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An empirical analysis of technical efficiency determinants in beekeeping farms: evidence and policy implications from Niğde Province, Turkey

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Abstract: Turkey has huge honey production potential. However, traditional production mode negatively affects the total production and productivity. The purpose of this study was to analyse the determinants of technical efficiency of beekeeping farms. This paper also aimed to examine the association between beekeeping subsidies and farm efficiency using stochastic frontier analysis on beekeeping farming. In this study, it was used primary data from 54 producers in Nigde province in 2017. Producers were selected through stratified sampling method. According to results, the mean technical efficiency of the beekeeping farms is 0.57. The beekeepers were found to be generally fairly inefficient. This implies that there will be need to develop new technologies to raise productivity. The most important factors, which determine technical inefficiency, are the existing of pure race bee in colony, education level of farmer, hive numbers, beekeeping subsidies, age of farmer, type of beehive and the number of migratory activity. The result revealed that pure race bee in colony had a great impact on beekeeping productivity. According to inefficiency model result, the government subsidy scheme for beekeeping had a net negative impact on the technical efficiency of beekeeping farm. For this reason, integrated development efforts and implementation of policies, which will develop the technology that will enable to use resources more efficiently in agriculture, have great importance to improve the sector.

Keywords: beekeeping, technical efficiency, subsidies, stochastic frontier analysis.

Introduction

Beekeeping farming has gained importance depending on increasing of demand to apicultural products all over the world. Beekeeping activity not only makes rural labour productive, but also makes destroyed natural resources valuable. Beekeeping is a production line that can be done continuously without consuming resources and is an important tool of sustainable rural development. Turkey has a great beekeeping potential in terms of its geographical structure, diversity of plants and nectar sources which are well suited for the production of honey. According to FAO 2017 data, 8.3 million colonies of 91 million and 105 thousand tonnes honey of 1.8 million tonnes were produced in Turkey in 2016 year. Turkey is the 2nd for honey production after China and 3rd for beehives after India and China in the world. Although Turkey is one of the most important honey producer countries, the average yield, which is 13 kg per hive, is quite low than the yield of other main producer countries such as China, USA, Russia and Canada (55 kg/hive, 27 kg/hive, 20 kg/hive and 57 kg/hive, respectively). In Turkey, there are many technical and economic problems in beekeeping sector, especially the low productivity (Cevrimli and Sakarya, 2018). On the other hand, the beekeeping sector in Turkey has not been supported sufficiently by the government policies implemented to livestock sector until today. Turkish government has started to support the sector for the purpose of encouraging bee raising and honey production since 2003. Support for beekeeping activity has been determined within the scope of the decree of animal husbandry support from 2005. Beekeeping activity was supported by subsidies and honey premium for beekeepers purchasing and using young queen until 2008. Since this year, these supports have been removed and beekeeping farmers have been paid subsidy per hive on the condition that farmers are registered in the Beekeeping Registration System. In this period, beekeeping subsidies for per hive has been increased from 5 TL to 10 TL. Although it is provided subsidy to beekeeping farmers, there are still many beekeeping farmers use low-efficiency technology, which in turn leads to low productivity and production levels.

The efficient use of the production factors with adaptation of new technologies is crucial in terms of meeting the raising food demand, increasing the living standards of farmers, making agriculture more efficient and ensuring agricultural development. Improving efficiency can have a twofold positive effect. First, efficiency gains will enhance the viability of individual farms and the industry as a whole, leading to an improved socio-economic status of rural people. Second, improved efficiency can lead to the conservation of resources, as well as reductions in the use of inputs leading to positive impacts on environmental health.

Another crucial issue according to policy makers is whether agriculture sector will be more efficient or not, as well. For these reason, the impact of agricultural support policies on farms' economic performance is an important question for policy makers. Economic performance can be studied by efficiency measures such as technical efficiency (TE) and productivity (Coelli *et al.*, 2005). Technical efficiency refers to the capacity of a farm to make efficient use of the existing technology, that is, either to produce at the maximum level with a given set and level of inputs or to use the minimum level of inputs to produce a specific level of output (Minviel and

Latruffe, 2017).

