultural sector and to what extent technology has been effective in this change. We have organised the study as follows. We present the method of the study in Section 2, report the main findings in Section 3, discuss the results in Section 4, and conclude the paper in Section 5.

I. METHODOLOGY

A. DATA AND VARIABLES

In this study, we have calculated the agricultural productivity of 81 provinces in Turkey for the years 2009-2019. We have computed the Malmquist total factor productivity (TFP) index with a single output and five input variables. The table below shows the variables we used to measure productivity, their contents, and descriptive statistics.

TABLE 1 | The definition and summary statistics of variables

Variable	Description	n	Mean	Min.	Max.	Std. Dev.
Q *	Agricultural Gross Domestic Product (GDP), (1000 ₺)	891	1.891.145	137.041	1,68E+07	1.860.265
K *	The sum of the number of agricultural equipment and machines (pcs)	891	54.197,59	25	309.862	53.213,71
L **	The number of enterprises by business record (pcs)	891	336,8563	7	2.345	372,0352
N ***	Total agricultural area (decare)	891	2.930.435	107.162,80	2,11E+07	2.863.403
T ***	The sum of the number of live animals (pcs)	891	4.302.850	45.615	4,51E+07	7.208.250
E ***	Electricity consumption for agricultural irrigation (MWh)	891	64.808,13	1	2.072.994	151.439,50

Sources: * TUIK (2021a), ** TUIK (2021b), *** TUIK (2021c).

GDP is measured based on the year 2009. Agricultural equipment and machines consist of plough, seed drill, fertilizer spreader, water pump, stationary milking machine, mobile milking machine, combine harvester and tractor. The total agricultural area (cultivated area) refers to total area of land covered with crops, vegetables, fruits, flowers and other permanent crops and fallow land. Land under permanent meadows and pastures are not included. Number of live animals is the sum of poultry, cow, calf, bull, ox, buffalo, camel, sheep, goat, horse, mule and donkey.

We can say that in studies on the measurement of agricultural productivity, researchers include many variables in their models. However, there is no comprehensive data set for the agricultural sector in Turkey that includes 81 provinces. Therefore, the data we can use at the provincial level for this sector is limited. In the studies dealing with the agricultural sector in the literature, variables such as the population living in rural areas and dealing with agricultural activities (Tipi and Rehber, 2006), the economically active population in agriculture (Coelli and Rao, 2005), the number of farm workers in crop and animal production (Lissitsa and Odening, 2005) are used as labor input. Since there is no agricultural labor force data at the provincial level in Turkey, we have used the variable of the number of enterprises by business record representing this sector as the labor input indicator. Number of enterprises include agriculture, forestry and fisheries.

Lastly, in studies involving agricultural productivity, electric energy or electricity consumption variables are used as an input in the calculation of productivity (see Karaman, 2008; Kaya and Aktan, 2011; Karaman and Özalp, 2017; Özkan, 2018). It is thought that the increase in irrigation opportunities, as well as other processes (fertilization, etc.) that increase productivity in agriculture in Turkey, especially in arid regions. Although agricultural irrigation is performed in different ways, electricity is important for the effective use of water. The variable of electricity consumption used in agricultural irrigation is also used as an input in some studies (see Özkan, 2018; Karaman and Özalp, 2017). Therefore, in this study, we have included the variable of electricity consumption for agricultural irrigation in the model.

