Efficiency analysis of beekeeping activities in Turkey and comparison by regions

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Abstract

In this study, the efficiency analysis was performed in beekeeping activities in the 26 sub-regions of Turkey within the scope of Level 2 of the Statistical Regional Units Classification and alternative policy suggestions were presented for more effective resource use. In the study, the data obtained from the Turkish Statistical Institute consisted of honey and beeswax production, the number of enterprises engaged in beekeeping activities, the number of old hives and new hives in 26 regions for the year 2023. In the study, data envelopment analysis was used to determine the technical efficiency of the regions in beekeeping activities. In the model, honey production and beeswax production were taken as outputs, and the number of enterprises engaged in beekeeping activities, the number of old hives and new hives were taken as inputs, and a model with 3 inputs and 2 outputs was created. According to the CCR model, TR62, TRA2, TR72 and TR42 regions, and according to the BCC model, TR62, TR51, TR32, TRA2, TR72, TR42, TR71, TR90, TRB2, TR10 and TRC2 regions were determined to be fully efficient. According to the CCR model, the average efficiency value of 26 regions was found as 0.63, and according to the BCC model, the average efficiency value of 26 regions was found as 0.85. According to the scale efficiency results, it was determined that TR62, TRA2, TR72 and TR42 regions operated at optimal scale, and the average scale efficiency value of the regions was found as 0.74. It was observed that 15.38% of the regions had constant returns to scale, 11.54% had decreasing returns to scale, and 73.08% had increasing returns to scale. When an evaluation was made in terms of inputs, it was seen that the number of enterprises should be reduced by 33.21%, the number of old hives by 55.20% and the number of new hives by 26.31%, and that honey production can be increased by 19.27% and beeswax production can be increased by 8.02% with the current inputs. It is recommended that producers in inefficient regions should be trained by extension staff in terms input use, and optimum use of existing resources should be ensured in order to reveal the current potential.

Keywords: Honey. Input use. Technical efficiency. Data envelopment analysis.

1. Introduction

Beekeeping, which is one of the agricultural activities that have been carried out all over the world since ancient times and which has now become an agricultural occupation and production branch in itself, can be briefly defined as "the art of using and managing honey bees" for specific purposes (Anonymous, 2023).

Today, balanced nutrition is one of the biggest problems in undeveloped and developing countries. The rapid increase in the world population expands the dimensions of the problem. Beekeeping is an agricultural activity that is given importance for various purposes in both developed and developing countries. The fact that it is not dependent on land, can be done with little capital and uses less labor compared to other agricultural branches are important features that bring beekeeping to the forefront (Erkan and Aşkın, 2001).

In addition to producing and collecting products that are extremely valuable for human health and nutrition, such as honey, beeswax, royal jelly, bee venom, pollen and propolis, honeybees also have great benefits in terms of natural balance and agricultural production with the pollination services they provide in natural and cultivated plants. For this reason, honeybees are used all over the world to produce both the valuable products listed above and to increase the quantity and quality of products in plant production, and significant benefits are obtained from honeybees (Anonymous, 2023).

Along with the concept of healthy living, which is considered extremely important in the world today, the tendency to provide the energy and nutrients the body needs from natural sources has been an important factor in the development and appreciation of beekeeping activity. The contribution of honey and other bee products in raising healthy and disease-resistant individuals is very important and they have antibacterial, antimicrobial, antiviral and antiparasitic functions due to the vitamins, minerals and enzymes they contain (TKDK, 2016).

In addition to its many other benefits, beekeeping has a privileged place among agricultural activities with its features such as generating income in a short time, being able to be done with a small capital and not being dependent on land availability. Beekeeping provides employment, income and healthy nutrition opportunities to the rural population in developing countries due to reasons such as low operating costs, less labor force use compared to other branches of production, products being easily stored and sold at value prices (Uzundumlu et al., 2011).

In the 21st century, beekeeping is gaining importance day by day throughout the world and it is becoming an increasingly important sector, especially with the widespread diversity of bee products and the learning of their benefits. Beekeeping has become a developing sector with the understanding of the importance of products such as beeswax, royal jelly, propolis, bee venom, especially honey obtained from bees, for human health. According to the data of the Food and Agriculture Organization of the United Nations, there were 101.6 million hives worldwide in 2023 (FAO, 2023) and this number increased by 2.2% compared to the previous year. In the total number of hives in the world, India ranked first with a share of 12.6%, China ranked second with a share of 9.1% and Turkey ranked third with a share of 8.6%. World honey production was 1,771,944 tons in 2021. China, with a share of 26.7% in world honey production, ranked first with 473 thousand tons, Turkey, with a share of 5.4%, ranked second with 96 thousand tons and Iran, with a share of 4.4%, ranked third with 77 thousand tons.

The average honey production per hive worldwide was around 17.40 kg in 2021. The honey yield per hive of India, which is the leader in the number of hives in the world, was 5.2 kg, while the honey yield of China, which ranked second, was 51.3 kg and the honey yield of Turkey, which ranked third, was 11.3 kg (FAO, 2023).

