Technical Efficiency in Nuts-2 Regions in the Agricultural Sector in Turkey: A Data Envelopment Analysis Application

Alamettin BAYAV

Fruit Research Institute, Eğirdir/Isparta, Turkey

ABSTRACT

Article Info:

Author(s)

Alamettin BAYAV

Received: *25/09/2021*

Accepted in revised form: *21/10/2021*

Published: *31/10/2021*

Corresponding author:

alamettinbayav@hotmail.com

Keywords:

Agriculture, Efficiency, Constant Returns to Scale, Variable Returns to Scale, Turkey

Technical Efficiency in Nuts-2 Regions in the Agricultural Sector in Turkey:

A Data Envelopment Analysis Application

Increasing agricultural efficiency and productivity is a crucial policy goal in most developing countries, as it is one of the main sources of overall growth. Technical efficiency is widely used to determine the performance of production units. For this reason, many studies have been carried out on efficiency, especially in health, education, and agriculture. In this study, the technical efficiencies of the regions were calculated using a non-parametric method, Data Envelopment Analysis. In the analysis, the total plant and animal production values were taken as output, an agricultural area, agricultural employment, amount of fertilizer used, number of tractors, and livestock unit corresponding to the number of animals were taken as inputs. In the study, data from 2015 to 2019 across five years were used. 26 level-2 regions were classified as decision making units, and their technical efficiency values were determined. The data for this study were obtained from the Turkish Statistical Institute and the Ministry of Agriculture and Forestry database. In the input-oriented analysis, according to the years' average, the mean of technical efficiency was 77.5% and 87.7%, respectively, under the assumption of constant returns to scale (CRS) and variable returns to scale (VRS). Both under the assumption of CRS and VRS, TR61, TR62, TR90 and TRC3 regions were determined to be fully effective. The regions with the lowest technical efficiency were TR33, TR82, TR72, TR10, and TR83 under the CRS assumption, while TR33, TR72, TR83, TR32, and TR42 under the VRS assumption. In the five years, there was a 6.10% decrease in the CRS assumption and 2.24% in the VRS assumption in technical efficiency ratios of the regions.

1. Introduction

Studies to determine efficiency and productivity are carried out in all sectors, especially in health, education, and agriculture. The increase in efficiency and productivity studies has accelerated, especially after developing data envelopment analysis (DEA) by Charnes et al. (1978). Recently, changes and regulations in agriculture have made efficiency studies attractive. Efficiency studies in agriculture in Turkey started in 1994, and there has been an increase in the number of studies carried out over time (Bayav and Karlı, 2020).

Agricultural production, especially plant production, is more vulnerable to natural conditions than other production branches. Since it is impossible to control the natural and climatic conditions, it is necessary to increase plant production efficiency. Ensuring productivity and sustainability in agricultural farms will be possible with the effective use of production inputs. There is excessive use of resources to increase agricultural production in Turkey. This situation harms the environment and destroys natural resources. Minimizing these losses is possible with the effective use of resources (Gündüz et al., 2011). Effective use of scarce resources is important for all national economies. Parametric stochastic frontier analysis (SFA) and non-parametric data envelopment analysis (DEA) are widely used as performance measurement methods in determining the efficiency of decision-making units (DMU).

Agriculture is the primary source of economic growth in many developing countries. Therefore, especially since increasing agricultural productivity and efficiency will lead to economic growth, productivity and efficiency are important in policy targets. For this reason, the number of studies on efficiency and productivity has increased recently.

Many branches use the concept of region. In recent years, regional and planning concepts have been evaluated as in a body around the world. Regional development is the basis for national development. Before any planning, it is necessary to determine the potential of the region to be planned. The easiest way to determine the region's potential is to collect accurate statistics and evaluate this information within a certain systematic (Taş, 2006).

One of the socio-economic problems encountered in developed or developing countries is the interregional development differences. Although this problem exists in every country, these differences are larger in underdeveloped and developing countries than in developed countries (Aktaş and Kabak, 2020). Although substantial resources are allocated to various strategies and policies to reduce interregional development differences, interregional development difference remains a significant problem in most countries in the world. This problem continues in developing countries and especially in Turkey (Köse et al., 2012).