B. MEASUREMENT OF AGRICULTURAL PRODUCTIVITY

We can say that the concept of productivity is discussed in different ways in studies related to the agricultural sector. These studies frequently include productivity level, measurement, change, development, productivity sources or determining factors and use various methods. Using various indices in calculating agricultural productivity is common, such as Tornqvist-Thiel index (Rosegrant and Evenson, 1992; Coelli, 1996), Divisia index (Koç et al., 2016), Malmquist index (Umetsu et al., 2003; Coelli and Rao, 2005; Lissitsa and Odening, 2005; Özok, 2006; Tipi and Rehber, 2006; Avcı and Kaya, 2008; Kaya and Aktan, 2011; Bilişik, 2015; Karaman and Özalp, 2017; Mollavelioğlu et al., 2017). However, there are also studies that include econometric model estimations besides index calculations (Coelli, 1996; Ball et al., 2002; Armagan and Ozden, 2007; Liu, 2007; Koç et al., 2016; Lee, 2017). On the other hand, some studies state that the growth accounting method and index calculation methods are among the most widely used methods in productivity calculation (see Lipsey and Carlaw, 2004). In addition, among the studies that include productivity in the literature, there are also studies that make use of survey data (Giang et al., 2019) or that include the evaluation of approaches and indicators related to productivity (Latruffe, 2010).

In this research, we have used the Malmquist TFP index based on data envelopment analysis, which is one of the non-parametric measurement methods, to determine the agricultural productivity level in Turkey. That the Malmquist TFP index uses data on quantities, measures inefficiency, is simpler in terms of implementation, and does not require econometric estimation makes the index superior to traditional TFP indices (Kaya and Aktan, 2011). One advantage of the Malmquist TFP index is that it separates productivity into technical change and productivity components (Arnade, 1998). Due to these advantages, we have preferred the Malmquist TFP index in the research.

The Malmquist index is defined using distance functions. Distance functions describe a multi-input, multi-output production technology without the need to specify a behavioural aim (such as profit maximization or cost minimization). Both output distance functions and input distance functions may be defined (Coelli and Rao, 2005). In this study, we have considered the output-oriented approach in the calculation of the distance function. The formula for this index is as in Equation 1 (Färe et al., 1994):

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)}\right)\left(\frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad (1)$$

Where x^t and x^{t+1} represent the inputs in the t and $t+1$ period, respectively. y^t and y^{t+1} represent the outputs in the t and $t+1$ period, respectively. $D_0^t(x^t, y^t)$ defines the distance from t observation to technology in t period, and $D_0^{t+1}(x^{t+1}, y^{t+1})$ defines the distance from $t+1$ observation to $t+1$ period technology. On the other hand, $D_0^t(x^{t+1}, y^{t+1})$ is the distance from $t+1$ observation to technology in t period, and $D_0^{t+1}(x^t, y^t)$ is the distance from t observation to technology in $t+1$ period.

To make the index more understandable, we can divide the Equation 1 into its components (Equation 2) to calculate the change in Technical Change (TECH) and Efficiency Change (EFF). In this process; EFF consists of the multiplication of Scale Change (SCL) and Pure Efficiency Change (PEFF). The multiplication of EFF and TECH also gives the Total Factor Productivity Change (TFP) (Färe et al., 1994; Avcı and Kaya, 2008; Yolsal, 2010):

$$\text{TECH} = \left[\left(\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}\right)\left(\frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right)\right]^{\frac{1}{2}} ;\ \text{EFF} = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t(x^t, y^t)}$$

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \text{TFP} = \text{TECH} * \text{PEFF} * \text{SCL}$$

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \text{TFP} = \text{TECH} * \text{EFF} \quad (2)$$

If the Malmquist index value is less than 1, it means that there is a decrease in the productivity of the decision unit while passing from the t period to the t+1 period. On the contrary, if it is equal to 1, there is no change in productivity. Lastly, if it is greater than 1, it means that the productivity increases (Yolsal, 2010).

II. RESULTS

We have used the DEAP (2.1) software to calculate the Malmquist TFP index. First, we have presented the index summary according to annual averages in the Table 2.