A total of 65 thousand tons of beeswax was produced worldwide in 2021. In world beeswax production, India ranked first with a share of 38.9% in 2021, Ethiopia ranked second with a share of 8.8%, Argentina ranked third with a share of 7.6% and Turkey ranked fifth with a share of 5.8%.

The suitable climatic conditions and honey vegetation, which are the main factors in bee breeding and bee products production, are seen as a great opportunity for Turkey, and the fact that 75% of the honey plant species and varieties existing in the world are in Turkey stands out as a great natural wealth. Turkey has a great beekeeping potential in terms of different climate and natural conditions, land structure, very rich vegetation and genetic diversity in honey bee populations. Beekeeping is a very important sector that shows rapid development in Turkey, as in other countries of the world, and structurally ensures the continuity and efficiency of natural balance and agricultural production (Sıralı, 2010).

It is an agricultural activity that is the main source of livelihood for families engaged in agriculture, as well as a second source of income besides other agricultural occupations. In addition to its low capital requirement, the fact that it does not require land, facilities, tools-machinery and much labor is among the advantages of this branch of production. In addition, another advantage is that all the necessary equipment and living materials, especially capital, in bee farming are supplied from Turkey (Öztürk, 2013).

In Turkey, the fact that the flowering times are spread almost throughout the year, the sufficient amount of timber required for hive production, the traditional importance given to bees and honey, the availability of labor that can be transferred to beekeeping, the fact that it does not require a significant investment and the fact that it can be done without being dependent on the land, increases the importance of beekeeping. Turkey is ahead of many countries in terms of the number of hives, honey and beeswax production, and the honey produced is among the highest quality honey in the world. However, the production amount per hive is quite low and behind the world average.

The total number of hives in Turkey in 2023 was 9,224,881 and the number of beekeeping enterprises was 100,399. In 2023, 114,886 tons of honey and 3971 tons of beeswax were produced in Turkey (Anonymous, 2023b).

In this study, Turkey's 26 sub-regions within the scope of Level 2 of the Statistical Regional Units Classification were analyzed using the Data Envelopment Analysis model, which helps measure the relative efficiency among decision-making units. It was determined whether regional resources were used effectively in beekeeping activities in Turkey and alternative policy suggestions were presented for more effective resource use.

2. Literature Review

Ören et al. (2010) performed economic analysis of beekeeping enterprises in Adana. Technical efficiency of beekeeping enterprises was found to be 85%. Based on this result, it was concluded that sample beekeepers could realize 15% savings in their input use while remaining at the same output level. It was also found that scale inefficiency was an important component of technical inefficiency.

Abdul-Malik and Mohammed (2012) examined the technical efficiencies of beekeeping farms and the factors affecting them by applying a stochastic production frontier function in the Tolon-Kumbungu district of Ghana's Northern region. The findings indicated that the average technical efficiency of these farms was 0.894. Additionally, most respondents demonstrated considerable efficiency in utilizing available resources. The key determinants of technical inefficiency among honey producers were identified as age, primary occupation, and social group membership.

Makri et al. (2015) conducted an economic analysis of the Greek beekeeping sector and assessed the efficiency of beekeeping farms using the Data Envelopment Analysis method. Their results revealed that beekeepers could maintain the same level of output by reducing their inputs by 34% in the short run and by 43% in the long run. Furthermore, the study suggested that most beekeepers needed to make significant changes to their scale of operation.

Ceyhan et al. (2016) explored current situation and problems of Turkish beekeeping sector. They determined the technical efficiency coefficient of beekeeping enterprises in Turkey as 0.84, allocative efficiency as 0.75 and economic efficiency as 0.62.

Shiferaw and Gebremedhin (2016) determined the technical efficiency of honey producers in Ethiopia by using stochastic frontier production model. The mean technical efficiency was found as 0.79, indicating that, on average, honey producers achieved 80% of the maximum output. This meant that 20% of the potential output was lost due to technical inefficiency. The findings suggested that investing in rural infrastructure could significantly enhance the technical efficiency of honey producers.

Gürer and Akyol (2018) examined the factors affecting the technical efficiency of beekeeping farms. The results revealed that the mean technical efficiency of these farms was 0.57, indicating that beekeepers were generally quite inefficient. The factors affecting technical inefficiency included the presence of purebred bees in the colony, the education level of the farmer, the number of hives, beekeeping subsidies, the farmer's age, the type of beehive used, and the number of migratory activities undertaken.

Ritten et al. (2018) applied data envelopment analysis to measure technical efficiency, returns to scale, and the factors affecting the efficiency of apiaries in the northern Rocky Mountain region that participate in the pollination services market. It was concluded that while over 25% of the apiaries were technically efficient, a significant number faced either increasing or decreasing returns to scale.

Aydın et al. (2020) assessed the economic structure and efficiencies of beekeeping enterprises in Çanakkale Province. The analysis revealed that the average total technical efficiency (constant return to scale) was 0.64, pure technical efficiency (variable return to scale) was 0.89, scale efficiency was 0.70, allocative efficiency was 0.74, and economic efficiency was 0.66. It was concluded that the age of the producer and engagement in agricultural activities other than beekeeping negatively affected economic efficiency. In contrast, factors such as land size, income per hive, and frequency of honeycomb changes positively affected economic efficiency.