In addition to some other reasons, it is thought that using resources at different efficiency levels between regions is effective in the emergence of these differences. From this point of view, it is seen that it is insufficient to provide the resources needed, especially in the underdeveloped regions, to eliminate the interregional development differences. For this reason, the importance of the effective use of existing resources is better understood (Ercan, 2006).

With the signing of Turkey's Accession Partnership Document to the European Union, a National Program has been prepared to implement the necessary conditions for candidacy. In 2001, as a requirement of the National Program and upon the request of the European Union, the first step was taken for the formation of statistical regions. According to the Council of Ministers' decision in the Official Gazette dated 22 September 2002 and numbered 24884, the Nomenclature of Territorial Units for Statistics (NUTS) was established in Turkey. According to this decision, Turkey created a regional system consisting of 3 levels similar to the European Union countries and divided into 12 regions at NUTS1, 26 regions at NUTS2, and 81 regions at NUTS3 under Nomenclature of Territorial Units for Statistics (NUTS). The regions in NUTS2 used in this study are: TR10 (İstanbul), TR21 (Tekirdağ, Edirne, Kırklareli), TR22 (Balıkesir, Çanakkale), TR31 (İzmir), TR32 (Aydın, Denizli, Muğla), TR33 (Manisa, Afyon, Kütahya, Uşak), TR41 (Bursa, Eskişehir, Bilecik), TR42 (Kocaeli, Sakarya, Düzce, Bolu, Yalova), TR51 (Ankara), TR52 (Konya, Karaman), TR61 (Antalya, Isparta, Burdur), TR62 (Adana, Mersin), TR63 (Hatay, Kahramanmaraş, Osmaniye), TR71 (Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir), TR72 (Kayseri, Sivas, Yozgat), TR81 (Zonguldak, Karabük, Bartın), TR82 (Kastamonu, Çankırı, Sinop), TR83 (Samsun, Tokat, Çorum, Amasya), TR90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane), TRA1 (Erzurum, Erzincan, Bayburt), TRA2 (Ağrı, Kars, Iğdır, Ardahan), TRB1 (Malatya, Elazığ, Bingöl, Tunceli), TRB2 (Van, Muş, Bitlis, Hakkari), TRC1 (Gaziantep, Adıyaman, Kilis), TRC2 (Şanlıurfa, Diyarbakır) ve TRC3 (Mardin, Batman, Şırnak, Siirt).

A few efficiency studies have been carried out in Turkey, taking into account the NUTS regions in the agricultural. Armağan et al. (2010) used ten-year data from 1994-2003 of 12 regions at NUTS1. The efficiency and productivity of the regions were calculated by calculating the DEA and the total factor productivity index. It was reported that there was a decrease in technical efficiency and total factor productivity in the regions except the West Marmara, Aegean, Mediterranean, and Eastern Black Sea Regions in the ten years examined. It was also emphasized that this decrease was reflected in Turkey in general. In the study carried out by Özden and Armağan (2012), agricultural efficiencies were calculated using 11-year data covering 2000-2010 at NUTS1.

Cobb Douglas production function was used in the SFA. It was determined that technical efficiency decreased by 4% on average. It was reported that the technical efficiency was the highest in the Aegean and Mediterranean Regions and the average technical efficiency was 50.7%. Aktan and Samut (2013) used the DEA method in their study, where they found the average technical efficiency as 75% at the level of 81 provinces (NUTS3). In the second stage, geographical regions were compared according to their technical efficiency with variance analysis. It was determined that the Eastern Anatolia Region has higher technical efficiency than other regions. Dudu et al. (2015) calculated technical efficiency with SFA at NUTS1 level with the data obtained through questionnaires in 2002-2004. It was reported that the Western regions were more efficient in agricultural productivity, and the order of efficiency changed in 2002 and 2004. It was determined that West Marmara, Aegean, and East Marmara Regions shared the first three ranks in 2002 and 2004. The authors emphasized that the most striking result in the ranking was experienced in the South East Anatolia Region, which fell from the sixth rank in 2002 to 11th in 2004.

In this study, the agricultural technical efficiency of Turkey's NUTS2 was determined by DEA and the regions were compared. It is thought that the results obtained will contribute to the literature and will guide agricultural policies.

2. Material and Methods

Five-year data covering the years 2015-2019 were used in the study. According to NUTS, 26 regions at level-2 were evaluated as DMUs, and their technical efficiency was calculated. The data used were obtained from the Turkish Statistical Institute and the Ministry of Agriculture and Forestry database.