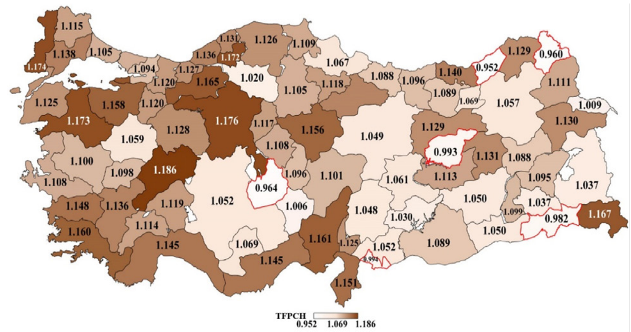
When we look at Malmquist index summary of annual averages, we see that the agricultural productivity in Turkey increased in some years (2010, 2011, 2012, 2014, 2015, 2017, 2018 and 2019) compared to the previous year, while it decreased in 2013 and 2016 compared to the previous year. In this period, the year with the highest productivity increase compared to the previous year is 2019, and there is increase in technological change in all years except 2013.

TABLE 2 | Malmquist Index Summary of Annual Averages

	(1) PEFF	(2) SCL	(3) TECH	(4) EFF (1*2)	TFP (3*4)
2009/2010	0.973	1.071	1.125	1.042	1.171
2010/2011	1.003	0.947	1.138	0.950	1.082
2011/2012	1.057	0.923	1.075	0.977	1.050
2012/2013	0.951	1.060	0.971	1.008	0.979
2013/2014	0.957	0.928	1.178	0.888	1.046
2014/2015	1.033	1.017	1.143	1.051	1.201
2015/2016	0.955	0.973	1.043	0.929	0.970
2016/2017	1.000	1.031	1.127	1.031	1.162
2017/2018	0.982	1.081	1.023	1.061	1.085
2018/2019	1.015	0.990	1.253	1.005	1.259
Mean	0.992	1.001	1.105	0.993	1.097

According to the provincial averages for the period of 2009-2019, the Malmquist TFP index value varies between 0.952 and 1.186 (see Table 3). We have presented the Malmquist TFP index summary according to the provincial averages in Table 3 to more clearly reveal the productivity increase or decrease in the provinces and the sources of productivity changes in the relevant period. In addition, the visual presentation of the findings is as follows.

FIGURE 1 | According to Provincial Averages TFP



According to the results, there is an increase in productivity 75 provinces in the relevant period. Afyonkarahisar (1.186), Ankara (1.176), Edirne (1.174), Balıkesir (1.173), Karabük (1.172), Yalova (1.169), Hakkari (1.167), Bolu (1.165), Adana (1.161) and Muğla (1.160) provinces have the highest increase. Bursa, Yozgat, Hatay, Aydın, Antalya, Mersin, Trabzon, Tekirdağ, Denizli and Zonguldak provinces are also in the top twenty. The provinces where the level of productivity increase is the least are Niğde (1.006), Igdır (1.009), Çankırı (1.020), Adıyaman (1.030) and Van (1.037) provinces. There is a decrease in productivity in 6 provinces according to the provincial averages for the period 2009-2019. These provinces are Rize (0.952), Ardahan (0.960), Aksaray (0.964), Şırnak (0.982), Tunceli (0.993) and Kilis (0.994). As seen in Figure 1, most of the productive provinces are located in the west of Turkey. Although there are agricultural activities in the east of Turkey, their productivity levels are quite low. In the socio-economic development ranking researches in Turkey (see SEGE, 2017), the provinces from the Marmara, Central Anatolia, Aegean and Mediterranean Regions are included in the first and second development levels, which include the most developed provinces. Therefore, these results also coincide with the socio-economic development results of the provinces in Turkey. In addition, agricultural production and agricultural industry are common economic activities in all of these regions. On the other hand, although Ankara is the capital of Turkey, it comes after Afyonkarahisar in terms of agricultural productivity. Because Afyonkarahisar has a developed transportation infrastructure and is located in an important transition region. The presence of advanced agricultural infrastructure, soil and water analysis laboratories and geothermal resources are effective in the high agricultural productivity in this province. In addition, many aspects such as Edirne's suitable structure for modern (mechanized) agriculture, the possibility of direct transportation to the port cities of Balıkesir and the absence of marketing and logistics problems of Karabük make these provinces advantageous in terms of productivity.