Güler (2021) evaluated the efficiency of beekeeping by provinces in Turkey. The research data included honey production, beeswax production, the number of beekeeping enterprises, and the number of hives from 81 provinces. Data envelopment analysis was applied to assess technical efficiency. The number of beekeeping enterprises and number of hives were used as input variables. In the first model, honey production was the output variable, while in the second model, both honey and beeswax production were considered output variables. The province of Ordu was among those achieving full efficiency in both models. The average efficiency values were calculated as 0.19 in the first model and 0.30 in the second model.

Uysal (2022) investigated the efficiency of beekeeping enterprises and the factors affecting to inefficiency. Technical efficiency of these enterprises was found as 0.89, allocation efficiency was found as 0.84, and economic efficiency was found as 0.81, respectively. The economic efficiency score indicated that inefficient enterprises could potentially reduce their production costs by 19%. Upon analyzing the factors affecting inefficiency, it was found that income per hive, subsidy rate, and the use of credit negatively affected efficiency levels.

Alabi and Anekwe (2023) assessed the technical efficiency of honey and beeswax production in Kaduna State, Nigeria. The factors affecting technical efficiency were determined as labor input, bee feed and sugar syrup, land size, number of beehives, quantities of antibiotics and vaccines, and costs associated with controlling honeybee pests, diseases, and predators. Socioeconomic factors such as age, gender, household size, educational level, experience in beekeeping, and cooperative membership were found to negatively affect technical inefficiency in honey and beeswax production. The average technical efficiency score was found as 56.3%, indicating a potential for improvement of 43.7%.

3. Materials and Methods

The main material of the study consisted of data on honey and beeswax production, number of beekeeping enterprises, number of old hives and new hives in 26 regions for the year 2023 obtained from the Turkish Statistical Institute. 26 Level-2 regions were created by grouping neighboring provinces (Level-3) that are economically, socially and geographically similar.

In the study, data envelopment analysis was used to determine the technical efficiency of the regions in beekeeping activities. Data Envelopment Analysis (DEA) is one of the most widely used methods in efficiency measurement. DEA, which is a nonparametric method, uses linear programming to determine the points on the curve obtained by using the inputs and outputs of the most efficient firm instead of using any production function (Fanchon, 2003). Data Envelopment Analysis not only measures the relative efficiency of Decision Making Units (DMUs) that include multiple input-output variables, but also provides guidance on the amount of inefficiency and why it occurs. With this feature, DEA can provide support to managers by determining the required input reduction and/or output increase amounts in inefficient units.

Basically three methods are used in Data Envelopment Analysis. In 1978, Charnes, Cooper and Rhodes - CCR (Charnes et al. 1978) developed a model under the assumption of Constant Return to Scale (CRS), where outputs increased at the same rate when the inputs were increased without changing the composition ratio of the inputs. With the original CCR model, which was the first DEA model and revealed efficiency proportionally, it was possible to examine the factors and envelopment surface of the model in detail (Banker et al. 1984). In 1984, Banker, Charnes and Cooper developed a model under the assumption of Variable Return to Scale (VRS), where outputs increased at a different rate when the inputs were increased without changing the composition ratio of the inputs. Since the BCC efficient frontier is below the CCR frontier under all conditions, the CCR efficiency value is less than or equal to the BCC efficiency value.

The constant returns to scale model is valid only when enterprises operate at optimum scale (Coelli et al. 1998). Since beekeeping enterprises in the regions of the study area are faced with incomplete competition conditions, the model was transformed into a variable returns to scale (VRS) model by adding a limiter that ensured convexity to the CRS model (Banker et al. 1984).

In DEA, total efficiency is divided into two discrete components: technical efficiency and scale efficiency. This separation allows to understand the cause of inefficiency in resources. Technical efficiency measurement can be found by estimating the efficient frontier under the assumption of variable returns to scale. Scale efficiency is considered as the success of producing at the appropriate scale, since it is seen as the result of losses caused by situations where production cannot be made at the optimal scale. Scale efficiency or inefficiency is expressed as the distance between the efficient frontier of constant returns to scale and variable returns to scale. Scale inefficiency is judged to be efficient if the scale efficiency is less than one, and scale efficiency is judged to be efficient if both the constant and variable efficiency at scale values are exactly equal to one. If the scale efficiency is less than one, it is decided that the scale is inefficient, and if it is equal to one and the values of both total and technical efficiency values are exactly equal to one, the scale is determined to be efficient.

Technical efficiency is defined as obtaining the maximum possible output by using the most appropriate input combination. This definition is the definition of output-oriented technical efficiency. Input-oriented technical efficiency is defined as the success of obtaining the current output level with the least possible use of resources (Bakırcı, 2006).

Returns to scale, which is an economic definition that shows that the increase in the amount of inputs will affect the potential production capacity, can be realized in three different ways: Increasing Returns to Scale (IRS), Constant Returns to Scale (CRS) and Decreasing Returns to Scale (DRS) (Wang and Cui, 2010).

