# Measuring the technical and economic efficiencies of the tobacco farms: a case study for Usak Province in Türkiye

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## Abstract

This study aimed to estimate the technical, economic and allocation efficiency levels for tobacco production in the enterprises that include tobacco production in Uşak. For this purpose, efficiency analyzes were performed using the Data Envelopment Analysis method based on the data obtained from the 71 tobacco-growing enterprises. Tobacco yield amount, area, labour force, machine power, fertilizer, pesticide and seed usage levels were used as the main variables in the analyses. Age, education level, household size, experience in tobacco farming, annual tobacco cultivation status, non-agricultural income status, knowledge level in tobacco production, satisfaction level and tendency to continue were included as socio-economic variables in the effectiveness model. The technical efficiency value was determined as 0.794. At this point, enterprises will be able to obtain the same amount of output by reducing the inputs they use by 20.6% on average. As compared to the enterprises that use the input most effectively, the enterprise with the lowest technical efficiency can use its inputs 39.9% effectively. The economic efficiency values of the enterprises varied between 0.099 and 1.000 and were calculated as 0.462 on average. Accordingly, it shows that there are enterprises that produce the same amount of product with 53.80% more cost among the examined enterprises. For tobacco-producing farms, the improvements in production efficiency are more important in terms of gaining income. A positive relationship was found between the efficiency levels and the scale of the enterprise, the rate of use of foreign labour and the rate of cultivation every year.

**Keywords:** Tobacco; Technical efficiencies; Economic efficiencies; Data envelopment analysis; Tobit analysis; Türkiye.

## 1. Introduction

It is known that tobacco differs from other agricultural products in terms of production, use, domestic and foreign trade, and some rules regulating these issues are almost always set by the central or local authorities. Although it is observed that these rules are mostly intended to guarantee the collection of high taxes taken from consumption, it is seen that the decisions to restrict consumption are put into practice due to some other factors such as health, safety and belief (Gümüş, 2009).

With the law numbered 4733 enacted in 2002 in Türkiye, the tobacco market was left to the private sector.

Tobacco is one of the important agricultural products in the historical process in Türkiye. Significant changes took place in the world share of tobacco production and foreign trade in Türkiye in the 1984-2020 period. Accordingly, Türkiye’s share in tobacco production in 2020 was 1.3%. This ratio changed between 2.4% and 4.1% in 1984-1999, between 1.2% and 3.0% in 2000-2008, and between 0.6 and 1.5% in 2009-2020, generally showing a downward trend (Figure 1).

The share of Türkiye’s tobacco export in the world tobacco exports is 3.1% in 2020. Türkiye's share in exports, as well as in the production, has shown a downward trend. The share of Türkiye’s tobacco imports in world tobacco imports is 2.9% as of 2020. Its share in Türkiye's imports, on the other hand, showed an increasing trend (Figure 1).

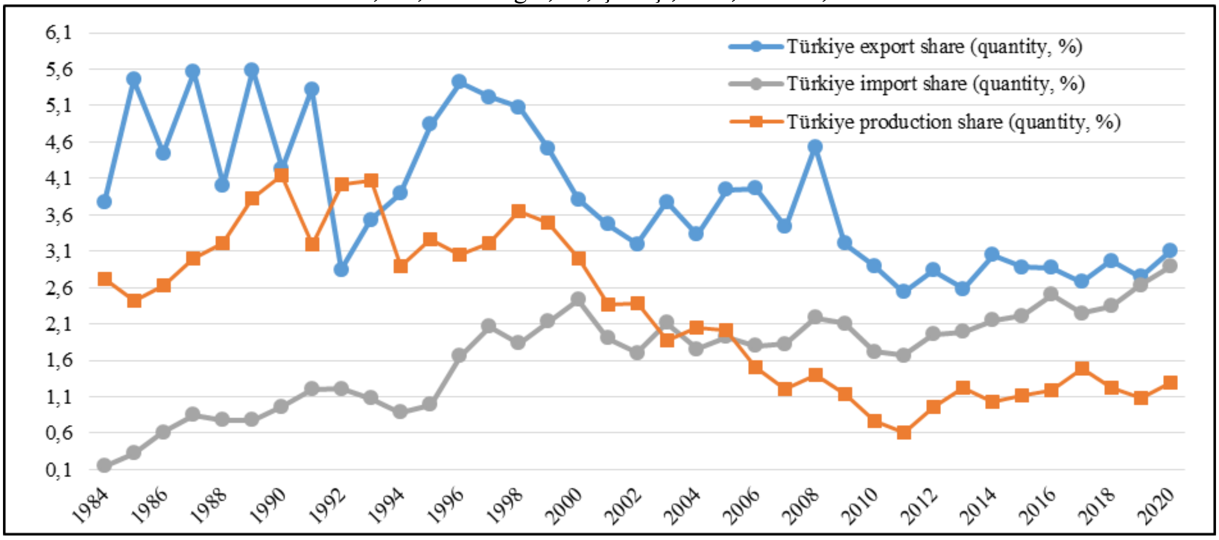


**Figure 1: Türkiye tobacco production and foreign trade share in the world (FAOSTAT, 2022)**

38.3% of the tobacco produced in the world and 63% of it in Türkiye has been exported. From 1984 to 2020, this rate changed between 19.7% and 42.5% in the world, with an average of 30.8%. This rate continues to increase in terms of the world. In Türkiye, this rate showed variations from 22.9% to 162.4% in the years between 1984 and 2020, and averagely it was 74.5% among these years. Türkiye's processed tobacco imports began in 1980, and tobacco imports as raw materials began in 1986. Its share in the world tobacco imports also increased after these years. Türkiye rose to eighth place in the world in terms of tobacco import value. Classically, Türkiye was an important tobacco exporter country. Türkiye's tobacco export amount provides an annual income of 433 million US dollars in the 1984-2020 period. Türkiye's tobacco import amount causes an annual income transfer of 286 million US dollars in the 1984-2020 period. Especially for 2015 and beyond, the import value exceeded the export value. Today, there is a foreign trade deficit of 100 million US dollars. On the other hand, when processed products are added, a foreign trade surplus of 255 million US dollars occurs.

This situation can be understood more clearly in Figure 2, which shows the difference in the export-import amount of Türkiye's tobacco and products and the difference in Türkiye's tobacco export-import values.