In general, agricultural subsidies do not aim explicitly at improving technical efficiency but instead aim at increasing production, supporting farmers' income or favouring the production of specific outputs including environmental outputs. It is largely recognized that, conceptually, subsidies can influence the decision making of agricultural producers in terms of input use, labor allocation, production choices, and/or investment (e.g., Guyomard, 1996; Hennessy, 1998; Sckokai and Moro, 2009; Latruffe *et al.*, 2016).

On the other hand, subsidies can increase TE if they provide an incentive to innovate or switch to new technologies (Harris and Trainor, 2005), or decrease TE if higher income from subsidies weakens the motivation in the form of slack or lack of effort (Bergström, 2000). However, if subsidies have the side effect of decreasing farm technical efficiency, this may lead to the question of whether a more effective way of supporting farms might exist (Minviel and Latruffe, 2017).

Therefore, how much and in what direction the subsidies affect farm performance is an empirical question. Several authors studied the effects of public subsidies on farm technical efficiency and found a negative effect in Hungary for crop (Bakucs *et al.*, 2010), India for crop (Dung et al., 2011), England for sheep, cereals, mixed farming and other crops (Hadley, 2006), Spain for beef cattle (Iraizoz *et al.*, 2005), Norway for cereals (Kumbhakar and Lien, 2010), United States for dairy (Lachaal, 1994), Sweden for dairy, beef cattle, pig (Manevska-Tasevska *et al.*, 2013), Greece for crop and livestock (Rezitis *et al.*, 2003) farms. Others found that subsides affected TE as positively in Denmark for dairy (McCloud and Kumbhakar, 2008), in England for dairy and beef cattle (Hadley, 2006).

In Nigde province, farmers have a long tradition of beekeeping and the province has huge potential for multi-floral honey production. However, traditional production mode still dominates the sub sector which negatively affects the total production and productivity. A number of studies have been conducted to better understand the honey production economics in Turkey (e.g.Vural and Karaman, 2009; Saner *et al.*, 2004; Aksoy *et al.*, 2017; Çiçek. 1993; Ören *et al.*, 2010); however, there are not any studies which investigate the assessment of subsidies on technical efficiency in the beekeeping farming.

For this reason, this paper aims to investigate to the extent of technical efficiency and identify the factors that affect the efficiency of the sector in Nigde province. Also the study examines the link between current sector-specific subsidies and technical efficiency for beekeeping farming. Determining which key factors influence the efficiency level is important to the beekeeping farmers as well as to the public policy makers. Understanding the factors that affect technical efficiency is a useful tool in exposing potential opportunities, increasing productivity and conserving resources. Knowing the determinants of technical efficiency in beekeeping farms will be a guide for draft specific and well-defined apiculture policies, which would increase technical efficiencies and the competitiveness of beekeeping farms. Ultimately, improving efficiency will ensure to develop of apiculture sector in the country.

Material and Methods

The primary data used for the study were collected during the 2017 production year through structured questionnaires by interviewing face to face with 54 producers in Nigde province. According to TURKSTAT 2017 data, 500 tonnes honey from 40 595 colonies were produced in Nigde. The number of beekeeping farmers has reached to 450 by increased 6.25 times comparing with 2010. However, the honey production amount of the province is not the desired level, although it has an appropriate fauna and climate structure. The honey production of the province constitutes only 0.44% of the whole country.

A multi-stage sampling technique was used for the study. The first stage was to identify the sample beekeeping farms size by using the stratified random sampling model and it is formulated as (Yamane, 1967):

$$n = \frac{\sum(NhSh)^2}{N^2 D^2 + NhSh^2}$$

where: n = sample value, Nh = unit number at layer h, Sh = standard deviation of the layer h, N = number of total units, D = d/Z, d = deviation from the mean number (5%), and Z = t value for (N-1) degrees of freedom and at a confidence limit (95%).

The second stage was to use a purposive sampling to get a respondent, since efficiency analysis requires firms working under similar conditions.