According to the findings in Table 3, it is revealed that there is an increase in technological change in Kilis, Tunceli, Şırnak, Aksaray, Ardahan provinces except Rize, where productivity decreases for the period 2009-2019. Although there is an increase in technological change in these provinces, there is a decrease in productivity due to negative changes in technical efficiency. In Rize, there is no change in technical efficiency. While there is a decrease in scale efficiency in Ardahan and Tunceli, there is no change in pure efficiency, and although scale efficiency increases in Kilis, there is a decrease in pure efficiency. In Şırnak and Aksaray, the decrease in technical efficiency is because of a decrease in both scale efficiency and pure efficiency.

It is noticeable that technical efficiency has increased in the provinces that are at the forefront of productivity change, while technical efficiency has decreased or remained unchanged in the last provinces. The technological change values showing the provincial averages for the 2009-2019 period are between 1.169 and 0.952, and the average of the technological change showing the provincial averages is 1.061. When we look at the results of the studies covering this subject in the literature, we see that the technological change value is determined in close ranges to these values, even though they are not the same values. Although there are studies involving different countries, regions or provinces, studies by Coelli and Rao (2005), Lissitsa and Odening (2005), Avcı and Kaya (2008), Tipi and Rehber (2006), Karaman and Özalp (2017), Kaya and Aktan (2011), Özok (2006) can