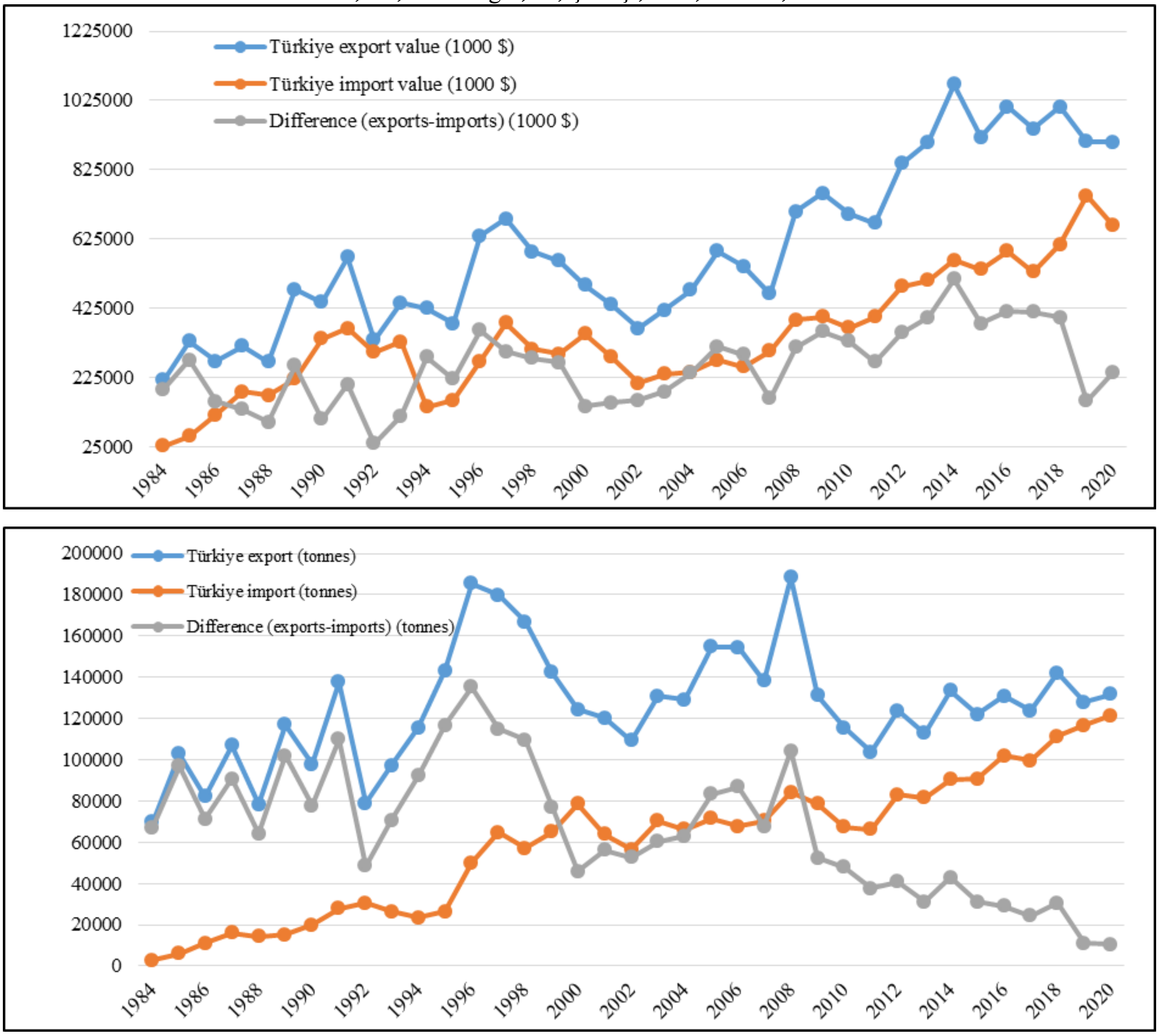


**Figure 2: Türkiye tobacco foreign trade (FAOSTAT, 2022)**

Therefore, tobacco product was chosen as the subject of the study. Along with the change in policies towards tobacco, there was a change in the number of producers. Parallel to the decrease in the number of tobacco producers, there was a significant decrease in the amount of production. Uşak province, which ranks sixth in the tobacco production in Türkiye, was chosen as the research area. While the share of tobacco production in Uşak province in Türkiye was 4.1% in 2004, fluctuations were observed over the years and the production share was 6.3% in 2021.

In this respect, the efficiency of tobacco production in the selected region was discussed. The primary methods used to measure the productivity of production units are divided into two groups. These are parametric and non-parametric methods. In both cases, the principle is to obtain a production limit and measure the efficiency of production units against this limit. The generated production limit represents the maximum output that can be achieved under a given technology. The production limit is calculated econometrically by parametric methods. In non-parametric techniques, a partial linear production limit is calculated using the observed data and there is no need to assume any functional form for the production limit (Battese, 1992; Hansen et al., 2002; Gül, 2005b; Cinemre et al., 2006; Gül, 2006; Gül et al., 2009; Gül et al., 2016; Gül et al., 2018).

In this study, the economic efficiency and technical applications of tobacco production in the sample of Uşak province were examined.

## 2. Literature Review

Studies on the economic structure of tobacco production in Türkiye are available in the literature (Gül and Saluk, 2017; Gül and Saluk 2018; Saluk, 2018; Saluk and Gül, 2018; Gül et al., 2022). However, studies on technical and economic efficiency analysis are limited.

Studies on the technical efficiency of tobacco-growing enterprises were conducted in Türkiye in 2004 (Abay et al., 2004) and 2006 (Ören and Alemdar, 2006). Of these, Abay et al. (2004) conducted face-to-face interviews with 300 tobacco farmers from provinces in the Aegean, Northwest, East-Southeast Anatolia and Black Sea regions, which account for 75% of tobacco production in Türkiye, and determined their efficiency measurements with Data Envelopment Analysis. They calculated the average technical efficiency score for all regions to be 0.456. They found that the inefficiency was not caused by suboptimal production, but by an inability to produce a certain level of output with the least amount of inputs possible. They reported a strong positive relationship between the efficiency of input use and the sustainability of agriculture. On the other hand, Ören and Alemdar (2006) estimated the technical efficiency of tobacco-growing enterprises in the Southeastern Anatolia region using parametric and non-parametric methods. They used data from 149 tobacco-growing enterprises. According to the results of the DEA model, the average efficiency of tobacco-growing enterprises was determined as 0.45 and 0.56. They calculated the average efficiency value obtained with the Stochastic Efficiency Frontier model as 0.54. They found a strong correlation between the results from the Data Envelopment Model and the Stochastic Efficiency Frontier model. They stated that there are significant resource use inefficiencies in tobacco production in Southeastern Anatolia. They stated that the average efficiency score is 0.55 and this result can be increased by 45% with the better use of available resources in the current technology.

In the studies in different countries, Rana et al. (2021) calculated the technical, allocation and cost-effectiveness of farm-level tobacco production in Bangladesh to be 0.85, 0.90 and 0.76, respectively, while the scale efficiency was 0.87. They reported that only 13% of farmers were operating at scale-efficient levels. They attributed the low cost-effectiveness to the excessive use of inputs and an inefficient choice of ratio. They expressed the use of mobile in agriculture and education as a promising factor to increase the efficiency of tobacco production.

Karagiannis and Sarris (2005) calculated the technical and scale inefficiencies of tobacco farms in Greece during the 1991-1995 period using the parametric approach. They found that the degree of technical efficiency is lower than the degree of scale efficiency, and therefore they calculated that a greater proportion of overall inefficiency is due to producing below the production limit rather than producing on an inefficient scale. The vast majority of farms reported that output needed to be expanded to reach optimal scale and exhibited insufficient scale.

Mushtaq et al. (2021) reported technical, pure technical and scale efficiency to be 0.902, 0.961, and 0.938, respectively in tobacco production in Iran with DEA.

Dube and Mugwagwa (2017) evaluated the technical efficiency of small-scale tobacco farmers in the Makoni region of Zimbabwe and the impact of contract farming on technical efficiency using a randomly selected sample of 98 farmers, 78% contract farmers and 22% non-contract farmers. They used stochastic frontier analysis to predict technical efficiency. They calculated that contract farmers had a higher average technical efficiency of 0.94, while non-contract farmers had an average technical efficiency of 0.67. They reported that the overall average technical efficiency of small-scale tobacco farmers in the Makoni region was 0.73, with contractual tobacco farmers being more productive than non-contractual tobacco farmers. They found that the education level of the farmer, the total area of cultivation, and the gender of the farmer were the determinants that significantly increased technical efficiency. They reported that access to loans other than contract farming loans reduced technical efficiency.

Tamba et al. (2015) analyzed the technical efficiency and economies of scale of Virginia tobacco farming in Bali. They analyzed data from 87 farmers using the data envelopment analysis model. They calculated the average technical efficiency to be 0.96 for Virginia tobacco farms in the Buleleng area.