The value of honey output and other beekeeping products (in quantity and later in money terms) was obtained by adding cash receipts from honey sold to those consumed in the households, and those released as gifts. Data on the level of production inputs used were also obtained. Since efficiency analysis requires firms working under similar conditions, villages were selected purposively.

In the technical efficiency analysis, the two productions –comb honey and extracted honey (kg/hive) - were considered as output variables. The other apiculture productions such as wax, propolis, royal jelly were found to be negligible. On the other hand, the inputs consisted of six major components: total feed (kg/hive), medicine expenses (TL/hive), total labor force (man hours/hive), other variable costs (TL/hive), and annual capital costs (TL/hive).

Total feed variable included cake and sugar syrup. Labor variable comprised both family and hired labor used in beekeeping farming included maintenance and guarding works during whole production season and was expressed as man hours per hive. The annual capital cost covered depreciations, interest on capital. The other variable cost covered related operating costs such as honeycomb, honey pot, frame, wire, packing, transporting, baiting, maintenance and repair of equipment.

The summary statistics of the variables used in the model were presented in Table 1. The table showed that the mean output (yield) was 9.23 kg per hive while the maximum and minimum yields were 3.54 kg and 40.00 kg per hive respectively. The average feeding material requirement per hive was 7.21 kg ranging from 2.5 kg to 18.33 kg. The average medicine cost was 2.40 TL per hive. Besides, average labor use per hive was 15.61 hours ranging from 6.56 hours to 36.96 hours per hive. The average expenses for queen purchasing, other variable and fixed costs per hive were 0.23 TL, 25.62 TL and 54.69 TL, respectively.

Table 1 - Summary statistics for variables used in the efficiency analysis

Variable	Minimum	Maximum	Mean	Std. Deviation
Output				
Honey (kg/hive)	3.54	40.00	9.23	6.91
Inputs				
Feed (kg/hive)	2.50	18.33	7.21	2.75
Medicine (TL/hive)	0.01	8.00	2.40	1.91
Labour (man hours/hive)	6.56	36.96	15.61	7.20
Other variable costs (TL/hive)	3.85	79.42	25.62	15.03
Fixed costs (TL/hive)	41.40	72.87	54.69	7.66

Furthermore, data on the farmer-specific (inefficiency) factors were also collected. They included hive numbers, the rate of received subsidy in total gross honey income, the race of bee, type of hive, age, education level of farmer and the number of migratory activity. When farm-level data are used, the method commonly employed by researchers to assess the impact of subsidies on farm efficiency is a regression of efficiency scores on a variable representing the farms' dependence on subsidies. In the literature, this is proxied either by the value of total subsidies received, or by the share of farm income stemming from government support, or by a ratio relating the amount of subsidies to the level of output or gross margin in order to control for size effects (Latruffe and Desjeux, 2016). In this study, subsidy rate was calculated as the share of beekeeping subsidies received in total gross honey production value for each farm. The number of migration activity refers to the number of times the colony location changed during a beekeeping season to reflect the flora differences.

Inefficiency model consisted of three dummy variable related to education level, pure race bee and hive type. The dummy for education level of farmer was taken the value one if farmer had a higher education and zero otherwise. Similarly, race of bee in colony is one of the important determinant of efficiency. For this reason, it was used dummy variable to represent the differences between pure and hybrid race of bees in the colony. If colony consisted of pure race bees then the variable took value one and zero otherwise. The dummy variable of type of beehives reflects the differences in the sizes of hive. Surveyed farmers used two types beehive in the research area. These were Dadant, which consisted of 12 frames, and Langstroth, which consisted of 10 frames. If the type of beehive was Dadant, the dummy variable took the one value and zero otherwise.

Efficiency is generally measured using either nonparametric methods such as data envelopment analysis (DEA) or parametric such as stochastic frontier analysis (SFA), which involve mathematical programming and econometric methods, respectively. Both methods have different merits and these methods have developed rapidly with extensive empirical applications in recent years. Since there is not yet obvious methodological and empirical support to the selection of the appropriate method for a particular problem, there have also been a number of comparative studies comparing the relative efficiency measures of the two methods (see e.g. Yu, 1998).

