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Increasing Honey Production Effectiveness in Erzincan and Van Provinces

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Abstract: The purpose of this research is to determine the efficiency of beekeeping enterprises in Van and Erzincan provinces of Türkiye and to make recommendations to increase production efficiency. A total of 300 well-prepared questionnaires were distributed in the research area, of which 295 were analyzed. In the study, production analyses were performed with and without the bootstrapping technique. Constant and variable returns to scale were found in the estimates of technical efficiency scores using both non-parametric data envelopment analysis (DEA) to produce efficiency scores and a truncated regression model to link the aforementioned scores with the characteristics of honeybee enterprises and beekeepers. The research revealed that cooperative membership and veterinary benefits had a 1% level of importance for income; some cities were found to have negligible beekeeping activity. Education level was also found not to be important. While determining the efficiency limits in DEA with and without bootstrapping, it was determined that 34.3% of enterprises without it had ineffective constant returns to scale compared to 39.5% for those with it. For variable returns to scale, 28.4% without bootstrapping worked ineffectively, while with bootstrapping, 29.4% were found to be ineffective. The study found that the same level of beekeeping can be maintained by reducing costs. In addition to its economic value, honey is an important source of income for the region. Beekeeping and honey production are important agricultural activities for increasing rural development to create new jobs and increase employment. As a form of alternative tourism, rural tourism combined with apitourism and gastronomy tourism and practices are important for the development of the Erzincan and Van provinces.

Keywords: technical efficiency; DEA; bootstrapping; honey; rural tourism

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1. Introduction

Production is the process of transforming inputs into outputs, and the greater the output, the better. Inputs are needed for production. Inputs are valuable resources that have alternative uses and are capable of production. Businesses want to use the inputs in the most efficient or advantageous way. The twin goals of a business' efficient use of resource inputs are producing as much output as possible from a certain amount of inputs and producing a certain amount of output using as few inputs as possible [1].

A certain amount of output can be produced using different input–output combinations. A firm's production technology is defined by the combination of inputs and outputs it implements at a given time. Efficiency and effectiveness analyses provide the success metrics that businesses often need. Using this information, decision-makers can make strategic decisions about a range of activities, from better sourcing to more profitable sales and marketing. Today, using limited agricultural resources in the most effective way is of great importance to providing balanced nutrition for an increasing world population.

Efficiency is the ability to maximize output using inputs at the least possible cost. It is expressed as a ratio of actual production over expected production. Maximum efficiency equals 1 (or 100%), while values below 1 indicate inefficiency. Of course, it cannot be greater than 1. Efficiency can be calculated in two ways: input-side and output-side. Since it is very difficult to intervene in the output of agricultural enterprises, input-oriented efficiency analysis is usually performed [1].

Data envelopment analysis (DEA) is a commonly used non-parametric method to measure the efficiency of production units (goods or services) that have similar characteristics [2]. The basic idea of DEA is to provide a methodology to determine the best among comparable decision-making units (DMUs) and establish an effective limit.

Balanced nutrition is one of the biggest concerns in developing countries, and honey as a food source is very important. It has energizing and nutritional value produced by honeybees from extracts collected from plants [3], and it is used against mouth, throat, and bronchial infections because of its anti-bacterial properties. Because beekeeping is not dependent on the land, it can be conducted with less capital, use less labor compared to other agricultural practices, and increase the income of landless or land-poor farmers in forest and border villages. For this reason, it is an agricultural activity that is given importance in both developed and developing countries.

Türkiye, which is a bridge between Europe and Asia, has a very rich structure and many beekeeping advantages in geography, climate, and flora when compared to other countries [4–6]. With the more conscious use of these advantages, the production of honey will increase and contribute to employment and the country's economy as it is a product that can be made at a low cost.

Türkiye ranks third after India (12,203,361 units) and China (9,377,850 units) in colony presence (8,179,085 units) but ranks second (104,077 tonnes) after China (466,487 tonnes) in honey production [7]. According to FAO data, 1,770,119 tons of honey was produced in 2020 [8]. While the world's average honey yield per colony is 20.1 kg/hive, this value is around 11.0 kg/hive in Türkiye [9]. Honey yield depends mainly on natural and environmental conditions [10], but increasing honey production and yield per hive depends on more professional beekeeping. Since the number of hives is the main criterion for yield per unit, it is also the most important criterion in evaluating the honey yield of the colony. In many studies, chi-square, multiple linear regression, and principal component analyses were performed, as well as analyses of the socioeconomic factors of beekeeping enterprises [11–13], economic evaluation [13–15], and productivity [16]. They found fixed and variable costs concerning the age of the enterprise, number of hives, bee breed, and beekeeping type per hive [17,18]. Okpokiri et al. (2015) [19] analyzed multiple linear regressions for business age, income, cooperative membership, access to credit, household size, and experience. The Cobb–Douglas production function was used to measure the interval to labor, capital, rent, and operating units.