Ilembu and Kuzilwa (2014) measured the technical efficiency of tobacco production and identified some determinants of technical inefficiency for the specified variables. Using the stochastic boundary analysis method, they calculated the technical efficiency to be 0.647. They reported that there is still an opportunity to expand tobacco production using the current level of inputs and technologies available in the region and that two inputs (labour and fertilizer) are misused. They found that the variables of farm size, use of input credits, non-farm income and education negatively affect technical inefficiency. They stated that only the age of the head of the household showed a positive relationship with inactivity. They suggested that participation in the input credit system should be encouraged to increase technical efficiency. They also recommended better extension programs, raising the education level of small farmers and providing farm management training, especially on the correct use of farm inputs, to increase technical efficiency.

According to Faisal et al. (2018) investigated the technical, allocation and economic efficiency of tobacco farmers using dataset collected from 210 farmers from two districts of Pakistan's Punjab Province (Dera Ghazi Khan and Rajanpur). Technical, allocation and economic efficiencies were calculated as 0.90, 0.82 and 0.75, respectively, using the data envelopment analysis (DEA) technique. Results based on Tobit regression analysis determined that for all three activities, household age, education, access to agricultural credit, and communication with extension staff had a significant and negative impact on the inefficiency score. They suggested that the government should take steps to improve the technical training of farmers, meet with extension representatives, ensure the quality of inputs and subsidize small farmers in purchasing inputs.

Kidane and Ngeh (2015) calculated with a stochastic frontier model, the mean efficiency for tobacco farmers was 73.9 percent in Tabora a major tobacco-producing region in Tanzania. They stated that age, education level, household size, and farm size are the main determinants of tobacco farmers' efficiency. They reported that the higher the education level of the farmers was the higher their technical efficiency.

Karagiannis and Sarris (2005) reported that farm debt and direct income transfers negatively affect technical efficiency. They also found a positive and statistically significant relationship between scale efficiency and firm size. They reported that the ratio of the family to the total workforce has a negative effect on technical efficiency but a positive effect on scale efficiency. This means that rental labour is more productive than family labour in achieving maximum output for certain inputs, but vice versa to reach optimal scale. Farmer age reports that it does not statistically significantly affect technical efficiency, but does affect scale efficiency.

According to Chune et al. (2022), Data envelopment analysis calculated the technical efficiency to be 0.49 among tobacco producers in Uganda. They also identified input prices, land size, age of farmers, farm income and farm location as determinants of technical efficiency. They recommended that the government should subsidize agricultural inputs and train farmers on input combinations to increase the level of technical efficiency in the region.

According to Chune et al. (2022) found a positive and statistically significant relationship between farm income and technical efficiency. On the other hand, they reported that it had a negative and statistically significant effect on land size and technical efficiency. In other words, they stated that small farms are technically more efficient than large farms. They found a positive and statistically significant relationship between age and technical efficiency.

## 3. Materials and Methods

### 3.1. Materials

The main material of this research was the data obtained by the survey method from the producers in the villages producing tobacco in the Eşme and Ulubey districts of Uşak. The data used in the research belonged to the 2019 production period.

### 3.2. Methods

With the Neyman Method (Yamane, 2001), one of the Stratified Random Sampling Methods, the number of interviewed producers was 71 farmers. The distribution of these 71 enterprises according to the strata was made using the “Neyman Method” (Çiçek and Erkan, 1996). Considering the frequency distribution of the tobacco cultivation area they own, 3 groups were formed. The first group of enterprises with less than 15 decares of tobacco cultivation (39.44%), the second group of enterprises with 15.1-30 decares of tobacco cultivation (32.39%), and 30.1 decares and more tobacco cultivation holdings constituted the third group (28.17%) (Figure 1).

The “Neyman Method” used for the sampling takes more samples from the layer with high variance. Therefore, we calculated the regional weighted average using the method outlined by Gül (1998) and Gül (2005a).

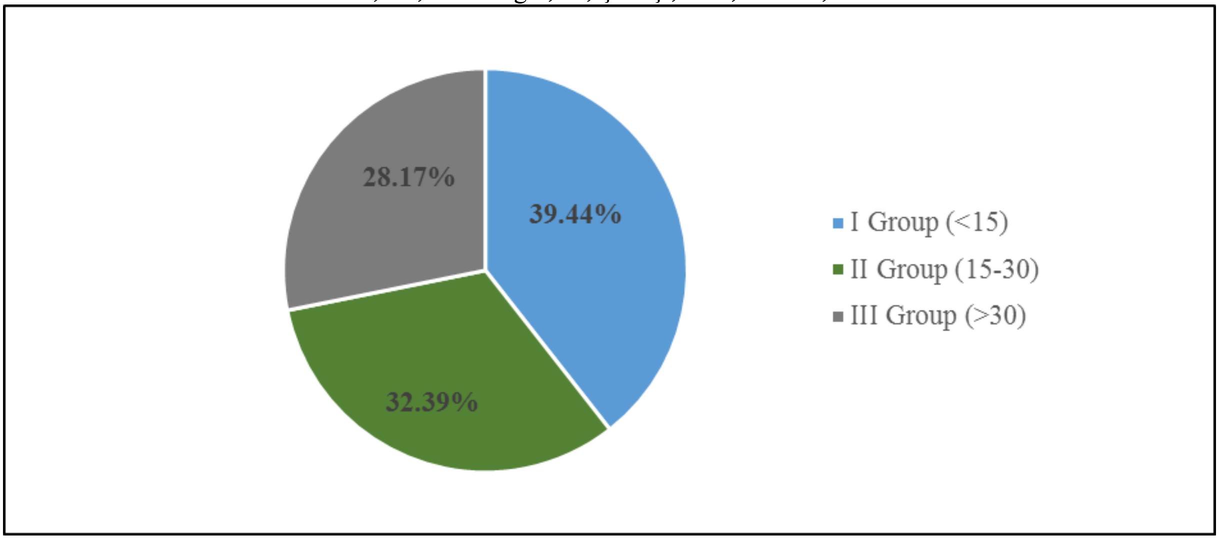


**Figure 3: Interviewed tobacco enterprises**

In the research, Data Envelopment Analysis (DEA) method was applied to reveal the economic and allocation efficiency results of tobacco-producing agricultural enterprises. A large number of computer software has been developed for the efficiency analysis (Coelli 1996). While calculating the activities, DEAP (Version 2.1) software written by Coelli (1996) was used. The activity values were calculated as input oriented. In the efficiency analysis of tobacco production, the variables that are used extensively in the production and expected to affect the production value the most were used. These values were yield per hectare (kg) as output, labour per hectare (hour), machine power (hour), area (ha), fertilizer (kg), pesticide (kg) and seed (kg) amounts. While calculating the economic and allocation efficiency values, the monetary value of the variables used in the model was also taken into account. Thanks to efficiency measurement, enterprises can know their position and success levels in the sectors they are involved in. Technical efficiency (TE) is the success of enterprises that reflects their ability to achieve maximum output from a given set of inputs. Allocative efficiency (AE) is the success of the farms in choosing the necessary inputs for production in the most appropriate way, taking into account the input and output prices and the production technologies applied. By combining these two measures, the general economic efficiency (EE) of the enterprises is calculated (Yolalan, 1993; Coelli et al., 2005). The relationship between socio-economic variables and efficiency values was examined with the help of Tobit regression analysis. In addition, two groups were formed as enterprises below the average economic efficiency score and enterprises above the average, and the explanatory power of socio-economic indicators in these group definitions was examined by logistic regression analysis.

## 4. Results and Discussion

It has an impact on all factors within the enterprises such as the age of the operators in the farms, education level, experience in agriculture, and experience in growing tobacco. The average age of the enterprises interviewed in the research area was 47.24 years. The ages of farms according to the groups were calculated between 44.52 years and 48.70 years. The education period of the farmers was between 6.10 years and 7.57 years in the groups. This value was calculated as 6.63 years on average and 6.74 years on the regional average (Table 1).

The majority of the farmers (63.38%) were primary school graduates, followed by secondary school graduates with 25.35%, high school graduates with 8.45%, and college and university graduates with 1.41%. The average household size in the enterprises interviewed is 3.49 people. The regional average was found to be 3.32 people. Accordingly, the lowest household size varied between 3.10 and 3.68 people.