The agricultural production is assumed stochastic, highly related to the unpredictable natural/environmental conditions, thus the alternative nonparametric Data Envelopment Analysis (DEA), which is highly sensitive to data noise, was considered less appropriate to be applied. Parametric methods include deterministic frontier production functions, stochastic frontier methods, and panel data models (Battese, 1992). The stochastic frontier function was specified as a log linear Cobb-Douglas production function (Aigner and Chu, 1968), which is derived for the beekeeping farm in this study. This study estimates the relative technical efficiency in its input-orientation (Coelli *et al.*, 2005), and explains the possibilities for improvements in the farms output by keeping the inputs fixed. Technical efficiency is estimated relative to the best performing farms included the data sample for each specialization. In this study, we adopted the model proposed by Battese and Coelli (1995), where the production function and exogenous effects influencing technical efficiency are estimated simultaneously. This model is represented as follows:

$$Yi = Xi\,\beta + Vi - Ui \qquad (1)$$

In Equation (1) Yi denotes the production of the i-th decision unit, β represents a (K x 1) dimensional vector of input parameters to be estimated, and Xi is (K + 1) row vector. Its first element is "one". There are 2 disturbance terms in this equation: Vi and Ui. The random error (Vi) accounts for measurement errors, other random factors, and effects of other unspecified input variables in the production function. On the other hand, Ui is a nonnegative random variable associated with inefficiency. Vi terms are assumed to be independently and identically distributed N (0, σv^2) random errors, independent of the Ui s; Uis are non-negative random variables, which are also assumed to be independently and identically distributed and truncated at zero of the normal distribution with mean μ and variance σu^2. A Cobb-Douglas production function was assumed for simplicity and convenience.

The maximum likelihood estimates for all the parameters of the SFA were estimated with FRONTIER version 4.1 software (Coelli, 1996). This software estimates the $\gamma = \sigma^2 / \sigma s^2$ parameter, which takes a value between zero and one. A value of $\gamma = 0$ indicates that the deviations from the frontier are due entirely to noise, while a value of one would indicate that all deviations are due to technical inefficiency.

The ratio of the observed output of the i-th farm relative to the potential output estimated by equation (1) provides the technical efficiency of i-th farm. Hence technical efficiency denoted by TEi is given by:

$$TEi = \exp(-ui) \qquad (2)$$

The value of the estimated technical efficiency coefficients ranges between 0 and 1, and denotes for farm efficiency between 0% - 100%.

In the efficiency analysis, it is important to determine the effects of external factors on efficiency. The Inefficiency Factors (TE Effects) Model was used to determine the effects of external factors on efficiency. In this model, efficiency scores and external variables that can cause inefficiency take part together, and production frontier and effects of external factors that can cause inefficiency are examined as a single stage. The Inefficiency Factors Model is obtained in the equation (3) when 'U' that is in the equation (1) is put into the model as a linear function of external variables. In the equation (3), 'Z' is the explanatory external variables vector and 'δ' is the variable coefficient in the vector.

$$Yi = \beta^* Xi + Vi - (\delta i^* Zi) \qquad (3)$$

The application of frontier models to investigate farm technical efficiency in agriculture has received considerable attention by researchers around the world (Battese, 1992; Bravo-Ureta *et al.*, 2007; Latruffe *et al.*, 2016). Since it can readily incorporate the technical efficiency component, a stochastic frontier function is preferred mostly. The stochastic production frontier gives the maximum level of output producible given inputs, the technology, and the production environment (Kumbhakar, 1987). The purpose is to determine a possible increase in the amount of honey production without changing the inputs.