In a production process, when the inputs are increased at the same rate, variable returns to scale occurs when the rate of increase in the output level and the rate of increase in the input level are different from each other. If this difference is in the positive direction; (i.e. if the increase in outputs is more than inputs) increasing returns to scale occurs, and if it is in the negative direction; (i.e. if the increase in outputs is less than inputs) decreasing returns to scale occurs. If the increase in the level of output does not differ from the rate of increase in inputs when inputs are increased at the same rate, in other words, if there is a one-unit increase in the amount of output in response to a one-unit increase in the amount of inputs, this means constant returns to scale (Aktaş, 2001).

In efficiency analysis, enterprises with efficiency coefficients between 0.95 and 1 can be classified as efficient, those with efficiency coefficients between 0.90 and 0.95 as less efficient and those with efficiency coefficients less than 0.90 as inefficient (Charnes et al. 1978).

In the model, honey production and beeswax production were taken as outputs, and the number of enterprises engaged in beekeeping activities, the number of old hives and the number of new hives were taken as inputs. In other words, a model with 3 inputs and 2 outputs was created. DEAP 2.1 package program developed by Coelli (1996) was used to estimate efficiency measurements.

4. Results and Discussion

In this study, TurkStat data for the year 2023 were used to determine the efficiency values of the regions in beekeeping activity. The variables used as output and input in the model are given in Table 1. In the model, honey production (tons) and beeswax production (tons) were used as output and the number of beekeeping enterprises, the number of old hives and the number of new hives were used as inputs.

Table 1: Input and output variables used in efficiency analysis

Inputs	Outputs
Number of beekeeping enterprises (I1)	Honey production (O1)
Number of old hives (I2)	Beeswax production (O2)
Number of new hives (I3)	

Descriptive statistics of the variables are given in Table 2. The average honey production in 26 regions in Turkey was calculated as 4419 tons, beeswax production was 153 tons, the number of beekeeping enterprises was 3862, the number of old hives was 9827 and the number of new hives was 344,976.

Table 2: Descriptive statistics of the variables used in the analysis

Variables	Unit	Average	Standard deviation	Minimum	Maximum
Honey production	Ton	4,419	5,181	507	22,775
Beeswax production	Ton	153	163	24	446
Number of beekeeping enterprises	Number	3,862	2,350	1,527	13,010
Number of old hives	Number	9,827	27,756	2	134,018
Number of new hives	Number	344,976	293,518	92,766	1,163,733

After determining the data set to be used in the study, the appropriate data envelopment analysis model should be selected. Since one of the main problems of developing countries such as Turkey is the inefficient use of scarce resources and since producers tend to control inputs rather than outputs, it seems more appropriate to choose "input-oriented models" that aim to reduce inputs. In this way, the resources saved can be transferred to other areas. Therefore, input-oriented efficiency measures were used in this study.

The efficiency scores of 26 regions in Turkey, which were selected as the decision-making unit in the study, are given in Table 3. According to the CCR model, it was determined that TR62, TRA2, TR72 and TR42 regions were fully efficient, TR90 region was efficient and TRB2 region was less efficient. According to the CCR model, the average efficiency value of 26 regions was found as 0.63. It was observed that TR51, TR41, TRA1, TRC1, TR63, TR82, TR52, TR71, TRB1, TR33, TRC3, TR83, TR21, TR81, TR10 and TR31 regions had lower efficiency values than the average efficiency value.

According to the BCC model, it was determined that TR62, TR51, TR32, TRA2, TR72, TR42, TR71, TR90, TRB2, TR10 and TRC2 regions were fully efficient, and TR81 region was less efficient. According to the BCC model, the average efficiency value of 26 regions was found as 0.85. It was observed that TR61, TRA1, TR63, TR82, TR52, TRB1, TR33, TRC3, TR83, TR21 and TR31 regions had lower efficiency values than the average efficiency value.

It was determined that TR51, TR32, TR71, TR90, TRB2, TR10 and TRC2 regions, which were fully efficient according to the BCC model, were not fully efficient in the CCR model. Regions that were technically efficient according to the BCC model were found to be efficient according to the CCR model, which measures total efficiency, since they could not achieve scale efficiency.

"Scale efficiency" was calculated by dividing the efficiency value obtained from the CCR model to the efficiency value obtained from the BCC model. According to the scale efficiency results, it was determined that TR62, TRA2, TR72 and TR42 regions operated at optimal scale. In addition, it was seen that TR61 and TR90 regions made production at a scale close to the optimal scale, TR22 and TRB2 regions were less efficient, TR51, TR32, TR71, TR10 and TRC2 regions, which were fully efficient according to the BCC model, were among the inefficient regions according to total technical efficiency since they were not at a sufficient level in scale efficiency. The average scale efficiency value of the regions was found as 0.74. It was determined that TR51, TR41, TRC1, TR63, TR82, TR52, TR71, TR33, TR21, TR81 and TR10 regions had scale efficiency values lower than the average scale efficiency value.