The average experience of the operator in agricultural production was found to be 24.73 years, and the regional average was 24.64 years. The period of experience in agricultural activity in the interviewed enterprises was between 22.30 years and 26.21 years (Table 1).

The farms had an average of 4.03 head of cattle and 1.76 head of sheep and goats. Agricultural loan usage amounts for 2019 were 7225.35 TRY on average and 7291.13 TRY on average in the region (Table 1).

Farms had an average debt of 9521.17 TRY. In the regional average, this value was 10229.46 TRY. The group with the least debt was the third group (6550.15 TRY). The group with the highest debt was the second group (11173.91 TRY) (Table 1).

**Table 1: Some characteristics of the farms**

| Indicators | Farm groups (da) | | | FA* | WA** |
|---|---|---|---|---|---|
| | <15 | 15-30 | >30 | | |
| Age of farmer (years) | 48.43 | 44.52 | 48.70 | 47.24 | 46.97 |
| Education level of the farmer (years) | 6.25 | 7.57 | 6.10 | 6.63 | 6.74 |
| Experience of the farmer in agriculture (years) | 26.21 | 22.30 | 25.45 | 24.73 | 24.64 |
| Number of cattle (head) | 6.79 | 2.83 | 1.55 | 4.03 | 4.72 |
| Number of sheep and goats (head) | 0.71 | 3.26 | 1.50 | 1.76 | 1.77 |
| Debt status (TRY) | 10285.71 | 11173.91 | 6550.15 | 9521.17 | 10229.46 |
| Credit usage amount (TRY) | 7535.71 | 7043.48 | 7000.00 | 7225.35 | 7291.13 |

*FA: Farms Average; **WA: Research Region Weighted Average

23.94% of the interviewed farms also participated in the agricultural activities outside of their holdings. The first and second group farms (28.57% and 26.09%) participated more in the agricultural activities (as wage earners) outside of their holdings. Of the farms interviewed in the research region, 85.92% provided income only from agriculture, while 14.08% provided both agricultural and non-agricultural income. The first and second groups of farms (17.86% and 17.39%) working the most in non-agricultural work were the farms (Table 2).

The rate of having a computer was 9.86% and the rate of having internet was 19.72% in the 71 farms studied. In general, the rate of having computers and internet in the farms interviewed was low. The second group farms ownership of computer and internet were the highest (17.39% and 26.09%) (Table 2). All farms have mobile phones. 76.06% of the farms had cars (Table 2).

97.18% of the farms interviewed had social security. 21.13% of them were cattle breeding and 7.04% of them were sheep breeding. 29.58% were using agricultural loans (Table 2).

It was determined that 83.10% of the 71 producers interviewed were members of an agricultural organization. The group with the highest number of agricultural organizations was the third group (Table 2). Most of the enterprises were members of the Agricultural Credit Cooperative and Chamber of Agriculture.

**Table 2: Some technical features of farms**

| **Indicators** | **Farm groups (da)** | | | **FA** |
|---|---|---|---|---|
| | **<15** | **15-30** | **>30** | |
| Non-operating agricultural income (%) | 28.57 | 26.09 | 15.00 | 23.94 |
| Non-farm income (%) | 17.86 | 17.39 | 5.00 | 14.08 |
| Computer ownership (%) | 7.14 | 17.39 | 5.00 | 9.86 |
| Internet ownership (%) | 10.71 | 26.09 | 25.00 | 19.72 |
| Car ownership (%) | 67.86 | 78.26 | 85.00 | 76.06 |
| Social security ownership (%) | 96.43 | 95.65 | 100.00 | 97.18 |
| Membership in the agricultural organisation (%) | 82.14 | 78.26 | 90.00 | 83.10 |
| Using agricultural loans (%) | 28.57 | 34.78 | 25.00 | 29.58 |
| Cattle breeder (%) | 28.57 | 17.39 | 15.00 | 21.13 |
| Sheep and goats breeder (%) | 3.57 | 13.04 | 5.00 | 7.04 |

The use of machine power by the producers in tobacco farming varied between 72.38 hours and 174.48 hours. Machine power was used between 3.54 hours and 5.52 hours and an average of 4.05 hours per unit area (decare = 0.1 hectares). Machine power was used for 50.48 hours per ton of tobacco production. Labour use in tobacco production was high. In the enterprise groups, 1578.61 hours and 2920.05 hours of labour were used. The labour used per unit area was between 59.29 hours and 120.47 hours, with an average of 77.38 hours. Labour use per ton of tobacco production was 963.40 hours. A significant portion of labour use was family labour (78.11% on average, 82.16% on average for the region). Therefore, family labour is widely used in tobacco cultivation, especially in small-scale enterprises (Table 3).

**Table 3: Use of machine power and labour in tobacco farming**

| Indicators | Farm groups (da) | | | FA | WA |
|---|---|---|---|---|---|
| | <15 | 15-30 | >30 | | |
| Machine power usage (hours per farm) | 72.38 | 108.41 | 174.48 | 112.81 | 96.94 |
| Machine power usage per decare (hours) | 5.52 | 4.00 | 3.54 | 4.05 | 4.35 |
| Machine power usage per ton (hours) | 68.26 | 43.29 | 48.89 | 50.48 | 51.65 |
| Family labour usage (hours per farm) | 1399.46 | 1777.09 | 1966.85 | 1681.62 | 1603.65 |
| Foreign labour usage (hours per farm) | 179.14 | 407.65 | 953.20 | 471.21 | 348.28 |
| Total labour usage (hours per farm) | 1578.61 | 2184.74 | 2920.05 | 2152.83 | 1951.93 |
| Labour usage per decare (hours) | 120.47 | 80.59 | 59.29 | 77.38 | 87.63 |
| Labour usage per ton (hours) | 1488.85 | 872.42 | 818.25 | 963.40 | 1039.98 |
| Family labour usage (%) | 88.65 | 81.34 | 67.36 | 78.11 | 82.16 |
| Foreign labour usage (%) | 11.35 | 18.66 | 32.64 | 21.89 | 17.84 |

The experience period of the farmers in tobacco production was calculated as 24.49 years, and the regional average was 24.32 years. This value was found to be 25.50 years in the first enterprise group, 22.43 years in the second enterprise group and 25.45 years in the third enterprise group (Table 4).

It was determined that a significant portion of the farms interviewed were moderately satisfied with tobacco cultivation and will continue to grow tobacco next year. Likewise, a significant portion of the enterprises stated that they have a knowledge level above the medium level about tobacco cultivation and agricultural struggle (Table 4).

In tobacco farming, the number of agricultural spraying of the producers was 3.90 times, the number of tillage was 2.32 times, the tractor hoe was 1.04 times and the hand hoe was 0.42 times. The number of harvests varied between 41 and 47 times (Table 4).