Abuja et al. (2017) [20] examined the effects of the number of hives, credit status, extension service, honey harvesting technique, hive location, operating experience, gender membership status, and education level on the honey yield per hive of small-scale beekeeping enterprises in Kenya. Mujuni et al. (2012) [21] investigated the level of adaptability of beekeepers to relevant technology by examining the honey yield per hive from different hive types for bee-keeping businesses in Western Uganda. Masuku (2013) [22] identified colony size and farm experience as determinants that affect overall honey production for small beekeepers in Swaziland. Al-Ghamdi et al. (2017) [23] offered data on the profitability and efficiency of honey production in conventional and box hives. The effect of hive type on honey production was rendered by Vural ve Karaman (2010) [24]. Castellenos-Potenciano et al. (2015) [13] addressed issues such as honey production, the number of hives, and total working time in beekeeping. Keziç et al. (2008) [14] addressed the number of hives and holdings, average honey yield per hive, and income.

All these studies should be supported by standardized measurements because agricultural enterprises, and therefore, beekeeping enterprises, do not know how efficiently they work. Knowing the measures used to calculate efficiency will increase the profit of the enterprise.

From another point of view, beekeeping is an income-generating activity that provides many economic benefits to individuals and countries, both environmentally and socially [25,26]. In addition, tourism, which is a branch of the economy, requires the protection of cultural and natural values together. The trend observed in tourism in recent years shows that tourists have started to focus on the environmentalist structure, such as eco-tourism, rural tourism, nature, and cultural tourism. Apis mellifera (API) tourism, which can be considered within the scope of both sustainable tourism and alternative tourism, aims to protect the natural beauty of honey production centers in Türkiye, where 90% of the world's pine honey production is carried out, and to provide tourism income to the local people as well as honey production income [7]. The rich tourism potential of all settlements in the Eastern Anatolia Region of Türkiye causes the region to be a tourist attraction center. Beekeeping is important as an agricultural activity that needs to be developed in an organized and conscious way in our provinces, which are famous for their breakfasts in terms of API tourism and gastronomy tourism, as well as having rich touristic attractions in Erzincan and Van provinces in the region.

With the bootstrap method, both the autocorrelation-related problem and the problem of determining the efficiency frontier by the inefficient enterprises are also solved. However, when the data envelopment method is compared with the stochastic frontier method, a production process is assumed to be independent of the production function in the data envelopment analysis because managerial skills do not appear as an input part of the production process, which limits DEA scores. Although the skills and experience of beekeepers in honey production are viewed as one of the important factors affecting the production process, unfortunately, it is not possible to use it as an input in DEA, so honey production or yield is independent of such an input component, which can be considered as a limitation of the study.

The aim of this study is to increase the efficiency of honey production, which is produced depending on nature and natural resources in order to meet the increasing demand for its consumption. When considered from this point of view, the study is important in two respects. It further expands the literature by using the two-stage dual-boot DEA model, unlike previous studies that first used the non-parametric procedure to estimate the technical efficiency (TE) of beekeeping holdings in the provinces of Van and Erzincan in the Eastern Anatolian region of Türkiye. Second, the study aims to determine the abundance (excess inputs) of resources used in honey production for each grower using input-oriented DEA Anang et al., 2022 [27] with the ability to identify surpluses (excess inputs) after calculating TE for each grower according to the production limit examined the relative performance of beekeepers with low abundance to determine how they could achieve optimality relative to breeders with zero abundance.

2. Materials and Methods

2.1. Study Area and Sampling Procedure

For the analysis, a survey was conducted with a total of 300 beekeeping enterprises in the province of Van, located in the Southeast of the Eastern Anatolia region of Türkiye, and Erzincan, located in the West, in the production season of 2020 (Figure 1).

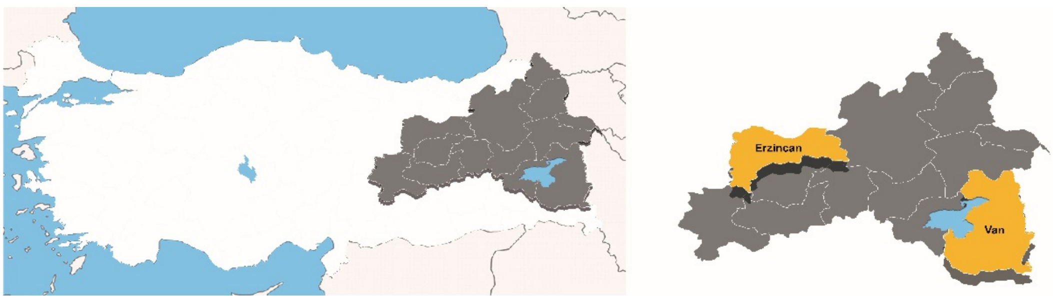

Figure 1. Map of the research area.

Erzincan and Van's provinces are the leading provinces in beekeeping activities in Eastern Anatolia due to the high number of colonies and the flora structure of the provinces. After data entry and cleaning, 5 participants were excluded due to incomplete information about beekeeping activities. The questionnaires were evaluated over 295 data. Participation in the surveys consists of volunteers. For the 2020 production season, we made a comparison between variations in honey yields from participating and non-participating beekeepers, and there were no significant differences, indicating the absence of the Hawthorne effect in our dataset. Additionally, we find that our dataset would not face the problem of self-election bias even if our participating farmers were randomly elected and both had effects. Self-election bias and Hawthorne are possible; these effects were offset by the bootstrapping technique used in this analysis [28].