The idea of measuring efficiency was first proposed by Farrell (1957) and later developed by Charnes et al. (1978), and this model is called the CCR model. Another DEA model is BCC, developed by Banker et al. (1984). With DEA, the relative efficiency of DMU with multiple inputs and outputs can be measured. By means of the efficiency score obtained as a result of the analysis, DMU can obtain information about its production structure, while at the same time, it can be compared with other DMUs in the sector. The main efficiency criterion in DEA is the weighted totals of the outputs dividing by the inputs' weighted totals (Çağlar, 2003).

Efficiency can be calculated for input and output-oriented. In input-oriented efficiency, it is determined how much the amount of input can be reduced without any change in output, while in output-oriented efficiency, it is determined how much the amount of output can be increased without any change in input (Coelli et al., 2005). In this study, an input-oriented approach was used. Under the assumption of VRS, the input-oriented approach can be as follows:

$$\begin{aligned} &Min_{ql} \quad q, \\ &St \quad -y_i + Yl \geq 0, \\ &\quad\quad qx_i - Xl \geq 0, \quad\quad (1) \\ &\quad\quad N1'l = 1, \\ &\quad\quad l \geq 0 \end{aligned}$$

Under the assumption of CRS, the input-oriented approach can be as follows:

$$\begin{aligned} &Min_{ql} \quad q, \\ &St \quad -y_i + Yl \geq 0, \\ &\quad\quad qx_i - Xl \geq 0, \quad\quad (2) \\ &\quad\quad l \geq 0 \end{aligned}$$

In equation 1 and 2, Y refers to the output matrix for the N number of DMUs; X refers to the input-oriented technical efficiency score valued from 0 to 1; q refers to the input matrix for N number of DMUs; λ refers to the Nx1 vector of the weights defining the linear combination of the peers of i. DMU; y_i refers to the output of the i. DMU and x_i refer to the input of the i. DMU. According to Farrell (1957), the value of q is less than or equal to 1 ($q \leq 1$). The analysis has been carried out in this study using both CRS and VRS assumptions with input orientation.

DEA is an effective method when used correctly. The ability to analyze multiple inputs and outputs and not requiring a functional form can be counted as its main advantage. However, its disadvantages are that it is sensitive to measurement errors and variable selection and is difficult to evaluate with hypothesis tests (Özden, 2010).

In the study, the agricultural efficiency of the regions was estimated at the NUTS2 level. One output and five inputs were used in the model. Agricultural production value (TL), consisting of the sum of plant and animal production value, was used as output. In addition, agricultural area (ha), agricultural employment (person), the amount of fertilizer used (tonnes) consisting of the sum of nitrogen, phosphorus, and potassium fertilizers, the number of tractors (units), and the livestock unit (LU) corresponding to the number of animals were used as inputs. The agricultural production value was deflated according to the producer price index of agricultural products based on 2015. The coefficient values specified in the 4342 numbered Pasture Law were taken as the basis for calculating LU values. DEAP 2.1 computer program developed by Coelli (1996) was used to calculate the technical efficiency values of the regions. Descriptive statistics of the variables are given in Table 1.