**Table 4: Farmers' participation in various explanations of tobacco production and various practices on farms**

| Statements and indicators | Farm groups (da) | | | FA | WA |
|---|---|---|---|---|---|
| | <15 | 15-30 | >30 | | |
| The farmer's experience in tobacco production (years) | 25.50 | 22.43 | 25.45 | 24.49 | 24.32 |
| The tendency of the farmer to continue in tobacco production* | 2.82 | 3.70 | 3.65 | 3.34 | 3.24 |
| Knowledge level of the farmer in tobacco production** | 3.07 | 3.26 | 3.30 | 3.20 | 3.17 |
| Farmer's level of satisfaction with tobacco production** | 2.68 | 2.61 | 2.65 | 2.65 | 2.65 |
| His/her level of knowledge about agricultural struggle*** | 3.04 | 3.30 | 3.40 | 3.23 | 3.18 |
| Number of harvests in tobacco | 41.36 | 45.65 | 46.50 | 44.20 | 43.54 |
| Number of sprays in tobacco | 3.93 | 3.91 | 3.75 | 3.87 | 3.90 |
| Number of tillage in tobacco | 2.11 | 2.48 | 2.75 | 2.41 | 2.32 |
| Number of hand hoes in tobacco | 0.46 | 0.39 | 0.35 | 0.41 | 0.42 |
| Number of tractor hoes in tobacco | 1.00 | 1.04 | 1.25 | 1.08 | 1.04 |

*5-point Likert scale (1 Definitely not thinking ….5 Definitely thinking)
**5-point Likert scale (1 Very low ….5 Very high)

***5-point Likert scale (1 Uninformed ….5 Well-informed)

The farms interviewed carry out tobacco cultivation every year. It was determined that he was moderately satisfied with tobacco farming and that they will continue to grow tobacco next year. Likewise, a significant portion of the farms stated that they had the above-intermediate level of knowledge about tobacco cultivation and agricultural struggle (Table 4). In tobacco farming, 80.28% of the producers used chemical fertilization, 40.85% hand hoe, 94.37% machine hoe, 97.18% agricultural spraying, and 61.97% weed spraying. 28.17% of them were applying foliar fertilizer. The rate of rotation farms varied between 30% and 35.71%. Especially in large-scale enterprises, ownership of tobacco seed planting machines was high (85%). This value was 50.70% of the enterprises interviewed (Table 5).

**Table 5: Application of some techniques of farms in tobacco production**

| Applications | Farm groups (da) | | | FA |
|---|---|---|---|---|
| | <15 | 15-30 | >30 | |
| Producing regular tobacco every year (%) | 89.29 | 100.00 | 100.00 | 95.77 |
| Applying chemical fertiliser (%) | 71.43 | 95.65 | 75.00 | 80.28 |
| Applying hand hoe (%) | 46.43 | 39.13 | 35.00 | 40.85 |
| Applying tractor hoe (%) | 89.29 | 95.65 | 100.00 | 94.37 |
| Applying chemical medicine (%) | 96.43 | 100.00 | 95.00 | 97.18 |
| Applying foliar fertiliser (%) | 17.86 | 39.13 | 30.00 | 28.17 |
| Applying rotation (%) | 35.71 | 39.13 | 30.00 | 35.21 |
| Tobacco seeder owner (%) | 17.86 | 60.87 | 85.00 | 50.70 |
| Applying herbicides (%) | 67.86 | 56.52 | 60.00 | 61.97 |

The average tobacco yield of 71 farms per hectare was determined as 817.69 kg. The lowest and highest yields per hectare were calculated as 267.86 kg and 1458.33 kg, respectively. In tobacco production, it was determined that an average of 958.90 hours of labour per hectare, 45.41 hours of machine power, 52.64 kg of chemical fertilizers, 551.31 grams of pesticides, and 25.10 kg of seeds were used (Table 6).

**Table 6: Summary statistics for variables used in the efficiency and Tobit analysis**

| Variables | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|
| **DEA model** | | | | |
| *Output* | | | | |
| Yield (kg per ha) | 267.86 | 1458.33 | 817.69 | 270.94 |
| *Inputs* | | | | |
| Area (ha) | 0.60 | 8.00 | 2.78 | 1.61 |
| Labour (h per ha) | 401.88 | 5501.43 | 958.90 | 623.16 |
| Machine (h per ha) | 26.75 | 72.00 | 45.41 | 11.92 |
| Fertiliser (kg per ha) | 0.01 | 484.00 | 52.64 | 77.05 |
| Pesticide (g per ha) | 0.01 | 2522.14 | 551.31 | 405.84 |
| Seed (kg per ha) | 0.03 | 42.86 | 25.10 | 7.76 |
| **Tobit model** | | | | |
| Age (year) | 30 | 66 | 47.24 | 7.89 |
| Education level (year) | 5 | 16 | 6.63 | 2.59 |

| | | | | |
|---|---|---|---|---|
| Family size (persons) | 2 | 6 | 3.49 | 0.92 |
| Experience in tobacco production (year) | 9 | 45 | 24.49 | 7.51 |
| Tobacco production every year (1: Yes 2:No) | 1 | 2 | 1.04 | 0.20 |
| Non-farm income (1: Yes 2:No) | 1 | 2 | 1.86 | 0.35 |
| Tendency to continue tobacco production | 1 | 5 | 3.34 | 1.01 |
| Knowledge level in tobacco production | 2 | 5 | 3.20 | 0.50 |
| Satisfaction level in tobacco production | 1 | 4 | 2.65 | 0.68 |

More input-oriented models are used in agriculture. While calculating the efficiency results for the input, the aim is to determine how much the input amounts can be reduced proportionally without making any changes in the output amount.

The technical efficiency value in enterprises was found to be 0.794. In other words, enterprises will be able to obtain the same amount of output and save 20.6% by reducing the inputs they use by 20.6% on average. In other words, enterprises can evaluate the inputs they use at the rate of 79.4%. Compared to the enterprises that use the input most effectively, the enterprise with the lowest technical efficiency can use its inputs 39.9% effectively, and this enterprise can increase its efficiency by 60.1% with the appropriate input combination (Table 7).

1 farm with technical efficiency score in the range of 0.31-0.40, 4 farms in the range of 0.41-0.50, 7 farms in the range of 0.51-0.60, 10 farms in the range of 0.61-0.70, 12 farms in the range of 0.71-0.80, 12 farms in the 0.81-0.90 range, 0.91-0.99 10 farms and 15 fully active farms have been identified. It was determined that 21.13% of the total farms were fully efficient in terms of technical efficiency (Table 7).

The technical efficiency scores we calculated are higher than these two studies (Abay et al., 2004; Ören and Alemdar, 2006) conducted in Türkiye. We can attribute the reasons for this (i) to the more uniformity of tobacco-growing enterprises in Uşak, and (ii) to improvements in technical practices.

Scale efficiency was determined as 81.1%. It was determined that 55 farms work with increasing returns to scale, 1 with decreasing returns to scale, and 15 farms with constant returns to scale. In other words, it can be stated that when 55 farms increase their scale, their efficiency will increase when 1 farm decreases its scale.

Allocative efficiency refers to how the producer operates both technically and economically. The criterion that compares the current situation with the most appropriate factor combination that enables the enterprise to produce at the lowest cost is the efficiency of allocation (Tarım, 2001). It is known that producers in Türkiye get their vocational training from their fathers or other family elders. Most of what has been known consists of previously experienced knowledge by living. Since there is no single source in this regard, the input composition ratios applied by each farmer are different. In addition, since there is no single price in the market regarding input prices, some producers provide inputs at higher prices and some at lower prices. Therefore, all producers can't produce a certain amount of output at the lowest cost using the most appropriate factor combination.

Allocation efficiencies on farms were obtained according to the DEA method and the allocation efficiencies of operators were calculated as 0.595 on average. It was determined that 1 enterprise was operating effectively (Table 7).

Economic efficiency is defined as the ratio of the minimum cost of a particular product to the observed cost of the enterprise. While the economic efficiency values of the farms ranged between 0.099 and 1.000, it was calculated to be 0.462 on average. The fact that the economic efficiency is 0.462 means that there are farms that produce the same amount of product with 53.80% more cost among the farms studied. It was determined that the economic efficiency of one of 71 farms was 100%. However, it was calculated that there were no farms with an efficiency between 0.81 and 0.99 (Table 7).