At the same time, in the context of a standard DEA, homogeneity in DMUs refers to the situation where all DMUs studied are subject to similar situations in terms of flora, topography, climate and extensively implemented agricultural techniques. When we implement this point of view, the homogeneity condition is met in the DMUs in our data set since all our farmers operate in the same region (Eastern Anatolia Region), have the same climatic situations, and for this reason, implement similar agricultural techniques. In addition, our output and input sets were created by considering representative (identical) measures. For instance, while farmers have the option to use different types of sugar, we have converted these uses into net sugar amounts. Similarly, we converted the total number of hours in the family and wage labor calculation and used the net man-hour equivalent instead. Thus, we have met the homogeneity requirement in all DMUs for each input and output used for beekeeping activities in the region.

Table 1 lists descriptions of variables used in empirical analysis, including units of measurement. Four variables (for example, fixed cost (Fixcost), variable cost (Varcost), family and labor hired (Labor), and the number of hives (Hivescount) capture the inputs used in honey production total (Honeyprod). By using these variables, minimization analysis was performed with a variable return to scale (VRS) approach based on input. With Double Bootstrap DEA, it was calculated to what extent businesses could reduce their inputs to reach a stable output. So, it was analyzed how low the input level of these variables could be produced with the same amount of honey.

Table 1. Descriptive statistics.

	Variable Description	Mean	Std. Dev	Min.	Max.
Output					
Honeyprod	Total honey production amount (kg)	2539.237	1951.990	200.000	9500.000
Inputs					
Labour (X1)	Labor (TRY)	12,389.407	7779.025	1437.500	43,175.000
Fixcost (X2)	Fixed costs (TRY)	4331.276	3334.857	186.667	16361.901
Varcost (X3)	Variable costs (TRY)	15,173.883	14,251.888	440.000	68,570.000
Hivenumber (X4)	Number of hives (pieces)	200.566	146.926	16.000	660.000
	Second Stage Variables				
City	1 If city Van, 0 Erzincan	0.495	0.501	0.000	1.000
Noschl	1 if the farmer did not attend any school, 0 otherwise	0.129	0.336	0.000	1.000
Elmnschl	1 if farmer attended an elementary school, 0 otherwise	0.373	0.484	0.000	1.000
Hghschl	1 if farmer attended a high school, 0 otherwise	0.308	0.463	0.000	1.000
Clgschl	1 if farmer attended a college school, 0 otherwise	0.190	0.393	0.000	1.000
Age	Age	46.186	12.560	22.000	77.000
BHSize	1 if household size less than 6 members, 0 otherwise	1.631	0.822	1.000	5.000
LnIncome		11.447	0.895	9.393	13.237
BRS	1 if it is a member of the beekeeping registration system, 0 otherwise	0.841	0.376	0.000	1.000
Unionmembr	1 if it is a member of a beekeeper's association, 0 if not	0.783	0.413	0.000	1.000
Coopmembr	1 if it is a member of the cooperative, 0 otherwise	0.061	0.240	0.000	1.000
Accointicg	1 if there is an income and expense record, 0 otherwise	0.573	0.496	0.000	1.000
Cobother	1 if there is any other source of income, 0 otherwise	0.505	0.501	0.000	1.000
Sclscrty	If there is social security 1, 0 otherwise	1.590	0.684	0.000	2.000
Vtrnaid	1 if using the vet, 0 otherwise	0.125	0.332	0.000	1.000

DEA includes multiple mutually exclusive dummy variables representing the city, education level, age, household size, membership in the beekeeping registration system, membership in beekeeping association, cooperative membership, income and expense record keeping status, social security status, and veterinary benefit status, along with single dummy variables representing income status which are used as explanatory variables affecting productivity scores.

Van and Erzincan provinces are located in the Eastern Anatolia Region of Türkiye. A ground puppet was used to determine that the province of Van, located in the southeast of the region, was more effective than the province of Erzincan, located in the west of the region. As a result, it was assumed that the province of Van would be more active. Because the most important factor that separates the province of Van from the province of Erzincan is that it is next to Lake Van, it was thought that the education level of the farmer would be effective on the efficiency as a dummy variable and the efficiency measurement was analyzed at every stage of the education. It is thought that as the level of education increases, the efficiency of the enterprise will increase, and therefore, the income will increase. Because it is thought that with the level of education, access to and benefiting from information will be faster, considering that there is a relationship between household size and efficiency, it was thought that the efficiency in a family of six on average would be less than the efficiency of a less populated family. It is thought that as the number of family members increases, the responsibility will increase, and there will be conflicts with family members who want to escape from the workload. It is assumed that the status of membership in the beekeeping registration system, membership in the beekeepers' union, and membership in the cooperatives related to beekeeping enterprises will also increase efficiency. If the enterprises have income and expense records, it is assumed that the enterprises are more efficient. Considering that if the enterprises have additional income sources and social security, it will affect the efficiency of the enterprises, it is thought that if there are other sources of income, it will be more effective because it is thought that the operator is able to produce comfortably as a hobby without having trouble making a living. In addition, it is expected that businesses will be more effective if they receive veterinary services. It is thought that the hive and bees must be healthy for quality honey (Table 1). DEA analyses with fixed and variable returns to the scale were performed without bootstraps and with double bootstraps, and technical efficiency was calculated.