Table 1: Descriptive statistics of variables*

NUTS2 Code	Agricultural Production Value (Million TL)	Agricultural Area (1.000 ha)	Agricultural Employment (1.000 people)	Amount of Fertilizer Used (1.000 tonnes)	Number of Tractors (1.000 units)	LU (1.000 units)
TR10	596.34 (23.68)	72.16 (0.54)	58.60 (14.29)	37.20 (11.45)	4.80 (0.45)	64.00 (7.52)
TR21	4764.82 (245.15)	941.43 (13.82)	125.80 (4.60)	174.00 (30.35)	59.60 (0.55)	337.00 (9.03)
TR22	5712.57 (167.77)	692.94 (9.75)	181.00 (8.75)	75.80 (8.90)	66.00 (0.71)	552.00 (16.51)
TR31	5200.08 (367.14)	326.16 (2.48)	153.00 (9.90)	59.80 (4.76)	34.60 (0.55)	474.60 (64.66)
TR32	8952.06 (507.75)	951.02 (9.46)	325.80 (3.56)	94.40 (8.68)	92.80 (5.07)	594.00 (64.60)
TR33	8084.36 (205.99)	1492.80 (11.50)	389.00 (38.65)	134.20 (11.19)	145.20 (6.42)	715.20 (45.34)
TR41	6120.22 (393.68)	951.50 (17.71)	157.00 (13.10)	93.20 (11.01)	74.80 (1.30)	335.40 (39.22)
TR42	3997.62 (630.59)	456.06 (10.39)	206.80 (24.05)	63.80 (5.81)	59.40 (0.55)	248.80 (9.20)
TR51	3598.14 (175.88)	1191.68 (26.01)	67.80 (4.44)	84.20 (14.34)	32.40 (0.55)	271.00 (47.99)
TR52	10487.95 (883.12)	2239.72 (39.13)	214.20 (6.76)	249.40 (27.28)	83.60 (1.52)	734.20 (75.63)
TR61	11326.10 (403.80)	713.77 (14.09)	250.20 (27.59)	69.40 (6.54)	68.60 (2.07)	451.20 (22.96)
TR62	11385.86 (765.26)	848.98 (29.24)	276.60 (20.74)	183.20 (25.98)	54.60 (1.14)	350.80 (31.90)
TR63	5800.35 (375.17)	707.94 (9.41)	200.60 (31.59)	132.20 (26.38)	42.40 (1.67)	314.40 (34.60)
TR71	6478.86 (675.48)	1672.28 (51.39)	154.00 (13.93)	132.80 (19.70)	67.80 (1.92)	525.20 (78.25)
TR72	5232.63 (312.83)	1996.05 (30.55)	199.20 (36.10)	120.00 (18.14)	66.40 (2.07)	572.20 (40.64)
TR81	899.60 (108.31)	135.02 (9.70)	123.00 (8.00)	7.20 (1.79)	22.80 (0.84)	87.00 (11.40)
TR82	1987.37 (217.26)	434.43 (13.64)	143.20 (15.11)	24.60 (2.30)	36.40 (0.55)	276.40 (29.45)
TR83	8201.62 (638.02)	1445.41 (15.20)	408.80 (27.37)	115.60 (14.89)	125.20 (2.39)	542.20 (47.40)
TR90	7768.59 (1308.61)	666.61 (5.06)	451.20 (23.08)	72.20 (4.02)	14.60 (0.55)	295.20 (21.44)
TRA1	2247.06 (105.97)	571.90 (13.54)	143.40 (32.75)	20.40 (3.05)	20.80 (0.84)	515.60 (47.22)
TRA2	2218.64 (206.09)	691.03 (20.33)	198.80 (23.75)	18.20 (2.49)	25.80 (2.77)	817.40 (56.28)
TRB1	2985.33 (130.79)	546.30 (8.14)	190.40 (24.25)	27.20 (4.55)	20.60 (1.14)	393.00 (38.21)
TRB2	2473.75 (91.82)	725.43 (25.25)	223.40 (30.26)	21.40 (2.79)	19.00 (2.74)	741.40 (20.95)
TRC1	4157.30 (931.15)	690.41 (11.09)	112.40 (18.11)	58.00 (10.00)	30.00 (1.22)	253.20 (25.07)
TRC2	8267.03 (563.57)	1693.30 (72.28)	316.00 (28.31)	268.20 (45.64)	26.80 (0.84)	655.00 (122.32)
TRC3	3424.75 (118.50)	599.83 (13.80)	59.40 (8.14)	120.20 (22.95)	11.60 (0.55)	463.20 (63.70)

*Values in parenthesis are the standard deviation.
Source: TURKSTAT, 2021; Anonymous, 2021.

3. Results and Discussion

DEA results of NUTS2 regions are given in Table 2. According to the regions, the variation of technical efficiency values 2015-2019 years was examined under the assumption of CRS and VRS. Five-year efficiency score results showed that TR61, TR62, TR90, and TRC3 regions out of 26 NUTS2 regions were fully efficient under the assumption of both CRS and VRS. Four regions were fully effective in the CRS assumption and seven regions in the VRS assumption. Regions with technical efficiency lower than one are interpreted as less technically efficient. The most striking result was obtained from the TR10 region. Because while it was 57.3% technical efficiency under the assumption of CRS, it was determined that it has 100% technical efficiency under the assumption of VRS.