In previous studies in which input utilization efficiency in beekeeping activity was determined, the technical efficiency score was found as 0.85 by Ören et al. (2010), 0.89 by Abdul-Malik and Mohammed (2012), 0.84 by Ceyhan et al. (2016), 0.79 by Shiferaw and Gebremedhin (2016), 0.57 by Gürer and Akyol (2018), 0.89 by Aydın et al. (2020), 0.89 by Uysal (2022), and 0.56 by Alabi and Anekwe (2023). Ritten et al. (2018) determined in their study that 25% of agricultural enterprises engaged in beekeeping activities were technically fully efficient. Güler (2021) carried out the efficiency analysis of beekeeping activities in Turkey on a provincial basis, and determined that Ordu province, which had the highest honey yield in Turkey, was among the fully efficient provinces in both models. In this study, it was determined that the TR90 Region, where Ordu province is located, was fully efficient according to the BCC model and efficient according to the CCR model, and this result was similar to the literature of Güler (2021).

Table 3: Efficiency Scores of the Regions

Regions	Code	Total Efficiency (CCR)	Technical Efficiency (BCC)	Scale Efficiency
Adana, Mersin	TR62	1.00	1.00	1.00
Ankara	TR51	0.41	1.00	0.41
Antalya, Isparta, Burdur	TR61	0.80	0.81	0.98

Aydın, Denizli, Muğla	TR32	0.77	1.00	0.77
Ağrı, Kars, Iğdır, Ardahan	TRA2	1.00	1.00	1.00
Balıkesir, Çanakkale	TR22	0.77	0.85	0.90
Bursa, Eskişehir, Bilecik	TR41	0.54	0.86	0.63
Erzurum, Erzincan, Bayburt	TRA1	0.42	0.56	0.76
Gaziantep, Adıyaman, Kilis	TRC1	0.25	0.87	0.29
Hatay, Kahramanmaraş, Osmaniye	TR63	0.50	0.70	0.71
Kastamonu, Çankırı, Sinop	TR82	0.32	0.65	0.49
Kayseri, Sivas, Yozgat	TR72	1.00	1.00	1.00
Kocaeli, Sakarya, Düzce, Bolu, Yalova	TR42	1.00	1.00	1.00
Konya, Karaman	TR52	0.38	0.76	0.50
Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	TR71	0.52	1.00	0.52
Malatya, Elâzığ, Bingöl, Tunceli	TRB1	0.38	0.47	0.82
Manisa, Afyonkarahisar, Kütahya, Uşak	TR33	0.41	0.67	0.61
Mardin, Batman, Şırnak, Siirt	TRC3	0.60	0.71	0.85
Samsun, Tokat, Çorum, Amasya	TR83	0.58	0.74	0.79
Tekirdağ, Edirne, Kırklareli	TR21	0.52	0.73	0.72
Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	TR90	0.97	1.00	0.97
Van, Muş, Bitlis, Hakkâri	TRB2	0.91	1.00	0.91
Zonguldak, Karabük, Bartın	TR81	0.59	0.94	0.64
İstanbul	TR10	0.44	1.00	0.44
İzmir	TR31	0.61	0.75	0.82
Şanlıurfa, Diyarbakır	TRC2	0.79	1.00	0.79
Average		0.63	0.85	0.74

The distribution of the regions according to their efficiency status is given in Table 4. According to the CCR model, it was determined that 15.38% of the regions were fully efficient, 3.85% were efficient, 3.85% were less efficient and 76.92% were not efficient. According to the BCC model, 42.31% of the regions were found to be fully efficient, 3.85% were found to be less efficient and 53.85% were found to be inefficient.

According to the scale efficiency results, it was seen that 15.38% of the regions made production at optimal scale. It was determined that 7.69% of the regions were efficient, 7.69% were less efficient, and 69.23% did not make production at optimal scale.

Table 4: Classification of regions according to technical efficiency

Efficiency status	Total efficiency (CCR)		Technical efficiency (BCC)		Scale efficiency	
	Frequency	%	Frequency	%	Frequency	%
Fully efficient(TE=1)	4	15.38	11	42.31	4	15.38
Efficient (0.95≤TE<1)	1	3.85	0	0.00	2	7.69
Less efficient(0.90≤TE≤0.949)	1	3.85	1	3.85	2	7.69
Inefficient (TE≤0.899)	20	76.92	14	53.85	18	69.23
Total	26	100.00	26	100.00	26	100.00

Returns to scale results are given in Table 5. According to the results, TR62, TRA2, TR72 and TR42 regions were determined to have constant returns to scale and these regions were evaluated as efficient regions. TR61, TR32 and TR90 regions were determined to have decreasing returns to scale. Since the increase rate in the output of these regions was less than the increase rate in their inputs, it was possible to say that they used their resources inadequately.

The regions with increasing returns to scale were TR51, TR22, TR41, TRA1, TRC1, TR63, TR82, TR52, TR71, TRB1, TR33, TRC3, TR83, TR21, TRB2, TR81, TR10, TR31 and TRC2. The increase rate in the output of these regions was higher than the increase rate in their inputs. The reason why these 19 regions could not produce at an optimal scale was that, while they could produce more than one unit of output with one unit of input, they produced output below their capacity due to external factors.