Results

Maximum likelihood results of stochastic frontier analysis are shown in Table 2. All production parameters were statistically significant. All variables except medicine had positive signs in line with a priori expectation. This implies that as these variable inputs increase, the output of honey also increases. Negative sign of medicine variable indicates an out of optimal usage of this input. Since log-linear model was employed, coefficients represented elasticity of honey output with respect to respective inputs. Labor had the greatest contribution to honey output by 0.565. This implies that the increasing by one percent on labor could raise the honey production by 0.57%. The coefficient for feed was 0.385 signifying that a unit increase of feed added to what was obtainable could lead to an increase in yield of honey production of up to 0.39%. Other variable costs included operating costs and fixed costs covered capital costs followed this with 0.31% and 0.31% respectively. This means that labor and feed were significant determinants of output of honey for beekeeping farming.

Highly significant gamma statistic indicated the presence of a high systematic inefficiency and implied that 99% of the variations in honey production could be attributed to inefficiencies.

Table 2 - Model results of stochastic frontier and inefficiency

Variables	Parameters	Estimated value	t-statistics
Stochastics frontier			
Constant	β_0	-1.704	-1.784*
Ln (feed)	β_1	0.385	4.681***
Ln (medicine)	β_2	-0.024	-1.926*
Ln (other variable costs)	β_3	0.308	6.282***
Ln (labor)	β_4	0.565	3.771***
Ln (fixed costs)	β_5	0.306	2.042**
Inefficiency model			
Constant	δ_0	1.117	1.666*
Hive numbers	δ_1	-0.003	-2.189**
Subsidy rate in gross honey income	δ_2	0.040	1.883*
Dummy (bee species; the pure race of bee :1; other:0)	δ_3	-0.759	-14.836***

Table 2 - continued

Variables	Parameters	Estimated value	t-statistics
Dummy (type of hive; Dadant with 12 frames: 1; Langsroth with 10 frames:0)	δ_4	-0.391	-0.462
Age of farmer	δ_5	0.005	0.664
Dummy (education of farmer; high school :1; other:0)	δ_6	-0.298	-4.088***
The number of migration activity	δ_7	-0.120	-0.857
Variance parameters			
	σ^2	0.141	4.572***
	γ	0.999	89797.249***
Log-likelihood function	-	-5.889	-

(***): Significant at 1%; (**): Significant at 5%; (*) Significant at 10%

Various restrictions were imposed on the model defined by equation 1. To check whether these restrictions were valid or not, the generalized likelihood ratio tests were used. The results of these tests of hypothesis for parameters of the stochastic frontier and inefficiency effects model for beekeeping farmers in Nigde province were presented in Table 3.

Table 3 - Hypothesis tests for SFA

Test No.	Null hypothesis	Log likelihood value	t-statistics	value	Decision
1	H_0: Cobb-Douglass=Translog	-5.89 -1.81	8.16	13.28	H_0 Accepted
2	H_0: $\gamma= \delta_0=\ldots= \delta_7=0$	-20,51	29.24	20.09	H_0 Rejected
3	H_0: $\gamma=0$	-20,41	29.04	15.09	H_0 Rejected
4	H_0: $\delta_1=\ldots= \delta_7=0$	-19,20	26.62	18.48	H_0 Rejected

The result of the first null hypothesis related to the functional form was presented in Table 3. The null hypothesis was accepted, and it was concluded that Cobb-Douglas production function was a representative model in stochastic frontier.

In Table 3, the second null hypothesis tested was that technical inefficiency effects were absent from the model. The omission of Ui is equivalent to imposing the restriction specified in the null hypotheses i.e. Ho : $\gamma = \delta_0 = \delta_1 = \delta_2 = ... = \delta_7 = 0$

When this restriction was imposed on the model represented by equation 1 and 2, the value of the logarithm of the likelihood function reduced to -20.51. This provided generalized likelihood ratio (LLR) test statistic of 29.24, which was larger than the critical value range of 20.09. Thus we rejected the null hypothesis of no technical inefficiency effects, given the specifications of the stochastic frontier and inefficiency effect model.