According to the regions' average, technical efficiency was 77.5% under the CRS assumption and 87.7% under the VRS assumption. The regions with the lowest technical efficiency were TR33, TR82, TR72, TR10, and TR83 under the CRS assumption, while TR33, TR72, TR83, TR32, and TR42 under the VRS assumption. When evaluated by years, the highest technical efficiency was calculated in 2015, and the lowest technical efficiency was calculated in 2018 in both assumptions. In 2019, technical efficiency decreased by 6.10% under the CRS assumption and 2.24% under the VRS assumption compared to 2015.

According to the CRS assumption, the regions with the highest decrease in technical efficiency over the years were TRC1, TR63, and TR42 regions with 42.29%, 36.40%, and 20.81%, respectively. On the other hand, the regions that increased their technical efficiency most were TRA1 (17.60%), TRB2 (13.34%), and TR71 (11.31%). Under the assumption of VRS, TR63, TRC1and TR83 were the regions with the highest decrease in technical efficiency with 26.98%, 23.13%, and 12.68% rates, respectively. Conversely, TR72 (19.16%), TR71 (11.68%), and TR21 (8.57%) were the regions with the highest increase in technical efficiency.

According to average technical efficiency, it could be seen that there were differences between regions and between CRS and VRS assumptions (Figure 1). 13 regions (50%) under the CRS assumption and 11 regions (42.31%) under the VRS assumption had efficiency below the regional average.

Table 2: Technical efficiency of regions

Region / Year	CRS							VRS						
	2015	2016	2017	2018	2019	Mean	Change (%)*	2015	2016	2017	2018	2019	Mean	Change (%)*
TR10	0.532	0.655	0.559	0.561	0.559	0.573	5.08	1.000	1.000	1.000	1.000	1.000	1.000	0.00
TR21	0.805	0.813	0.765	0.722	0.774	0.776	-3.85	0.831	0.834	0.846	0.783	0.902	0.839	8.54
TR22	0.756	0.753	0.627	0.626	0.627	0.678	-17.06	0.804	0.820	0.749	0.731	0.765	0.774	-4.85
TR31	1.000	1.000	0.918	0.971	0.940	0.966	-6.00	1.000	1.000	0.985	1.000	1.000	0.997	0.00
TR32	0.644	0.664	0.613	0.611	0.648	0.636	0.62	0.662	0.677	0.656	0.621	0.649	0.653	-1.96
TR33	0.446	0.485	0.458	0.450	0.451	0.458	1.12	0.461	0.501	0.492	0.478	0.487	0.484	5.64
TR41	0.864	0.976	0.781	0.778	0.730	0.826	-15.51	0.883	0.982	0.876	0.813	0.830	0.877	-6.00
TR42	0.716	0.605	0.547	0.505	0.567	0.588	-20.81	0.766	0.736	0.698	0.680	0.714	0.719	-6.79
TR51	1.000	1.000	1.000	0.941	0.939	0.976	-6.10	1.000	1.000	1.000	1.000	1.000	1.000	0.00
TR52	1.000	0.915	0.926	0.970	0.965	0.955	-3.50	1.000	1.000	1.000	0.986	1.000	0.997	0.00
TR61	1.000	1.000	1.000	1.000	1.000	1.000	0.00	1.000	1.000	1.000	1.000	1.000	1.000	0.00
TR62	1.000	1.000	1.000	1.000	1.000	1.000	0.00	1.000	1.000	1.000	1.000	1.000	1.000	0.00
TR63	0.967	0.774	0.651	0.623	0.615	0.726	-36.40	0.997	0.827	0.717	0.696	0.728	0.793	-26.98
TR71	0.858	0.704	0.789	0.857	0.955	0.833	11.31	0.873	0.721	0.812	0.862	0.975	0.849	11.68
TR72	0.553	0.493	0.538	0.591	0.588	0.553	6.33	0.569	0.519	0.569	0.606	0.678	0.588	19.16
TR81	1.000	0.886	0.831	0.402	0.900	0.804	-10.00	1.000	1.000	1.000	1.000	1.000	1.000	0.00
TR82	0.539	0.528	0.503	0.403	0.501	0.495	-7.05	0.880	0.810	0.818	0.788	0.853	0.830	-3.07
TR83	0.663	0.616	0.506	0.521	0.566	0.574	-14.63	0.678	0.635	0.533	0.558	0.592	0.599	-12.68
TR90	1.000	1.000	1.000	1.000	1.000	1.000	0.00	1.000	1.000	1.000	1.000	1.000	1.000	0.00
TRA1	0.733	0.643	0.590	0.672	0.862	0.700	17.60	0.941	0.988	1.000	1.000	1.000	0.986	6.27
TRA2	0.894	0.659	0.744	0.589	0.897	0.757	0.34	0.971	0.904	0.905	0.890	0.956	0.925	-1.54
TRB1	0.807	0.725	0.750	0.796	0.697	0.755	-13.63	1.000	1.000	1.000	1.000	0.901	0.980	-9.90
TRB2	0.772	0.745	0.784	0.657	0.875	0.767	13.34	1.000	1.000	1.000	0.914	1.000	0.983	0.00
TRC1	0.889	0.951	0.750	1.000	0.513	0.821	-42.29	0.964	1.000	1.000	1.000	0.741	0.941	-23.13
TRC2	0.882	0.987	0.922	1.000	0.861	0.930	-2.38	0.939	1.000	1.000	1.000	0.934	0.975	-0.53
TRC3	1.000	1.000	1.000	1.000	1.000	1.000	0.00	1.000	1.000	1.000	1.000	1.000	1.000	0.00