Table 5: Returns to Scale Results of the Regions

Regions	Code	Returns to Scale
Adana, Mersin	TR62	CRS
Ankara	TR51	IRS
Antalya, Isparta, Burdur	TR61	DRS
Aydın, Denizli, Muğla	TR32	DRS
Ağrı, Kars, Iğdır, Ardahan	TRA2	CRS
Balıkesir, Çanakkale	TR22	IRS
Bursa, Eskişehir, Bilecik	TR41	IRS
Erzurum, Erzincan, Bayburt	TRA1	IRS
Gaziantep, Adıyaman, Kilis	TRC1	IRS
Hatay, Kahramanmaraş, Osmaniye	TR63	IRS
Kastamonu, Çankırı, Sinop	TR82	IRS
Kayseri, Sivas, Yozgat	TR72	CRS
Kocaeli, Sakarya, Düzce, Bolu, Yalova	TR42	CRS
Konya, Karaman	TR52	IRS
Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	TR71	IRS
Malatya, Elâzığ, Bingöl, Tunceli	TRB1	IRS
Manisa, Afyonkarahisar, Kütahya, Uşak	TR33	IRS
Mardin, Batman, Şırnak, Siirt	TRC3	IRS
Samsun, Tokat, Çorum, Amasya	TR83	IRS
Tekirdağ, Edirne, Kırklareli	TR21	IRS
Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	TR90	DRS
Van, Muş, Bitlis, Hakkâri	TRB2	IRS
Zonguldak, Karabük, Bartın	TR81	IRS
İstanbul	TR10	IRS
İzmir	TR31	IRS
Şanlıurfa, Diyarbakır	TRC2	IRS

The distribution of the regions according to their returns to scale is given in Table 6, and it was observed that 15.38% had constant returns to scale, 11.54% had decreasing returns to scale, and 73.08% had increasing returns to scale. It was determined that the honey and beeswax production obtained by regions with increasing returns to scale was significantly lower than the regions with decreasing and constant returns to scale. It was found that regions with decreasing returns to scale produced 1.63 times more honey and 1.36 times more beeswax than the regions with constant returns to scale, but the number of enterprises was 1.99 times, the number of old hives was 1.94 times and the number of new hives was 2.15 times higher.

It was determined that regions with constant returns to scale produced 3.23 times more honey and 3.23 times more beeswax than the regions with increasing returns to scale, but the number of enterprises was 1.38 times higher, the number of new hives was 1.72 times higher and the number of old hives was 11.47% lower.

Table 6: Distribution of the regions according to return to scale

Return to Scale	Frequency	%	Honey (ton)	Beeswax (ton)	Number of enterprises	Number of old hives	Number of new hives
CRS	4	15.38	7,780	284	4,231	1,456	416,564
DRS	3	11.54	12,686	387	8,417	2,830	896,185
IRS	19	73.08	2,406	88	3,064	12,694	242,872

According to the input-oriented BCC model, the potential correction rates that ineffective regions should make at the input and output levels in order to become efficient are given in Table 7. In order for TRB1 Region, which had the lowest efficiency score, to become technically efficient, there should be a 53.35% decrease in the number of enterprises, a 53.35% decrease in the number of new hives, and an 82.60% decrease in the number of old hives. The first three regions that should reduce the number of old hives at the highest rate were TRC3, TRC1 and TR21. The regions that should reduce the number of new hives at the highest rate were TRB1 and TRA1 regions. While the improvement rates in the number of old hives varied greatly by regions, the improvement rates in the number of new hives and the number of enterprises did not vary much as in the number of old hives. It was seen that the first three regions that should reduce the number of enterprises at the highest rate were TRB1, TR82 and TRA1 regions.

When evaluated in terms of output values, it was seen that TR22, TR41, TRB1, TR33, TR83 and TR31 regions did not need to increase honey and beeswax production and can only become efficient with improvements in inputs. The regions that need to increase only honey production were TR61 with 57.66%, TRA1 with 1.15%, TR63 with 14.01%, TR82 with 6.19%, TR52 with 47.67% and TR81 with 106.13%. The regions that need to increase only in beeswax production were TRC3 with 91.20% and TR21 with 12.44%. It was concluded that

TRC1 region will become efficient if it increases both honey production (56.21%) and beeswax production (16.67%).

Table 7: Potential improvement rates in inputs and outputs of inefficient regions according to BCC model (%)

Regions	Efficiency score	Honey (ton)	Beeswax (ton)	Number of enterprises	Number of old hives	Number of new hives
TR61	0.81	57.66	0.00	-35.81	-19.13	-19.13
TR22	0.85	0.00	0.00	-14.65	-30.11	-14.65
TR41	0.86	0.00	0.00	-25.61	-50.33	-13.94
TRA1	0.56	1.15	0.00	**-44.28**	-44.28	**-44.28**
TRC1	0.87	56.21	16.67	-23.54	**-93.86**	-12.75
TR63	0.70	14.01	0.00	-29.81	-29.81	-29.81
TR82	0.65	6.19	0.00	**-49.95**	-58.59	-34.67
TR52	0.76	47.67	0.00	-24.44	-24.44	-24.44
TRB1	0.47	0.00	0.00	**-53.35**	-82.60	**-53.35**
TR33	0.67	0.00	0.00	-33.21	-82.23	-33.21
TRC3	0.71	0.00	91.20	-29.17	**-98.51**	-29.17
TR83	0.74	0.00	0.00	-41.60	-55.23	-26.44
TR21	0.73	0.00	12.44	-31.89	**-85.31**	-27.40
TR81	0.94	106.13	0.00	-36.05	-6.53	-6.53
TR31	0.75	0.00	0.00	-24.82	-67.03	-24.82