The third null hypothesis or resection considered in Table 3 was that the model was an average response model. This was rejected since estimated generalized likelihood ratio (LLR) test statistic was significantly different from zero at 1%. This implied that the ordinary average response function was not a suitable specification of beekeeping farming in the area. If gamma is close to zero, the differences in the production will be entirely related to statistical noise, while if gamma close to one reveals the presence of technical inefficiency. The estimate of parameter (0.999), which measured the variability of the two sources of error, suggested 99.9 % of the total variation of total production related to inefficient error term and 0.1 % of the total variation attributed to the stochastic random errors. This implied that the variation of the total production among the different farmers was due to the differences in their production inefficiencies, indicating that traditional production function ordinary least squares (OLS) was not an adequate representation of our data. The presence of inefficiency was also confirmed by the high values of the contribution of the inefficiency (u) to the total error.

Another question of particular interest to this study was whether the seven specific factors, considered in the inefficiency model, had a significant influence upon the degree of technical inefficiency associated with the beekeeping farmers. Thus a test of null hypothesis that, H0: $\delta_1 = \delta_2 = \ldots = \delta_7 = 0$ was conducted. When this restriction was imposed on the model, the value of the logarithm of the likelihood fraction reduces to -19.20. This provided a likelihood ratio test statistic of 26.62, which was larger than the critical value of 18.48. Thus the null hypothesis that seven specific factors did not have an influence upon the technical inefficiency was also rejected. This indicated that the joint effect of these seven explanatory variables on the levels of technical inefficiencies was significant, although the individual effects of some of the variables were not statistically significant.

Results of the inefficiency model were given in Table 2. Hive number, the rate of subsidies in gross honey income, the race of bee, type of hive, the number of migration activity during a production season, age and education status of farmer were included as inefficiency variables in the analyses. Hive number variable had negative sign as expected and it were found statistically significant at 5% level. The rate of subsidies had negative influence on the technical efficiency (as presented in Table 2, technical inefficiency was increasing) at beekeeping farming. In recent studies, higher dependence on subsidies has usually been associated with farms with lower technical efficiency (Latruffe, 2010; Zhengfei and Lansink, 2006; Manevska-Tasevska *et al.*, 2013). The negative influence of farm subsidization on technical efficiency has usually been explained as a result of farms over capitalization (Brümmer and Loy, 2000) decreasing farmers' motivation to perform well (Bergström, 2000; McCloud and Kumbhakar, 2008; Zhengfei and Lansink, 2006; Zhu and Lansink, 2010), or market imperfections (such as credit problems or risk attitudes) in the agricultural sector (Rizov *et al.*, 2012). When the subsidy payment is substantial, farmers spend more time on other activities which can also negatively affect farm productivity (Kumbhakar and Lien, 2010; Manevska-Tasevska *et al.*, 2013).

The pure race of bee considered as dummy variable of bee species was found to have a positive effect on efficiency and statistically very significant at 1% level. This result is expected since the main indicator of productivity is the race or ecotype characteristics of bee. This finding also is line with Ruttner (1988). Negatively significant coefficient of education implied that higher levels of education decreases inefficiency. Since education has the positive effect of on acquisition of new information, farmers can adopt new agricultural technologies and be able to increase output using the existing recourses more efficiently. This finding was also consistent with the results of other studies from Turkey (e.g., Dudu *et al.*, 2015; Gül *et al.*, 2016; Demircan *et al.*, 2010).

Beekeeping, which is performed by migrating to various regions according to flowering period not depending on stable regions, is named as "migratory beekeeping". There are many reasons for beekeepers to do migratory beekeeping to increase honey production, harvesting honey several times in each year such as flowering period varies by regions, to keep bee colonies from intensive pesticide applied agricultural areas, different climate conditions (Sharma and Bhatia, 2001; Gaga and Esaulov, 2016). In the analysis it was found that the increasing of the number of migrant beekeeping activity affected positively to the technical efficiency but it was not statistically significant. Similarly, the signs of coefficients for type of hive and age of farmer were in line with expectations but these were statistically insignificant.

Technical efficiencies score of farm was estimated from SFA approach and their frequency distributions were summarized in Table 4. The table showed that technical efficiency of sample beekeeping farmers ranged widely below 0.60. Predicted technical efficiencies differed among sample farms, ranging between 0.20 and 1.00, with a mean technical efficiency of 0.57.