*It refers to the change in 2019 compared to 2015.

EURASIAN JOURNAL OF AGRICULTURAL ECONOMICS
Academic Journal

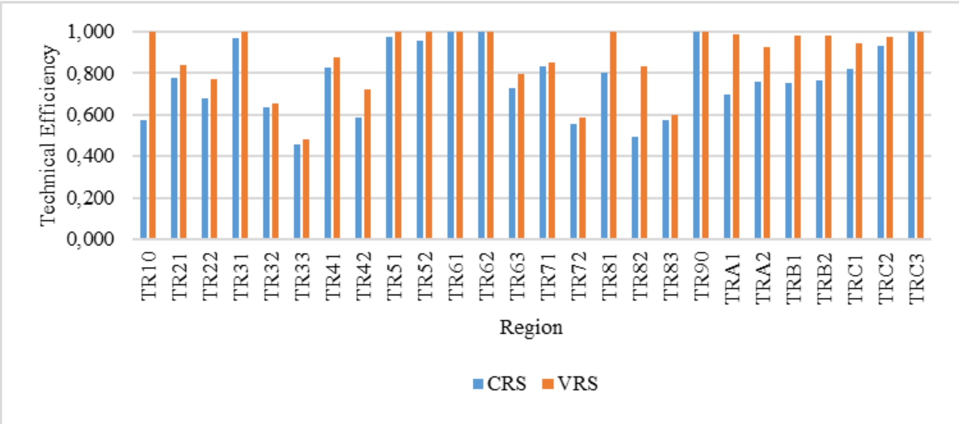

Figure 1. Technical efficiency by regions

4. Conclusion

Especially in developing countries, agricultural efficiency analysis is important in contributing to the growth of countries. Two main methodologies were developed to measure efficiency, namely the parametric and non-parametric approach. In this study, non-parametric DEA with input-oriented CRS and VRS approaches were used. When evaluated in general, regions were more efficient in the VRS model than in the CRS model. Among the 26 regions, TR61 (Antalya, Isparta, Burdur), TR62 (Adana, Mersin), TR90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane) and TRC3 (Mardin, Batman, Şırnak, Siirt) were the regions with the highest efficiency. The regions with the lowest technical efficiency were TR33 (Manisa, Afyon, Kütahya, Uşak), TR82 (Kastamonu, Çankırı, Sinop), TR72 (Kayseri, Sivas, Yozgat), TR10 (İstanbul), and TR83 (Samsun, Tokat, Çorum, Amasya) under the CRS assumption, while TR33 (Manisa, Afyon, Kütahya, Uşak), TR72 (Kayseri, Sivas, Yozgat), TR83 (Samsun, Tokat, Çorum, Amasya), TR32 (Aydın, Denizli, Muğla), and TR42 (Kocaeli, Sakarya, Düzce, Bolu, Yalova) under the VRS assumption. However, in the CRS and VRS models, there was a decrease in the average efficiency over the years. The main reason for this is that the rate of technology transfer to agriculture is slow, and farmers do not afford to invest in technology.