**Table 7: Frequency distributions of efficiency scores obtained with the DEA model**

| **Efficiency score** | **Technical Efficiency (TE)** | | **Allocative Efficiency (AE)** | | **Economic Efficiency (EE)** | |
|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **%** | **N** | **%** |
| 1.00 | 15 | 21.13 | 1 | 1.41 | 1 | 1.41 |
| 0.91-0.99 | 10 | 14.08 | 3 | 4.23 | 0 | 0.00 |
| 0.81-0.90 | 12 | 16.90 | 8 | 11.27 | 0 | 0.00 |
| 0.71-0.80 | 12 | 16.90 | 20 | 28.17 | 4 | 5.63 |
| 0.61-0.70 | 10 | 14.08 | 1 | 1.41 | 11 | 15.49 |
| 0.51-0.60 | 7 | 9.86 | 14 | 19.72 | 12 | 16.90 |
| 0.41-0.50 | 4 | 5.63 | 10 | 14.08 | 19 | 26.76 |
| 0.31-0.40 | 1 | 1.41 | 7 | 9.86 | 8 | 11.27 |
| <0.31 | 0 | 0.00 | 7 | 9.86 | 16 | 22.54 |
| Minimum | 0.399 | | 0.099 | | 0.099 | |
| Maximum | 1.000 | | 1.000 | | 1.000 | |
| **Mean** | **0.794** | | **0.595** | | **0.462** | |
| Std. Deviation | 0.17 | | 0.22 | | 0.18 | |

All the inputs taken into the efficiency calculation were found to have recorded overuses at varying rates. There were problems in the use of chemical fertilizers in 33.80%, machine power in 22.54%, seeds in 15.49%, pesticides in 11.27%, use of labour in 7.04% and land use in 4.23% of the enterprises. Chemical fertilizer was used at the highest rate with an excess of 107.68%. The rest is pesticides (39.76), farm size (28.48%), seeds (18.35%), machine power (14.46%) and labour (4.58%) (Table 8).

**Table 8: Farms using input slacks and excessive inputs**

| Inputs | Number of farms | Mean input usage | Mean input slack | Excessive input usage (%) |
|---|---|---|---|---|
| Area (ha) | 3 | 2.78 | 0.79 | 28.48 |
| Labour (h per ha) | 5 | 958.90 | 43.91 | 4.58 |
| Machine (h per ha) | 16 | 45.41 | 6.57 | 14.46 |
| Fertiliser (kg per ha) | 24 | 52.64 | 56.68 | 107.68 |
| Pesticide (g per ha) | 8 | 551.31 | 219.19 | 39.76 |
| Seed (kg per ha) | 11 | 25.10 | 4.61 | 18.35 |

The economic efficiency score, which enables the farms to produce with the optimum input composition by reducing their resources to the minimum cost, is 0.372 in the region average. The economic efficiency score was calculated as 0.315 in the first layer, 0.543 in the second layer, and 0.576 in the third layer. To be fully effective, enterprises need to reduce their input costs by 62.8% (Table 8).

Resource use efficiency compares the current situation of the enterprises with the most appropriate input combination and making production with minimum cost (Tarım, 2001). The resource utilization efficiency score was calculated as 0.474 according to the regional average. Resource utilization efficiency was 0.398 in the first layer, 0.702 in the second layer, and 0.754 in the third layer (Table 8).

The technical efficiency score was calculated to be 0.807 according to the regional average. It was determined that this score was 0.814 in the first layer, 0.785 in the second layer and 0.779 in the third layer. Tobacco enterprises will be able to achieve the same output by reducing the inputs they use by 19.3%. In other words, enterprises cannot evaluate 19.3% of the inputs they use (Table 8).

According to the results of the efficiency analysis, the reason for the low economic efficiency or high economic inefficiency in the enterprises is the low resource use efficiency. It has been determined that there are problems in the distribution of the inputs used by enterprises in the production. The reason for the technical inefficiency in the enterprises is the low scale efficiency. It is that the enterprises do not have the size of the scale in which they can optimally evaluate the resources they use for production.

**Table 9: Efficiency scores of tobacco farms**

| Farm groups | Technical Efficiency (TE) | Allocative Efficiency (AE) | Economic Efficiency (EE) |
|---|---|---|---|
| <15 | 0.814 | 0.398 | 0.315 |
| 15-30 | 0.785 | 0.702 | 0.543 |
| >30 | 0.779 | 0.754 | 0.576 |
| FA | 0.794 | 0.595 | 0.462 |
| WA | 0.807 | 0.474 | 0.372 |

It was determined that there is a statistically insignificant relationship between the education level, household size, non-agricultural income status, satisfaction level of tobacco production, tendency to continue tobacco production, potassium use, credit utilization and economic activities of farmers (Table 10).

A positive and statistically significant 5% correlation was found between their economic activities and their annual tobacco-growing status (Table 10). In other words, the operators who have grown tobacco every year have worked with high economic efficiency scores. This result supports the idea that specialized farmers use their resources better.

A statistically significant 5% correlation was found between their economic activities and their level of knowledge of tobacco production (Table 10). In other words, operators with a high level of knowledge of tobacco production worked more effectively. This result supports the idea that the higher the level of knowledge among the producers, the better the use of resources.

A statistically significant 1% correlation was found between their economic activities and the rate of foreign labour used in tobacco farming (Table 10). In other words, the operators with a high rate of foreign labour used in tobacco cultivation have higher economic efficiency scores. This result supports the idea that resources are used better in specialized enterprises.

It was determined that there was a positive, statistically significant 5% relationship between the tobacco field groups and their economic activities (Table 10). In other words, operators with low tobacco areas have lower economic efficiency scores. This result means that the increase in tobacco areas in the enterprise will also increase economic efficiency.

**Table 10: The parameters and their standard errors of the Tobit model**

| Variable | Coefficient | Std. Error | z-score | Significance |
|---|---:|---:|---:|---:|
| Farmers’ education level (year) | 0.002 | 0.006 | 0.273 | 0.785 |
| Family size (persons) | 0.002 | 0.019 | 0.102 | 0.919 |
| ***Tobacco production every year (1:Yes)*** | ***0.160*** | ***0.073*** | ***2.192*** | ***0.028****** |
| Non-farm income (1:Yes) | 0.026 | 0.044 | 0.598 | 0.550 |
| Tendency to continue tobacco production | 0.022 | 0.017 | 1.331 | 0.183 |
| ***Knowledge level in tobacco production*** | ***0.069*** | ***0.032*** | ***2.149*** | ***0.032****** |
| Satisfaction level in tobacco production | 0.002 | 0.023 | 0.072 | 0.942 |
| ***Foreign labour rate (%)*** | ***0.005*** | ***0.001*** | ***3.448*** | ***0.001******* |
| Potassium per hectare (kg) | -0.001 | 0.001 | -0.833 | 0.405 |
| Agricultural credit utilisation | -0.004 | 0.033 | -0.111 | 0.912 |
| ***Farm groups*** | ***0.061*** | ***0.024*** | ***2.495*** | ***0.013****** |
| ***Constant*** | ***-0.212*** | ***0.122*** | ***-1.739*** | ***0.082***** |

| | |
|---|---|
| R-squared | 0.582 |
| Adjusted R-squared | 0.496 |

*** Significant at 1%, ** Significant at 5%, * Significant at 10% level of statistical

In the study, the Binary Logistic Regression model was also applied, taking into account the economic efficiency score. Economic efficiency score was obtained as dependent (0: Enterprises with economic efficiency score below average (0.462 and below) (47.89% of enterprises), 1: Enterprises with economic efficiency score average and above (0.463 and above) (52.11% of enterprises)) and variable which was the education level of the operators, the annual tobacco cultivation status, the non-agricultural income status, the level of satisfaction with tobacco production, the tendency to continue tobacco production, the rate of the foreign labour force, the use of potassium per hectare, the farm width groups and the credit utilization indicators as independent variables (Table 11).

Logistic regression is not concerned with estimating the value of the dependent/response variable. Instead, it tried to estimate the probability of the dependent variable taking the value 1 and the realization of the tested variable with another definition. Since the result obtained is a probability value, it can only take values between 0 and 1 (Alpar, 2013).