2.2. Modeling Approach

Data envelopment analysis (DEA) is a non-parametric approach. DEA determines the efficiency of decision-making units (DMU) relative to the inputs and outputs they use. In this approach, the DMU functions without requiring any special function structures to define the frontiers. This approach is determined by a linear programming approach that compares each honey producer with its respective virtual 'best' producer, with the same input with a higher level of output (output-oriented production) or the same output level with a lower level of input (input-oriented production). The first version of such a linear programming method was adopted to create a production frontier where DMUs can scale inputs and outputs linearly without any change in efficiency. Using production theory, DEA can estimate a discrete part frontier without subjecting the data to any functional constraints. In DEA, the location of the frontier is determined by the effective set of DMUs lying there; inefficient DMUs are found below the frontier. In DEA, the key is determined by two metrics: either constant returns to scale or variable returns to scale. The concept of constant returns to scale occurs when the same increase in the input level is reflected in the output. On the other hand, the concept of returns to scale is different when there is a change in inputs; the amount of change in outputs is different from that of inputs. Such a difference is either incremental (increasing returns to scale) or declining (descending to scale). The constant return to scale is the determinant of total activities. However, as we said, returns that vary according to scale can be both increasing and decreasing or even constant returns and gives pure technical efficiency [26]. In this study, the input-based approach and the variable return to scale approach were adopted since honey producers generally have a determination ability in choosing input components rather than controlling outputs.

Due to its simple and practical features, DEA has been widely applied in evaluating productivity (such as production, irrigation, and energy) in a diverse range of agricultural sectors and has benefited from a significant improvement in its theory. These methods are generally used to detect the effects of environmental and contextual factors on productivity by following a two-step process. In the first step, efficiency scores are obtained:

$$\begin{gathered} \min \hat{\theta}_i \\ \hat{Q}_i,\ \lambda \\ subject\ to - y_i + y_\lambda \geq 0 \\ \hat{Q}_i\ ,\ \chi_i + \chi_\lambda\ \geq 0 \\ \lambda\ \geq\ 0 \end{gathered} \tag{1}$$

Here, the technical efficiency score for the *i*th beekeeping farm is displayed; λ is an Nx1 constant, where N is the number of honey producers in the sample; Y_i shows the yield of honey per hive for ith entrepreneur, while X_i shows an input vector used in the production of honey (Y_i); Y_λ and X_λ indicate a point foreseen due to the radial contraction of the input vector X_i. The main purpose of the linear programming above is to reach the minimum. The X_i input vector decreases to X_λ on the condition that the output level Y_λ is constant.

In the second stage, the inverse of the efficiency scores is applied to elicit the assumption of the truncated regression. The regression model is as follows:

$$\hat{\delta}_i = z_i' \beta + \varepsilon_i \tag{2}$$

where z is a (NxK) matrix set of nondiscretionary variables, β is a vector set of associated parameters to be estimated, and ε_i is a continuous independent and identically distributed (iid) random error term, while. Given the requirement for $\geq 1-$, ε_i is normally distributed at $(1-)$ with left cutoff (truncation) and standard deviation.

Examining these effects can help managers improve their decision-making processes and allow them to evaluate the cost and profitability of each choice that can be made. However, this second stage has some flows when applied with DEA, as the estimated efficiency scores are biased and serially correlated, and the environmental and contextual variables to be used in the second stage affect the output and the input. Furthermore, the two-stage bootstrap procedure proposed by [29] is applied, which allows for consistent inferences within the models, describes the efficiency scores, and estimates the standard errors and confidence intervals for them. Then, the adoption of a maximum likelihood estimation and bootstrapped resampling procedure removes the multicollinearity hurdles between efficiency scores and provides robust results.

3. Results and Discussion

In descriptive statistics, income, cooperative membership, and veterinary benefit are significant at the 1% significance level, while all other variables are not significant. Income is an important variable in terms of the continuity of the activity, and its significance confirms the analysis. Income is the most important economic factor and determines the continuity of the business. Cooperative membership is meaningful as it supports beekeepers in the supply of inputs and product sales. Membership in the beekeeping association turned out to be meaningless and shows that it has no positive or negative effects. Ref. [3] (2011) found statistical significance in the study they conducted for the TRA2 region to determine the factors affecting the increase in yield in beekeeping, the status of being a member of the beekeepers' union, and the honey yield of the enterprises whose sole source of income is beekeeping. Benefiting from veterinarians is an important variable in terms of technical support in beekeeping (Table 2).

Table 2. The significance of the descriptive factors.