The importance of resource use comes to the fore in the concept of efficiency. From this point of view, it is essential to increase the efficiency of the regions. In particular, the results of regional studies should be taken into account in national policies. In addition, it is thought that regional studies should be repeated from time to time to guide agricultural policies.

References

Aktan, H. E. & Samut, P. K. (2013). Analysis of the efficiency determinants of Turkey's agriculture sector by two-stage data envelopment analysis (DEA). Ege Academic Review, 13(1), 21-28.

Aktaş, A.& Kabak, M. (2020). Veri Zarflama Analizi ile Düzey-2 Bölgelerinin GSYİH Katkısının Analizi. Ankara Hacı Bayram Veli Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 20. Uluslararası Ekonometri, Yöneylem Araştırması ve İstatistik Sempozyumu EYİ 2020 Özel Sayısı, 191-206.

Anonymous (2021). The Ministry of Agriculture and Forestry database.

Armağan, G., Özden, A. & Bekçioğlu, S. (2010). Efficiency and total factor productivity of crop production at NUTS1 level in Turkey: Malmquist index approach. Quality & Quantity, 44, 573-581. https://doi.org/10.1007/s11135-008-9216-5

Banker, R. D., Charnes, A. & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9), 1078-1092. https://doi.org/10.1287/mnsc.30.9.1078

Bayav, A. & Karlı, B. (2020). A survey of efficiency studies in the agricultural sector in Turkey (1994-2016). Fruit Science, 7(2), 32-41.

Charnes, A., Cooper, W.W. & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2, 429-444.

Coelli, T. J. (1996). A guide to DEAP version 2.1: A data envelopment analysis (computer) program, Center for Efficiency and Productivity Analysis, The University of New England, Armidale / Australia.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J. & Battese, G. E. (2005). An Introduction to Efficiency and Productivity Analysis (2nd ed.), Newyork: Springer.

Çağlar, A. (2003). Efficiency measurement of municipalities with data envelopment analysis (Unpublished Ph.D. thesis). Hacettepe University Graduate School of Science and Engineering, Ankara.

Dudu, H., Çakmak, E. H. & Öcal, N. (2015). Drivers of farm efficiency in Turkey: A stochastic frontier analysis. World Journal of Applied Economics, 1(1), 45-63. https://doi.org/10.22440/EconWorld.J.2015.1.1.HD.0005

Ercan, F. (2006). Bölgesel kalkınmada değişim: Devlet merkezli bölgesel kalkınmadan piyasa merkezli bölgesel birikime. In A. Arı (Ed.), Bölgesel kalkınma, politikalar ve yeni dinamikler (pp. 45-116). İstanbul: Derin Yayınları.

Farrell, M. J. (1957). The measurement of productive efficiency. Royal Statistical Society, 120(3), 253-290.

Gündüz, O., Ceyhan, V. & Esengün, K. (2011). Measuring the technical and economic efficiencies of the dry apricot farms in Turkey. Journal of Food, Agriculture & Environment, 9(1), 319-324.

EURASIAN JOURNAL OF AGRICULTURAL ECONOMICS
Academic Journal

Köse, S., Eser, U. & Konur, F. (2012). Regional development disparities in Turkey: A data envelopment analysis (level-2 regions). Manisa Celal Bayar Üniversitesi Sosyal Bilimler Dergisi, 10(2), 77-97.

Özden, A. (2010). Günümüzde etkinlik kavramı ve ölçüm metotları. Türkiye IX. Tarım Ekonomisi Kongresi, 22-24 Eylül, Şanlıurfa, 740-747.

Özden, A. & Armağan, G. (2012). The efficiency comparison in Turkish agriculture in terms of NUTS1 regions. 10. Ulusal Tarım Ekonomisi Kongresi, 5-7 Eylül, Konya, 764-771.

Taş, B. (2006). Adaptation process to the European Union (EU) for Turkey's new region concept: The nomenclature of territorial units for statistics (NUTS). Afyon Kocatepe University Journal of Social Sciences, 8 (2), 185-197.

TURKSTAT (2021). Turkish Statistical Institute, https://www.tuik.gov.tr/