Total potential improvement rates for all inefficient regions are given in Table 8. Accordingly, when evaluated in terms of inputs, it was seen that the number of enterprises should be reduced by 33.21%, the number of old hives by 55.20% and the number of new hives by 26.31%. When the same analysis was performed for outputs, it was seen that honey production can be increased by 19.27% and beeswax production by 8.02% with the current inputs. It was seen that the most inefficiently used input was the number of old hives, while in terms of output, honey production was the output that should be increased the most.

Table 8: Total potential improvement rates of inputs and outputs (%)

Outputs	Potential improvement rate (%)
Honey (ton)	19.27
Beeswax (ton)	8.02
Inputs	Potential improvement rate (%)
Number of enterprises	-33.21
Number of old hives	-55.20
Number of new hives	-26.31

Reference sets and virtual targets were determined for inefficient regions. Table 9 shows how often efficient regions were shown as references and the reference sets that inefficient regions should take as examples in order to be efficient.

Although TR32, TR90 and TRC2 regions were efficient, they were not cited at all. TR51 region was cited as a reference 1, TRA2 region 2, TRB2 region 3, TR42 region 6, TR10 region 7, TR71 region 8, TR62 region 9 and TR72 region 12 times. It is noteworthy that although TR72 region was cited as a reference 12 times, the rate of being cited as a reference remained at low levels. It was taken as reference by the TR61 region at a rate of 22.5%, while the reference rates by the TR52, TR33, TR81 and TR31 regions were at the level of 1%.

When Table 9 was interpreted for the regions with the lowest efficiency values, the efficiency value of the TRB1 region was 0.47, and the regions that should be taken as reference in order to be efficient were TR72, TR10, TR71 and TR62 regions. It was determined that the TRB1 region can make the necessary improvements by taking TR72 region as an example with 16.5%, the TR10 region with 69.9%, the TR71 region with 3.2% and the TR62 region with 10.3%.

It was noticeable that the only region that TRC1 region should take as a reference was TR10 region. TR82 region's reference rate for the TR51 region was quite high (95.2%), while the rate of taking TR72 region as a reference was determined as 4.8%.

Table 9: Frequency of references for efficient regions and reference sets for inefficient regions

Regions	Efficiency score	Reference frequency	Reference set
TR62	1.00		9
TR51	1.00		1
TR61	0.81	TR72 (0.225) TRA2 (0.707) TR62 (0.068)	
TR32	1.00		0
TRA2	1.00		2
TR22	0.85	TR62 (0.051) TR42 (0.274) TR72 (0.182) TR71 (0.492)	
TR41	0.86	TR42 (0.04) TR72 (0.042) TR71 (0.917)	
TRA1	0.56	TRB2 (0.011) TR72 (0.152) TR10 (0.777) TR62 (0.061)	
TRC1	0.87	TR10 (1.00)	
TR63	0.70	TRB2 (0.012) TR72 (0.067) TR62 (0.135) TR10 (0.786)	
TR82	0.65	TR72 (0.048) TR51 (0.952)	
TR72	1.00		12
TR42	1.00		6
TR52	0.76	TRB2 (0.013) TR72 (0.069) TR10 (0.877) TR62 (0.042)	
TR71	1.00		8
TRB1	0.47	TR72 (0.165) TR10 (0.699) TR71 (0.032) TR62 (0.103)	
TR33	0.67	TR62 (0.014) TR42 (0.036) TR71 (0.944) TR72 (0.006)	
TRC3	0.71	TR42 (0.154) TR71 (0.671) TR62 (0.175)	
TR83	0.74	TR72 (0.179) TR42 (0.088) TR71 (0.733)	
TR21	0.73	TR42 (0.21) TR71 (0.79)	
TR90	1.00		0
TRB2	1.00		3
TR81	0.94	TR72 (0.002) TRA2 (0.394) TR10 (0.605)	
TR10	1.00		7

TR31	0.75	TR62 (0.175) TR10 (0.336) TR72 (0.013) TR71 (0.476)	
TRC2	1.00		0

5. Conclusion

In this study, whether the 26 sub-regions within the scope of Turkey's Statistical Regional Units Classification Level 2 used resources efficiently in beekeeping activities and their technical efficiency scores were determined. Because producers tend to control the inputs more than the outputs, Farrell's (1957) input-oriented efficiency measures were used in this study.