TABLE 3 | Malmquist Index Summary of Provinces Averages

Provinces	eff	tech	peff	scl	tfp	Provinces	eff	tech	peff	scl	tfp
Afyonkarahisar	1.06	1.12	1.03	1.03	1.01	Izmir	0.98	1.01	0.96	1.03	1.11
Ankara	1.06	1.11	1.04	1.02	1.01	Kırşehir	1.00	1.11	0.99	1.01	1.11
Edirne	1.05	1.12	1.02	1.03	1.01	Çorum	1.00	1.10	0.97	1.03	1.11
Balıkesir	1.05	1.12	1.01	1.04	1.01	Istanbul	0.99	1.12	1.02	0.97	1.11
Karabük	1.05	1.12	1.05	1.00	1.01	Kayseri	1.00	1.11	0.99	1.01	1.10
Yalova	1.00	1.01	1.00	1.00	1.01	Manisa	0.97	1.01	0.96	1.01	1.10
Hakkari	1.02	1.01	1.00	1.02	1.01	Batman	0.99	1.11	1.01	0.98	1.10
Bolu	1.04	1.12	1.03	1.01	1.01	Uşak	0.96	1.01	0.99	0.97	1.10
Adana	1.03	1.12	1.00	1.03	1.01	Giresun	1.00	1.10	1.01	0.99	1.10
Muğla	1.04	1.12	1.00	1.04	1.01	Nevşehir	1.01	1.09	1.00	1.01	1.10
Bursa	1.04	1.12	1.00	1.04	1.01	Bitlis	0.97	1.01	0.99	0.98	1.10
Yozgat	1.06	1.09	1.00	1.06	1.01	Kocaeli	0.98	1.12	0.97	1.01	1.09
Hatay	1.03	1.12	1.01	1.02	1.01	Gümüşhane	1.00	1.09	1.00	1.00	1.09
Aydın	1.03	1.12	1.00	1.03	1.01	Şanlıurfa	1.00	1.09	1.00	0.99	1.09
Antalya	1.02	1.01	1.00	1.02	1.01	Muş	0.98	1.11	0.99	0.99	1.09
Mersin	1.02	1.12	0.99	1.04	1.01	Ordu	0.99	1.10	1.02	0.98	1.09
Trabzon	1.02	1.11	1.01	1.01	1.01	Bayburt	1.00	1.07	1.00	1.00	1.07
Tekirdağ	1.02	1.12	1.00	1.02	1.01	Karaman	0.97	1.11	0.98	0.99	1.07
Denizli	1.02	1.12	1.00	1.02	1.01	Samsun	0.96	1.11	0.94	1.02	1.07
Zonguldak	1.02	1.12	1.00	1.02	1.01	Malatya	0.97	1.09	1.01	0.97	1.06
Tokat	1.04	1.09	1.04	1.01	1.01	Kütahya	0.97	1.09	0.99	0.98	1.06
Bingöl	0.97	1.01	1.00	0.97	1.01	Erzurum	0.98	1.08	0.98	1.00	1.06
Bartın	1.01	1.12	1.00	1.01	1.01	Gaziantep	0.96	1.09	0.98	0.99	1.05
Ağri	0.98	1.01	0.98	1.00	1.01	Konya	0.96	1.10	0.95	1.01	1.05
Artvin	1.01	1.12	1.00	1.01	1.01	Diyarbakır	0.96	1.09	1.01	0.96	1.05
Erzincan	1.03	1.09	1.03	1.00	1.01	Mardin	0.96	1.09	0.98	0.98	1.05
Eskişehir	1.01	1.12	1.00	1.02	1.01	Sivas	0.97	1.08	0.99	0.98	1.05
Düzce	1.01	1.12	0.99	1.02	1.01	K.maraş	0.97	1.08	0.97	1.00	1.05
Kastamonu	1.01	1.12	1.00	1.01	1.01	Siirt	0.93	1.11	0.95	0.98	1.04
Çanakkale	1.01	1.12	0.99	1.01	1.01	Van	0.93	1.12	0.97	0.96	1.04
Osmaniye	1.02	1.10	1.02	1.01	1.01	Adıyaman	0.95	1.08	0.97	0.99	1.03
Bilecik	1.01	1.11	1.02	0.99	1.12	Çankırı	0.93	1.09	0.99	0.94	1.02
Sakarya	1.00	1.12	0.97	1.03	1.12	Igdır	0.92	1.10	0.92	1.00	1.01
Isparta	1.02	1.10	1.01	1.01	1.12	Niğde	0.93	1.08	0.97	0.96	1.01
Amasya	1.01	1.11	1.00	1.01	1.12	Kilis	0.93	1.07	0.90	1.04	0.99
Kırıkkale	1.02	1.10	1.02	1.00	1.12	Tunceli	0.90	1.10	1.00	0.90	0.99
Kırklareli	0.99	1.12	0.96	1.04	1.12	Şırnak	0.96	1.02	0.96	1.00	0.98
Burdur	1.00	1.12	0.97	1.03	1.11	Aksaray	0.90	1.07	0.95	0.95	0.96
Elazığ	0.98	1.01	1.02	0.97	1.11	Ardahan	0.94	1.02	1.00	0.94	0.96
Kars	0.99	1.12	1.00	0.99	1.11	Rize	1.00	0.95	1.00	1.00	0.95
Sinop	1.00	1.11	0.99	1.01	1.11						

be given examples. Coelli and Rao (2005) have found the technical/technological change value in the ranges of 0.947-1.033 (93 developed and developing countries), the same values have been determined by Lissitsa and Odening (2005) as 0.916-1.080 for Ukraine, by Avcı and Kaya (2008) as 0.958-1.039 for transition economies and Turkey, by Tipi and Rehber (2006) as 0.992-1.045 for Turkey's Southern Marmara region. Karaman and Özalp (2017) have calculated this value between 0.946 and 1.107 for 12 NUTS Level-I regions of Turkey, Kaya and Aktan (2011) have calculated between 0.712 and 2.660 for 81 provinces and last, Özok (2006) has calculated between 0.945 and 1.089 for 80 provinces of Turkey.