In the study, the Likelihood Ratio (LR-Likelihood Ratio) was used to test the acceptability of the statistical general significance of the Logit model and the explanatory power of the obtained equation. According to this hypothesis test; when the restricted and unconstrained log-likelihood values were examined, the LR value obtained in the model is greater than 21.03, which corresponds to the critical value of $\chi^2(12)$ at the 5% level (39.732). The result of the LR hypothesis test shows the acceptability of the statistical general significance of the estimated Logit model and supports the explanatory nature of the obtained equation.

In logistic regression models, error chi-square statistics ($x^{2\beta}{}_o$) are used to measure whether the variables that are not included in the initial model can have a significant contribution to economic efficiency, that is, whether the established model is statistically significant or not. The significance of this value indicates that the coefficients of the independent (explanatory) variables that are not included in the model are significantly different from zero (0) (Çokluk, et al. 2014). The chi-square error value for the socio-economic variables selected for inclusion in the model was found to be [$x^{2\beta}{}_o$=31.924, p<0.01]. When one or more of the variables selected to enter the model are added to the model, they will make a positive contribution to the explanation of the economic efficiency model.

The effects of the socio-economic characteristics of the examined enterprises on the probability of economic efficiency were found to be statistically significant at the determined importance level; It can be said that the variables with positive coefficients increase the probability of economic efficiency, while the variables with negative coefficients decrease the probability of economic efficiency.

The exponential coefficients Exp(B) of the model are logarithms of the original coefficients. This means that exponential coefficients cannot take negative values. If the value of the exponential coefficient is above 1, it indicates the original coefficient with a positive sign, and if the exponential coefficient is below 1, it indicates the original coefficient with a negative sign (Alpar, 2013).

The exponential coefficient Exp(Bi) value indicates how many times the dependent variable (Y) is likely to be observed with the effect of the independent variable (Xi), or how many percent more probability it is to be observed (Özdamar, 2013), provided that other variables remain constant (Özdamar, 2013).

As a result of the logit model, economic efficiency is one of the socio-economic variables selected for estimation as probability; the rate of the foreign labour force, farm width groups and loan utilization were found to be statistically significant (Table 11).

Since the model is statistically significant and the correct prediction rate of the model is high, it can be accepted that explanatory variables explain the model well.

The rise in the rate of foreign labour increases the probability of an increase in economic activity by 1.08 times. There is a statistically significant relationship between the producer's use of credit and the probability of economic activity being above the average. According to this result, it is stated that the producers' use of credit will increase their economic efficiency by 4.41 times. The small scale of the producers reduces the probability of their economic efficiency being above the average. Being small in scale reduces the probability of its economic efficiency being above the average by 0.12 times (Table 11).

Since there is no statistically significant relationship between the education level of the examined operators, their tobacco cultivation status, their non-agricultural income, their satisfaction with tobacco production, their tendency to continue tobacco production, the use of potassium per hectare and the probability of their economic activity being above the average, it is avoided to comment.

The correct prediction rate of the model was calculated as 80.03%, according to the estimation results obtained by using the logit model for the analysis of the effects of the socio-economic factors affecting the economic efficiency of the examined enterprises on the probability of their economic activity being above the average. The shadow specificity coefficient was estimated to be 0.572.

**Table 11: The parameters and their standard errors of a binary logistic model**

| Variables | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Farmers' education level (year) | -0.003 | 0.155 | 0.000 | 1.000 | 0.986 | 0.997 |
| Family size (persons) | 0.372 | 0.482 | 0.593 | 1.000 | 0.441 | 1.450 |
| Tobacco production every year (1:Yes) | -19.931 | 20527.364 | 0.000 | 1.000 | 0.999 | 0.000 |
| Non-farm income (1:Yes) | -1.292 | 1.081 | 1.428 | 1.000 | 0.232 | 0.275 |
| Tendency to continue tobacco production | 0.404 | 0.412 | 0.958 | 1.000 | 0.328 | 1.497 |
| Knowledge level in tobacco production | 0.288 | 0.733 | 0.154 | 1.000 | 0.694 | 1.334 |
| Satisfaction level in tobacco production | 0.313 | 0.576 | 0.295 | 1.000 | 0.587 | 1.367 |
| ***Foreign labour rate (%)*** | ***0.075**** | ***0.039*** | ***3.809*** | ***1.000*** | ***0.051*** | ***1.078*** |
| Potassium per hectare (kg) | -0.019 | 0.023 | 0.693 | 1.000 | 0.405 | 0.981 |
| ***Farm groups (da)*** | | | ***5.285*** | ***2.000*** | ***0.071*** | |
| ***Farm groups (da) group(1)*** | ***-2.122***** | ***1.058*** | ***4.024*** | ***1.000*** | ***0.045*** | ***0.120*** |
| Farm groups (da)group(2) | -0.349 | 0.963 | 0.131 | 1.000 | 0.717 | 0.705 |
| ***Agricultural credit utilisation (1 use)*** | ***1.483**** | ***0.893*** | ***2.755*** | ***1.000*** | ***0.097*** | ***4.405*** |
| Constant | -4.490 | 3.598 | 1.557 | 1.000 | 0.212 | 0.011 |

** Significant at 5%, * Significant at 10% level of statistical

In our study, we found a positive and statistically significant relationship between the economic activities of tobacco enterprises and the rate of foreign labour used in tobacco cultivation. Similar results are also found in the study of Karagiannis and Sarris (2005).

In our study, we determined that there is a positive, statistically significant relationship between the tobacco field scale and the economic activities of the enterprises. Similar results are available in the studies of Karagiannis and Sarris (2005), Ilembu and Kuzilwa (2014), and Dube and Mugwagwa (2017). Chune et al. (2022) found this relationship is inverse in their study..

## 5. Conclusions and Recommendations

Türkiye has an important position in tobacco production. The province of Uşak, which is the sample area, is in the top six in Türkiye's tobacco production and meets 6.3% of the production.

Technical, allocation and economic efficiency scores were found to be higher in enterprises with the large-scale area. The use of foreign labour and the cultivation of tobacco each year also have an impact on efficiency. The scale of the enterprise, the level of knowledge in tobacco cultivation, and the use of foreign labour and credit are also effective in enterprises with high economic efficiency scores.

The economic efficiency of tobacco enterprises is 0.462 and it is low. Increasing the scale of the land, the use of foreign labour and the use of credit will enable farmers to make more informed production decisions and increase efficiency. The data collected for efficiency analysis in this study covers a single production season. The dominance of the law of diminishing yields in agriculture and the fact that there are many external factors affecting agricultural production reveal the necessity of repeating such studies.

## 6. References

ABAY, C; MIRAN, B; GÜNDEN, C. An analysis of input use efficiency in tobacco production with respect to sustainability: The case study of Turkey. *Journal of Sustainable Agriculture*, vol. 24, n. 3, p. 123-143, 2004.

ALPAR, R. *Applied Multivariate statistical methods* (in Turkish). Detay Yayıncılık, Ankara, 2013.

BATTESE, G.E. Frontier production functions and technical efficiency: A survey of empirical applications in agricultural economics. *Agricultural Economics*, vol. 7, p. 185-208, 1992.

CHUNE, M.D; TAKOY, M.M; PETER, O. Analysis of technical efficiency and its determinants among tobacco producers in Uganda: An application of data envelopment analysis. *International Journal of Agricultural Research, Innovation and Technology*, vol. 12, n. 1, p. 24-29, 2022.

CINEMRE, H.A; CEYHAN, V; BOZOĞLU, M; DEMIRYÜREK, K; KILIÇ, O. The cost efficiency of trout farms in the Black Sea Region, Turkey. *Aquaculture,* vol. 251, n. 2, p. 324-332, 2006.