		%10 *		%5 **		%1 ***	
		5%	**95%**	**2.5%**	**97.5%**	**0.5%**	**99.5%**
(Intercept)	−2.9473	−4.4491	−2.1367	−4.8595	−1.7235	−5.2865	−0.8741
City	0.0867	0.0589	0.1218	0.0399	0.1122	0.0244	0.1241
Elmnschl	0.1855	0.1418	0.2422	0.1361	0.2527	0.1083	0.2667
Hghschl	0.1904	0.1434	0.2527	0.1334	0.2666	0.1034	0.2804
Clgschl	0.2224	0.1682	0.3011	0.1453	0.3064	0.1058	0.3284
Age	0.0033	0.0022	0.0046	0.0019	0.0048	0.0014	0.0051
BHSize	0.0489	0.0396	0.0631	0.0384	0.0671	0.0325	0.0717
LnIncome ***	0.0035	−0.0102	0.0188	−0.0142	0.0224	−0.0208	0.0263
BRS	−4.7544	−7.1401	−4.0103	−7.0656	−3.1662	−7.5887	−2.1242
Unionmembr	4.8937	4.1458	7.2920	3.3157	7.2618	2.2466	7.8129
Coopmembr ***	−0.0116	−0.0410	0.0200	−0.0328	0.0376	−0.0472	0.0529
Accointicg	0.0751	0.0510	0.1069	0.0545	0.1246	0.0387	0.1358
Cobother	0.0977	0.0759	0.1312	0.0786	0.1472	0.0543	0.1552
Sclscrty	1.5900	1.2141	2.2463	1.0177	2.4246	0.6250	2.6034
Vtrnaid ***	−0.0198	−0.0455	0.0118	−0.0559	0.0129	−0.0639	0.0302
sigma	0.0373	0.0345	0.0454	0.0325	0.0470	0.0304	0.0491

Note: *, ** and *** show statistically significance level at 10%, 5% and 1%.

The fact that the city variable is insignificant indicates that there is no difference between cities in terms of beekeeping activities. Again, the education variable (primary, secondary, high school graduate) turned out to be insignificant in beekeeping and shows that the work performed is not related to non-vocational education [30]. In the study conducted for organic beekeeping and honey production in the Iğdır region, no relationship was found between income and education level. Again, in the study of [31] (2021) in the Amasya region, no relationship was found between education and income, and they stated that this was due to the fact that more time was devoted to business life. The number of family members does not affect the beekeeping activity positively or negatively. It is understood that keeping records in beekeeping, keeping income and expense records, having other income sources, and having social security does not have an effect on beekeeping activities (Table 2).

Dea in Fixed and Variable Income by Scale

Technical efficiency was calculated as 65.7% in the analysis made with raw data (without bootstrap) at a constant return to scale. In other words, beekeeping enterprises work ineffectively at a rate of 34.3%. In the analysis made with bootstrap data, the technical efficiency was found to be between 56.9% and 64.6%, with an average of 60.5%. In other words, beekeeping enterprises work ineffectively at a rate of 39.5% (Table 3).

Table 3. Descriptive stat for efficiency scores for CRS and VRS.

	CRS *						VRS **					
	Mean	**Std. Dev**	**Min.**	**Max.**	**Obs.**	**Disc.**	**Mean**	**Std. Dev**	**Min.**	**Max.**	**Obs.**	**Disc.**
eff	0.657	0.176	0.204	1.000	295	0	0.716	0.177	0.310	1.000	295	0
bias	0.051	0.039	0.011	0.252	295	0	0.070	0.048	0.015	0.226	295	0
bceff	0.605	0.152	0.193	0.957	295	0	0.646	0.142	0.29	0.932	295	0
stdrbceff	0.033	0.041	0.006	0.431	295	0	0.053	0.061	0.008	0.398	295	0
LowerCI	0.569	0.141	0.184	0.913	295	0	0.598	0.126	0.276	0.896	295	0
UpperCI	0.646	0.172	0.201	0.987	295	0	0.706	0.174	0.306	0.991	295	0

* CRS = Constant Returns to Scale; ** VRS = Variable Returns to Scale.

In the analysis performed with raw data (without bootstrap) with variable returns to scale, technical efficiency was calculated as 71.6%. In the analysis made with bootstrap data, the technical efficiency was found to be between 59.8% and 70.6%, on average 70.0%. In other words, businesses with variable returns to scale operate inefficiently at a rate of 30.0% (Table 3).

In the analysis performed without bootstrap at a constant return to the scale, there is no enterprise with technical efficiency between 0–20%, and 20 enterprises operating at 100% technical efficiency were calculated. There are two enterprises with a technical efficiency of 30% or less. There are 170 enterprises with technical efficiency between 40% and 70%, and they constitute 57.6% of the total enterprises (Table 4). The distribution of technical efficiency (Eff.crs) without bootstrap at a constant return to scale is shown graphically in Figure 2. It is also seen in Eff.crs that the efficiency limits are the highest at 1.000 and the lowest at 0.200 in the analysis for all businesses.

Table 4. Distribution of technical efficiency in beekeeping businesses.