It is necessary to question the reasons provinces are ahead or behind in productivity change. In this process, it is useful to first consider the situation of the provinces in terms of the variables discussed in this study. To summarize the 2009-2019 average values of the parameters used in the index according to the provinces, Muğla is in the first place with an average agricultural GDP (1000 ₺) value of 8.473.921, and Zonguldak is in the last place with 217.049. In addition, Hatay, Izmir, Nevşehir, Sakarya, Çorum, Rize, Gümüşhane, Kırklareli and Istanbul provinces are in the top ten in this value, while Bilecik, Kahramanmaraş, Aksaray, Düzce, Afyonkarahisar, Burdur, Çankırı, Elazığ and Balıkesir provinces are in the last ranks. When the number of enterprises include agriculture, forestry and fisheries is examined, according to the average data, Konya (1.774), Istanbul (1.431), Adana (1.365), Ankara (1.221) and Antalya (1.179) are in the top five. After these provinces, Izmir, Balıkesir, Tekirdağ, Mersin and Edirne come in the ranking. Şırnak, Bayburt, Ardahan, Bingöl and Tunceli are the provinces where this value is the lowest. In terms of the total number of agricultural equipment and machines, Konya ranks first with 280.390 units, followed by Manisa, Izmir, Bursa and Balıkesir provinces. Antalya, Ankara, Aydın, Samsun and Edirne provinces are also in the top ten. Starting from the end, the provinces where this value is the least are Rize, Trabzon, Hakkari, Artvin and Bingöl, respectively. In addition, the value of the provinces of Tunceli, Giresun, Siirt, Şırnak and Yalova is also quite low. On the other hand, Konya (19.400.000), Ankara (11.900.000), Şanlıurfa (11.500.000), Sivas (8.286.120) and Yozgat (6.471.338) are in the top five in total agricultural area input, followed by Kayseri, Diyarbakır, Çorum, Eskişehir and Adana provinces. The provinces that are in the last place in terms of this value are Yalova, Artvin, Bingöl, Hakkari, Bartın, Ardahan, Karabük, Rize, Tunceli and Zonguldak starting from the last. Manisa, Balıkesir, Bolu, Sakarya, Izmir Afyonkarahisar, Mersin, Konya, Ankara and Bursa provinces stand out in the total number of animals. Rize has the lowest data, with an average value of 63.389. The provinces of Yalova, Artvin, Bayburt and Gümüşhane follow this province. The said value is also quite low in the provinces of Giresun, Trabzon, Sinop, Tunceli and Kilis. Finally, when we look at the electricity consumption of the provinces according to the places of use, Şanlıurfa (726.294), Konya (711.124), Izmir (337.298), Manisa (249.731) and Mardin (241.782) ranks first in electricity consumption for agricultural irrigation, according to the averages of 2009-2019. The provinces ranked last in this value are Rize, Ardahan, Hakkari, Artvin and Bayburt provinces starting from the end.

III. DISCUSSION

The results got from this study are consistent with other studies that rank the provinces or regions in Turkey (see Özok, 2006; Tipi and Rehber, 2006; Kaya and Aktan, 2011; Karaman and Özalp, 2017). In addition, the findings of this study are also consistent with SEGE (2017), one of the socio-economic development ranking studies in Turkey. However, to reveal the reasons for provinces to be ahead or behind in productivity change and to evaluate the results more accurately, it is necessary to consider the prominent characteristics of the provinces. When geography, transportation, infrastructure, trade, industrial and economic structure, product and production factors are evaluated as a whole, of course, each province has its own structure and several prominent features. For example, when the provinces in the last place in productivity change are examined, these provinces' natural resources, flora, etc. appear to have rich potential (see Eastern Anatolia Development Agency, 2019). However, Tunceli, Şırnak, Aksaray and Ardahan, which are in the last place in productivity change, have a continental / harsh continental climate and Rize is the rainiest province of Turkey. When these situations are considered, it is noticeable that these provinces, which are in the last place in productivity change, are more disadvantaged in terms of climatic characteristics, especially in terms of production diversity, compared to the provinces that are in the first place in productivity change. In addition, that Rize, which is in the last place in the index, is a province that receives precipitation and is rich in river resources, also affects agricultural irrigation in this province. This province is the province with the lowest electricity consumption input values in agricultural irrigation. Based on these results, we can state that natural conditions are an effective and determining factor in agricultural productivity change in Turkey. In addition, when we look at the provinces that come in the top five in productivity, there are research institutes within General Directorate of Agricultural Research and Policies in Ankara, Edirne and Balıkesir, and there are private sector agricultural research organizations in Afyonkarahisar, Ankara, Edirne and Balıkesir. There are also state universities with veterinary programs in Afyonkarahisar, Ankara and Balıkesir. In the provinces in the last five, there are no research institutes under the General Directorate of Agricultural Research and Policies and only Aksaray has a state university with a veterinary program. These issues also reveal why these provinces are in the front / back.