COELLI, T.J. *A guide to DEAP Version 2.1*: A Data Envelopment Analysis Computer Program, CEPA Working Paper 96/08, Department of Econometrics, University of New England, Armidale, 1996.

COELLI, T.J; RAO, D.S.P; O'DONNELL, C.J; BATTESE, G.E. *An Introduction to efficiency and productivity analysis* (Second Edition). Springer Science & Business Media, 2005.

ÇIÇEK, A; ERKAN, O. *Agricultural economics research and sampling methods* (in Turkish). Gaziosmanpasa University Agricultural Faculty, Publications No: 12, p. 118, Tokat, 1996.

ÇOKLUK, Ö; ŞEKERCIOĞLU, G; BÜYÜKÖZTÜRK, Ş. *Multivariate statistics Spss and lisrel applications for social sciences* (in Turkish). Pegem Akademi, Ankara, 2014.

DUBE, L; MUGWAGWA, K.E. Technical efficiency of smallholder tobacco farmers under contract farming in Makoni district of Manicaland province, Zimbabwe: A Stochastic Frontier Analysis. *Scholars Journal of Agriculture and Veterinary Science*, vol. 4, n. 2, p. 68-78, 2017.

FAISAL, M; CHUNPING, X; AKHTAR, S; RAZA, M.H; NAZIR, A; MUSHTAQ, Z; AJMAL, M.A. Economic analysis and production efficiency of dark sun cured rustica tobacco production A case study of Punjab, Pakistan. *Journal of Social Sciences and Humanity Studies*, vol. 4, n. 4, p. 7-14, 2018.

FAOSTAT. *Food and Agriculture Organization of the United Nations*. Date of access: 20.10.2022, website: https://www.fao.org/faostat/en/#data/QCL, 2022.

HANSEN, B.G; HEGRENES, A; STOKSTAD, G. *Characterizing Efficient Dairy Farms and Farmers*. p.123-136. In: Farm Management. Proceedings of NJF Seminar No. 345. NILF-report 2003-2, Norway, 2002.

GÜL, M. Production cost and producer problems of maize in irrigated areas of Yüregir province (in Turkish). *M.Sc. Thesis*, Cukurova University, p. 118, Adana, 1998.

GÜL, M. Economic analysis of apple farming in the trans-taurus mountains region (in Turkish). *PhD Thesis*, Cukurova University, p. 405, Adana, 2005a.

GÜL, M. Technical efficiency and productivity of apple farming in Antalya province of Turkey. *Pakistan Journal of Biological Sciences*, vol. 8, p. 1533-1540, 2005b.

GÜL, M. Technical efficiency of apple farming in Turkey: A case study covering Isparta, Karaman and Nigde provinces. *Pakistan Journal of Biological Sciences*, vol. 9, n. 4, p. 601-605, 2006.

GÜL, M; KOÇ, B; DAĞISTAN, E; AKPINAR, M.G; PARLAKAY, O. Determination of technical efficiency in cotton growing farms in Turkey: A case study of Cukurova Region. *African Journal of Agricultural Research*, vol. 4, n. 10, p. 944-949, 2009.

GÜL, M; DEMIRCAN, V; YILMAZ, H; YILMAZ, H. Technical efficiency of goat farming in Turkey: A case study of Isparta province. *Revista Brasileira de Zootecnia*, vol. 45, n. 6, p. 328-335, 2016.

GÜL, M; SALUK, N. Economic structures of tobacco farms: The case of Denizli province in Turkey. *Columella-Journal of Agricultural and Environmental* Sciences, vol. 4, n. 1, Suppl.), p. 217-222, 2017.

GÜL, M; KÖSE, S; ŞİRİKÇİ, B.S; KADAKOĞLU, B. Economic analysis of tobacco production in Turkey: The case of Usak province. *Scientific Papers Series Management*, Economic Engineering in Agriculture and Rural Development, vol. 22, n. 4, 279-286, 2022.

GÜL, M; YILMAZ, H; PARLAKAY, O; AKKOYUN, S; BILGILI, M.E; VURARAK, Y; HIZLI, H; KILIÇALP, N. Technical efficiency of dairy cattle farms in East Mediterranean Region of Turkey. Scientific Papers Series Management, *Economic Engineering in Agriculture and Rural Development*, vol. 18, n. 2, p. 213-225, 2018.

GÜL, M; SALUK, N. Analysis of the capital structure of tobacco producers in Denizli. Conference on Agriculture, Forest, Food Sciences and Technologies (ICAFOF 2018), April 2-5, 28p, İzmir, Turkey, 2018.

GÜMÜŞ, A.H. A Study on the marketing situation of Turkey's tobacco production, its problems and recommendations for alternative marketing types (in Turkish). *PhD Thesis*, Ege University, p. 372, İzmir, 2009.

ILEMBU, B; KUZILWA, J. Technical efficiency analysis of tobacco production in Tanzania. *Interdisciplinary Journal of Contemporary Research in Business*, vol. 6, n. 3, p. 246-265, 2014.

KARAGIANNIS, G; SARRIS, A. Measuring and explaining scale efficiency with the parametric approach: The case of Greek tobacco growers. *Agricultural Economics*, vol. 33, p. 441-451, 2005.

KIDANE, A; NGEH, E.T. A comparative analysis of technical efficiency of smallholder tobacco and maize farmers in Tabora, Tanzania. Journal of Development and Agricultural Economics, v. 7, n. 2, p. 72-79, 2015.

MUSHTAQ, Z; WEI, W; SHARIF, M; CHANDIO, A.A. Evaluating energy consumption efficiency in tobacco production: Applying data envelopment analysis. *E&M Economics and Management*, vol. 24, n. 3, p. 23-39, 2021.

ÖREN, M. N; ALEMDAR, T. Technical efficiency analysis of tobacco farming in Southeastern Anatolia. *Turkish Journal of Agriculture and Forestry*, vol. 30, n. 2, p. 165-172, 2006.

ÖZDAMAR, K. *Statistical Data Analysis with Package Programs 2* (Multivariate Analysis) (in Turkish). Kaan Kitabevi, Eskişehir, 2013.

PARLAKAY, O. Technical and economic efficiency of peanut production in Turkey (in Turkish). *PhD Thesis*, Çukurova University, p. 150, Adana, 2011.

RANA, J; KAMRUZZAMAN, M; SHARNA, S.C; RANA, S. Growth and efficiency analysis of tobacco production in Bangladesh: A non-parametric approach. *SN Business & Economics*, vol. 1, n. 12, p. 1-19, 2021.

SALUK, N; GÜL, M. *Production cost and profitability of tobacco producers in Denizli*. Conference on Agriculture, Forest, Food Sciences and Technologies (ICAFOF 2018), April, 2-5, Izmir, Turkey, p. 27, 2018.

SALUK, N. Effects of privatization on tobacco farmers: A case of Denizli province (in Turkish). *M.Sc. Thesis*, Suleyman Demirel University, p. 134, Isparta, 2018.

TAMBA, I.M; AMBARAWATI, I.G.A.A; ANTARA, M; BUDIASA, I.W. Technical efficiency and economies of scale for partnership-based of virginia tobacco farming in Buleleng, Bali, Indonesia: A non-parametric approach. *Journal of Economics and Sustainable Development*, vol. 6, n. 14, p. 130-136, 2015.

TARIM, A. *Data Envelopment Analysis Mathematical Programming Based Relative Efficiency Measurement Approach* (in Turkish). Sayıştay Yayınları, Ankara, 2001.

YAMANE, T. *Basic Sampling Methods*. Translated by A. Esin; M.A. Bakir; C. Aydin; E. Gurbuzsel. Literature Publishing No:53, p. 118, 2001.

YOLALAN, R. *Inter-Business Relative Effeciency Measurement* (in Turkish). Milli Prodüktivite Merkezi Yayınları: 483, Ankara, 1993.