	CRS		VRS	
Efficiency Range	**Without Bootstrap**	**With Bootstrap**	**Without Bootstrap**	**With Bootstrap**
0 < eff ≤ 10	0	0	0	0
10 < eff ≤ 20	0	1	0	0
20 < eff ≤ 30	2	1	0	1
30 < eff ≤ 40	15	22	5	13
40 < eff ≤ 50	41	58	30	37
50 < eff ≤ 60	62	70	51	68
60 < eff ≤ 70	67	57	67	60
70 < eff ≤ 80	44	48	50	64
80 < eff ≤ 90	31	32	36	49
90 < eff ≤ 100	33	6	56	3
eff = 100	20	0	38	0

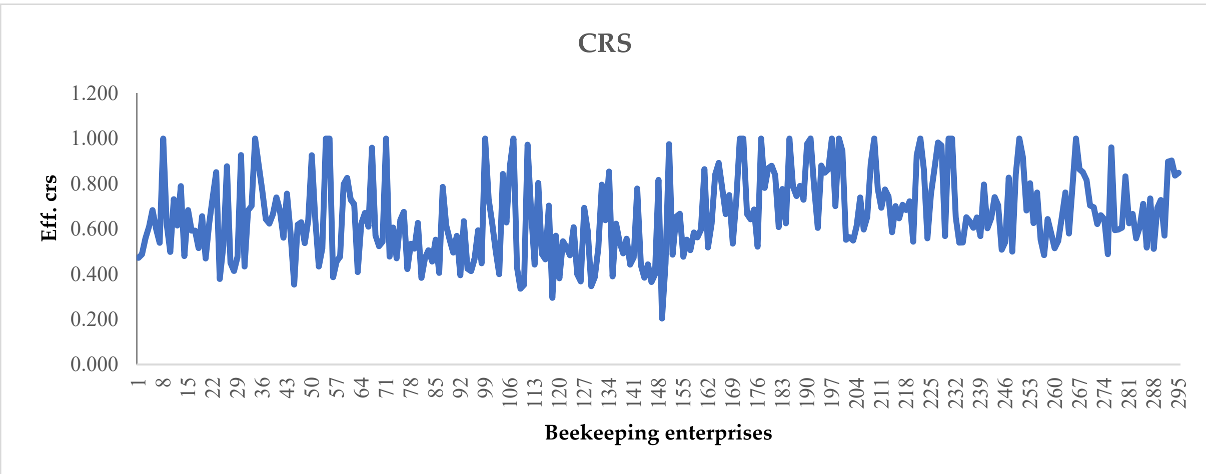

Figure 2. Technical efficiency limits in the analysis performed without bootstrap at constant return to scale.

In the analysis performed with bootstrap with a constant return to scale, there is no business between 0–10% and 100% technical efficiency. There are two enterprises with a technical efficiency of 30% or less. There are 185 enterprises with technical efficiency between 40% and 70%, and they constitute 62.7% of the total enterprises (Table 4). In Figure 3, the distribution of technical efficiency with bootstrap at a constant return to scale (BCeff.crs) is shown graphically. According to Figure 3, BCeff.crs showed a different distribution from the Eff.crs distribution seen in Figure 2. There are no businesses that reach the 1.000 level.

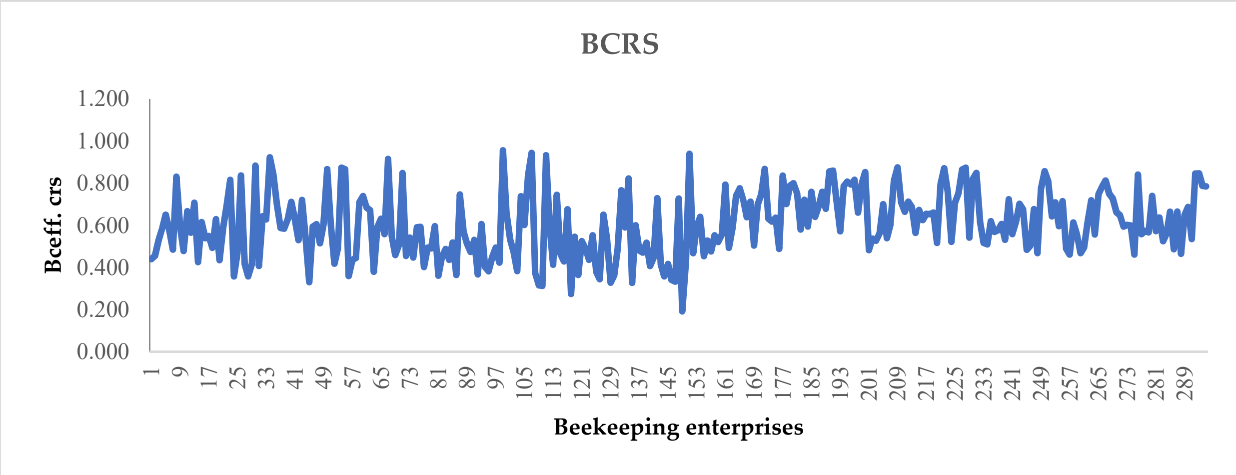

Figure 3. Technical efficiency limits in the analysis performed with bootstrap at constant return to scale.

In the analysis performed without bootstrap with variable returns to scale, there is no business with 0–30% technical efficiency, and 38 businesses operating at 100% technical efficiency were calculated. There are five businesses with 40% technical efficiency. There are 168 enterprises with a technical efficiency of 50–80%, and they constitute 56.9% of the total enterprises (Table 4). In Figure 4, the distribution of technical efficiency without bootstrap (Eff.vrs) at variable returns to scale is shown graphically. There are many businesses that are at the 1000 mark on the Eff.vrs chart.