Table 4 - Frequency distributions of technical efficiency scores

Efficiency scores	Frequency
=1.00	1
>0.90- <1.00	5
≥0.80-<0.90	4
≥0.70-<0.80	4
≥0.60-<0.70	6
≥0.50-<0.60	8
≥0.40-<0.50	14
≥0.30-<0.40	8
<0.30	4
Total	54
Mean	0.566
Minimum	0.203
Maximum	1.000

Besides, the some characteristics of beekeeping farms was also given in Table 5. Comparing with inefficient farms, the table showed that the most efficient farms consisted of the farmers who were younger and had more experienced and higher education level. Also it was seen that the most efficient farms did the most migratory beekeeping from the table.

Table 5 - The characteristics of beekeeping farms according to efficiency scores

Efficiency scores	0.40<	0.40-0.49	0.50-0.69	0.70-0.89	0.90≥
Farmers' age (year)	53.15	52.85	44.71	45.38	43.50
Farmers' education level (year)	9.31	9.77	8.36	10.75	9.83
Family size (person)	3.62	3.69	3.86	4.38	4.17
Farmers' experience (year)	16.54	22.38	20.14	17.75	24.83
The rate of migratory beekeeping(%)	23.08	30.77	42.86	62.50	66.67

Discussion and Conclusions

This study empirically estimated technical efficiency and determined the factors that influence the efficiency of beekeeping farming by using a stochastic frontier model. The results indicated that the mean technical efficiency (57%) of the sampled respondents was too far from the frontier and it is possible to increase honey production by 43% without changing the amount of input in an enterprise. This implies that there will be need to develop new technologies to raise productivity. The major direct variables (inputs), which will increase production, are labor and feed. This implies that the combined effects of the above stated direct variables will bring about a substantial increase in beekeeping output. This also means that the stable availability of these inputs will provide commensurate beekeeping products.

Results from the model for the inefficiency effects in the production frontier help better understand the determinants of efficiency in beekeeping sector. The existence of pure race bee in colony has a great impact on beekeeping productivity. There are several honeybee races and ecotypes in Turkey but the pure stocks are being hybridized due to migratory beekeeping and commercial queen rearing . These hybrids may have undesirable characters (Akyol and Kaftanoğlu, 2001). For this reason, the pure race bees should be protected in their local zones for the breeding works and the future generations. For this purpose, special isolated zones and mating stations should be established under the supervision of research institutes or agricultural organizations. The controlled breeding works of the different ecotypes' bees and distributing of them to producers will provide to be made beekeeping with the efficient hybrids. Thus, honey productivity can be increased significantly by proper hybridization.

Further, increasing of education level of farmer was found as one of the important determinants of efficiency due to access to information, good farm management and adaptation of new production methods. For this purpose, information on resource management practices should be transferred to the low educated farmers through the adequate extension personnel.

In the study, it was also investigated the links between technical efficiency and subsidies in beekeeping farming. As regards beekeeping farming, it was found that the support payment made per hive in the current system has decreasing effect on the technical efficiency. The negative effects of beekeeping subsidies can be explained by income and insurance effects of subsidies (Zhu and Lansink, 2010). According to farmers, subsidies for beekeeping are considered as an additional income source instead of a production incentive or adaptation of new technologies. For this reason, integrated development efforts and implementation of policies, which will develop the technology that will enable to use resources more efficiently of in agriculture, have great importance to improve the sector and farmers' life standard.

It is also considered that the analysing of impacts of agricultural policies on efficiency and productivity before implementation is expected to positive contribution to the sector.

The major problem encountered in this study was the time and cost of data collection process. For this reason the data covered relatively limited sample size for a just single year due to the lack of accessibility of the farm accounting record-keeping system in Turkey such as FADN. This database should also cover beekeeping farms sufficiently and be provided to access by all stakeholders. Thereby, it can be done a cross-country comparison of entire major beekeeping production zones by using of panel date to enhance the usefulness of these findings.

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