As a result of the analysis, it was determined that TR62, TRA2, TR72 and TR42 regions were fully efficient according to the CCR model (constant returns to scale), and the average efficiency value of 26 regions was found as 0.63. According to the BCC model (variable returns to scale), TR62, TR51, TR32, TRA2, TR72, TR42, TR71, TR90, TRB2, TR10 and TRC2 regions were determined to be fully efficient and the average efficiency value of 26 regions was found as 0.85. According to the scale efficiency results, it was determined that TR62, TRA2, TR72 and TR42 regions operated at optimal scale and the average scale efficiency value of the regions was found as 0.74.

It was concluded that the TR62 region, including Adana and Mersin provinces, was fully efficient in both models. In honey production in Turkey, Adana province ranked 2nd, and Mersin province ranked 7th, in Turkey's beeswax production, Adana province ranked 3rd, and Mersin province ranked 5th. The share of the number of new hives owned by producers in these two provinces in Turkey was found as 5.50% (Adana) and 3.64% (Mersin), while the share of the number of the enterprises engaged in beekeeping activities was 2.46% for Adana and 2.76% for Mersin. When examined in terms of the presence of old hives, Adana ranked 20th and Mersin ranked 45th. In line with these data, it was concluded that the TR62 region, which stands out in beekeeping with its rich natural and agricultural vegetation as well as its climate characteristics, was very active in honey production.

It was determined that TRA2 region, including Kars, Ağrı, Ardahan and Iğdır provinces, used its resources efficiently according to both models. Although these provinces ranked in the middle in Turkey in terms of the number of enterprises, number of hives, honey production and beeswax production, they reached optimum output with their existing inputs. These provinces have favorable characteristics in terms of beekeeping with a rich flora in terms of vegetation, flowering of plants at different times and abundance of local flowers. In addition, the feature that brings Ardahan to the forefront in beekeeping and honey production is the Caucasian Bee. Caucasian Bee is one of the four bee races known in the world and has economic value.

The TR72 region, including Kayseri, Sivas and Yozgat provinces, was also determined to be fully efficient in both models. Sivas ranked 4th in Turkey's honey production with a rate of 5.56%, and 1st in beeswax production with a rate of 10.18%. In addition, it ranked 2nd in Turkey in terms of the number of enterprises engaged in beekeeping activities and 6th in terms of the presence of new hives. Although Kayseri and Yozgat provinces were at the bottom in terms of input and output amounts, they realized the highest possible honey and beeswax production with optimum input use.

TR42 region, including Kocaeli, Sakarya, Düzce, Bolu and Yalova provinces, achieved the highest efficiency score in both models. While Kocaeli province ranked 5th in Turkey in honey production, it was quite low in terms of the number of enterprises and the presence of hives. However, the amount of output obtained in this region with the available inputs was quite high compared to other regions.

The TR90 region, including Trabzon, Ordu, Giresun, Rize, Artvin and Gümüşhane provinces, was efficient according to the CCR model, fully efficient according to the BCC model, and produced at a near-optimal scale. Although Ordu province, ranked 5th in Turkey in terms of the number of enterprises and 2nd in terms of the number of new hives, it ranked first in honey production and 4th in beeswax production. The Eastern Black Sea Region has an important potential in terms of both the number of colonies and honey production. Although technical beekeeping principles are known, deficiencies and traditional habits of benefiting from experience still persist (Kuvancı et al. 2017). Except for Ordu province, beekeeping in the region will be able to reach much better levels by increasing the yield per colony by using inputs more optimally.

The TRB2 region, including Van, Muş, Bitlis and Hakkari provinces, was less efficient according to the CCR model, fully efficient according to the BCC model, and produced at a scale close to optimal. While honey production was at a medium level in these provinces, beeswax production was proportionally higher. Beekeeping is an important sector that turns the rugged terrain, which is considered a disadvantage in the TRB2 Region, into an advantage for the region. Because the rugged terrain of the region creates topographic differences, and this makes the beekeeping season longer than other regions (Anonymous, 2014b). If more production is made with the existing inputs in this region, optimal scale production in beekeeping activity can be realized in the region.

TR51, TR32, TR32, TR71, TR10 and TRC2 regions were efficient according to the BCC model, while they were not efficient according to the CCR model. Producers in these regions will be able to produce at the optimal scale if they receive the necessary technical support to produce more with the existing inputs.

In both models, inefficient regions were TR61, TR22, TR22, TR41, TRA1, TRC1, TR63, TR82, TR52, TRB1, TR33, TRC3, TR83, TR21, TR81, TR31. It is important for the producers in these regions to be trained by extension staff in terms of input use, and existing resources should be used optimally to reveal the current potential. In addition, the continuation of extension activities for modern beekeeping practices is of great importance in terms of increasing efficiency as well as increasing honey yield and quality in enterprises.

The establishment of local beekeeping associations and cooperatives can be promoted to increase the potential of beekeeping in these regions. In addition, by organizing training programs that emphasize the economic and environmental benefits of beekeeping, farmers can be trained on modern beekeeping techniques and support can be provided for the supply of quality bee colonies. Increasing subsidies for beekeeping in agricultural policies and supporting research and development studies on beekeeping can also promote the development of beekeeping in these regions. In addition to these, eliminating the infrastructure deficiencies related to beekeeping, improving the feeding areas of bees and taking efficient measures to struggle with bee diseases can be important steps to increase the efficiency of beekeeping.

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