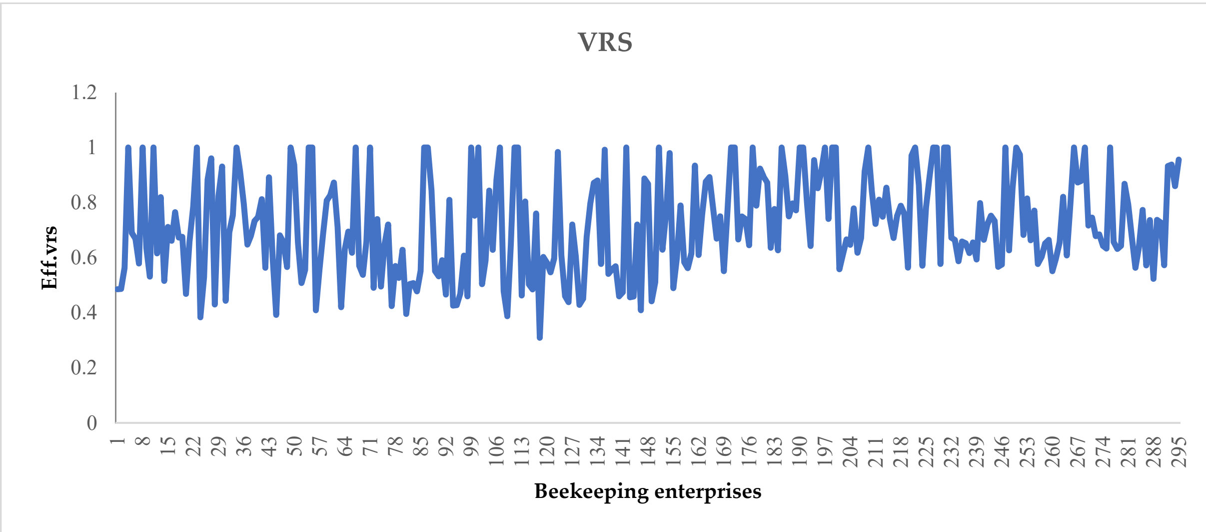

Figure 4. Technical efficiency limits in the analysis performed without bootstrap with variable returns to scale.

In the analysis performed with bootstrap with variable returns to scale, there is no business between 0–20% and 100% technical efficiency. There is one business with a technical efficiency of 30% or less. There are 192 enterprises with a technical efficiency of 50–80%, and they constitute 65.1% of the total enterprises (Table 4). The distribution of technical efficiency with bootstrap at variable returns to scale (Bceff.vrs) is graphically shown in Figure 5. As seen in Graph 5, there are no businesses within the 1000 limit captured by Eff.vrs in Graph 4.

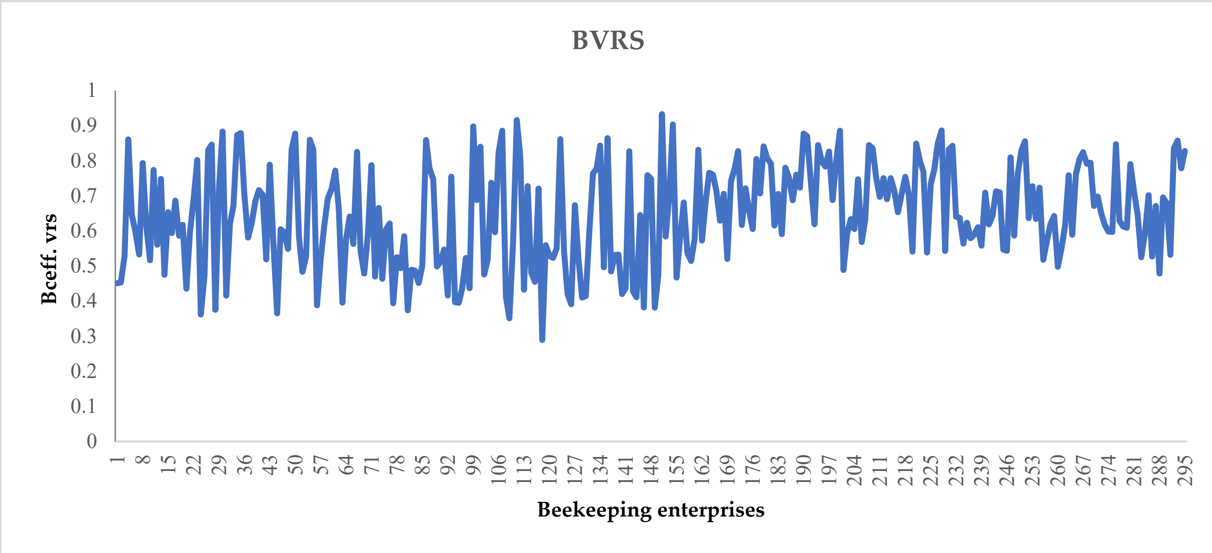

Figure 5. Technical efficiency limits in bootstrap analysis with variable returns to scale.