CONCLUSIONS

In this study, we have investigated the level of agricultural productivity in Turkey over the period 2009-2019 with the Malmquist TFP index. Our findings show that technological change in the agricultural sector in Turkey is an effective factor in the change of productivity levels of provinces. According to the provincial averages for the period of 2009-2019, in the Malmquist index findings, we have determined that the TFP index value changed between 1.186 and 0.952, productivity increased in 75 provinces and decreased in 6 provinces. Our results show that Afyonkarahisar, Ankara, Edirne, Balıkesir, Karabük, Yalova, Hakkari, Bolu, Adana and Muğla provinces come first in productivity increase, and Niğde, Iğdır, Çankırı, Adıyaman and Siirt are the provinces with the lowest productivity increase. In addition, according to the results, the provinces of Rize, Ardahan, Aksaray, Şırnak, Tunceli and Kilis are in the last place in the index and there is a decrease in productivity in these provinces. The reason for the change in the TFP index ranking of the provinces is quite different. Here various factors such as geography, transportation, infrastructure, trade, investment, products and production have an impact.

According to the index values containing the provincial averages in the relevant period, we have found that there is an increase in technological change in all provinces except Rize, and a decrease in technological change in Rize. In terms of the increase in technological change, the provinces of Bingöl, Yalova, Ağrı, Uşak, Hakkari, Elazığ, Bitlis, Manisa, Izmir and Antalya are in the first place. Based on these results, we can say that technological change affects the change in productivity levels in all provinces in Turkey, and that technology is a determining factor in productivity in all provinces.

We can derive several policy implications and recommendations from our results. As it is known, the importance and impact of technology and applications used by countries to increase productivity in the agricultural sector vary according to countries. In Turkey, it is important to develop and implement technologies that will make the sector productive, to follow up new products, production and developments, to develop policies considering the problems of the sector, to encourage and support infrastructure, research and publication studies on technology. On the other hand, we can state that Turkey has not fully reached the targeted levels to eliminate regional development differences (Şahin and Kaplan, 2021). As emphasised by Takım and Ersungur (2018), the incentives implemented in Turkey do not sufficiently reduce regional imbalance. Institutions' lack of coordination prevents accurate measurement of monitoring, evaluation, and performance results, and also hampers the complete demonstration of the effectiveness of incentives. Therefore, steps need to be taken to increase the effectiveness of the regional incentive system. In this process, the regional incentive system can be revised and, based on the findings of this research, it can build an incentive system based on performance and efficiency in which provinces or businesses operating in this field are classified according to their productivity. Initiatives in this direction can be made not only for Turkey but also for other developing economies. The implementation of these policies will improve the agricultural sector and make it more efficient.

Finally, we can offer some suggestions for variables and researchers. There is no comprehensive data set at the regional level in the agricultural sector. It can take new steps under the leadership of the competent authority to develop this field. In addition, this study covers 81 provinces of Turkey and the factors affecting productivity were not analysed in the research. In new studies to be done, analysis can be made with different data sets and the factors affecting productivity can be investigated.

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