Efficiency analysis can be performed in terms of input and output. Since it is assumed that inputs can be intervened while performing efficiency analysis in agricultural enterprises, an input-oriented efficiency analysis has been made. In other words, obtaining the same honey production using the least input was analyzed. In an output-oriented analysis, the total efficiency value of the provinces was examined, and it was determined that the number of provinces with full efficiency was 2 (Aydın, Ordu) and the total efficiency value was 0.19 in the model where the honey production amount was taken into account as output [32]. In a study conducted for the province of Hatay in Türkiye, 40 (87%) of the beekeeping enterprises were found to be efficient as a result of the input-oriented BCC method of data envelopment analysis. According to the input-oriented BCC method of beekeeping enterprises, the average efficiency value was calculated as 0.97 [33].

Average honey production in beekeeping enterprises is 2539.237 kg. In the analysis made with bootstrap-free data, the same amount of honey can be produced by saving a total cost of 9512.97 ₺, including 3870.41 ₺ labor costs, 1258.23 ₺ fixed costs and 4384.33 ₺ variable costs, and 56,57 hives in variable return to scale (Table 5). In other words, we can produce the same amount of honey by reducing these cost items when it is fully worked.

Table 5. Savings can be made in the analysis without bootstrap with variable return to scale.

		Without Bootstrap VRS					
		Mean	**Std. Dev**	**Min.**	**Max.**	**Obs.**	**Disc.**
Honeyprod		2539.237	1951.990	200.000	9500.000	**295**	**0**
Labour	**(X1)**	3870.41	3862.62	0	21,853.42	295	0
Fixcost	**(X2)**	1258.23	1411.35	0	8685.43	295	0
Varcost	**(X3)**	4384.33	5751.10	0	32,416.60	295	0
Hivenumbr	**(X4)**	56.57	60.20	0	369.92	295	0

Average honey production in beekeeping enterprises is 2539.237 kg. In the analysis made with bootstrap data, the same amount of honey can be produced by saving 11,674.95 ₺ total cost, including 4689.53 ₺ labor cost, 1557.81 ₺ fixed cost and 5427.61 ₺ variable cost and 71.64 hives in variable return to scale (Table 6). In other words, we can produce the same amount of honey by reducing these cost items when it is fully worked. When these results are considered, the operating profit can be maximized by calculating the effectiveness and saving inputs.

Table 6. Savings that can be made in the analysis performed with bootstrap with variable returns to scale.

		With Bootstrap VRS					
		Mean	**Std. Dev**	**Min.**	**Max.**	**Obs.**	**Disc.**
Honeyprod		2539.237	1951.990	200.000	9500.000	**295**	**0**
Labour	**(X1)**	4689.53	3992.63	269.98	23,026.10	295	0
Fixcost	**(X2)**	1557.81	1480.19	41.80	9239.16	295	0
Varcost	**(X3)**	5427.61	5751.10	78.94	33,587.24	295	0
Hivenumbr	**(X4)**	71.64	63.75	2.23	405.97	295	0

4. Conclusions

In the study, efficiency analysis with and without bootstrap was conducted as a result of face-to-face interviews with 295 beekeepers in the provinces of Van, located in the southeast of Türkiye's Eastern Anatolia region, and Erzincan, located in the west. As a result of the analyzes made for the provinces of Van and Erzincan in the research, it was determined that 34.3% of the enterprises were operating ineffectively in the analyzes without bootstrap at a constant return to scale, while it was found that the enterprises were ineffective at the rate of 39.5% in the analyzes with bootstrap. In variable returns to scale, it is seen that the enterprises are ineffective at a rate of 30.0%.

In the analysis performed without bootstraps with variable returns to scale, 2,539,237 kg of average honey amounted to 3870.41 TRY labor costs, 1258.23 TRY fixed costs, and 4384.33 TRY variable costs, a total of 9512.97 costs and 56.57 hives savings can be achieved. In the analysis made with bootstrap with variable returns to scale, the average amount of honey produced was 2539.237 TRY as labor costs of 4689.53 TRY, fixed costs of 1557.81 TRY and variable costs of 5427.61 TRY in total, 11,674.95 TRY costs and 71, We can produce 64 by reducing the number of hives.

In the analyses made with the data with and without bootstrap, the same amount of honey can be produced by making significant savings in the inputs according to the variable return to scale. More income can be obtained by increasing the efficiency and effective use of resources. In this regard, income increase can be achieved by providing training on the effective use of resources to all farmers, especially in the provinces of Erzincan and Van, where research was conducted.

The majority of Türkiye's population lives in the western region. As local flavors and products come to the forefront by preserving the natural life in the eastern provinces, domestic and international tour arrangements to provinces Erzincan and Van have increased in recent years. The honey produced in provinces Erzincan and Van is first offered to tourists in breakfast presentations. In addition, incoming tourists buy a significant amount of honey produced in high quality at high altitudes. This increases the demand for honey and honey products in the region. If the efficiency of beekeeping enterprises is increased, honey production will increase and meet the increasing demand. The producer who provides an increase in income economically will produce more. In this way, it is thought that the tourism sector, especially in rural areas, such as API tourism and gastronomy tourism, will increase and strengthen both by protecting ecology and supporting rural development.

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