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Research Article

Drivers of Farm Efficiency in Turkey: A Stochastic Frontier Analysis[1]

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Abstract

This paper analyzes the efficiency structure of Turkish agriculture in farm household level by using various models of stochastic frontier analysis. A household level survey conducted in 2002 and 2004 is used in the analysis. Firstly, an efficient production frontier is estimated by a panel data model. By using these estimates, relative importance of inputs and their interaction with various farm characteristics are inspected. The parameters of production frontier show that agricultural production is crucially dependant on land and there is an excessive employment of labor. Secondly, the efficiency scores are estimated at farm household level. The results are reported according to NUTS-I regional classification and many other farm specific characteristics. The western parts of the country are found to be relatively more efficient and there is a high deviation in the mean efficiencies of different regions. There is an increase in mean efficiencies of all regions from 2002 to 2004. Besides, crop patterns, farm size, education level of household chief and irrigation are found to be effective on efficiency.

Keywords: Technical Efficiency, Turkish Agriculture, Stochastic Frontier Analysis

JEL Codes: Q10, Q12, D24

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1. Introduction

Agriculture has been on the reform agenda since mid-1990s in Turkey. The main motive was decreasing the burden of agricultural subsidies on the finances of the government. This burden was not only related to the budget, but also distributed through several funds and state economic enterprises, causing considerable difficulties for the financial discipline. Political and economic instability has postponed the reforms until the end of the decade. Economic crisis of 2001 made these reforms inevitable. Subsidization system has been changed substantially by Agricultural Reform Implementation Program (ARIP).

The focus of public discussions that are held just before and after 2001 economic crisis was on the macroeconomic implications of government intervention through the state economic enterprises and agricultural sales cooperatives to sustain a predetermined level of price. ARIP has largely been designed in response to these discussions. Although ARIP was a necessary step to transform the agriculture, it has not been sufficient to solve the main problems. ARIP was mainly concerned with macro structure of agriculture and it has not been supported by additional measures to create appropriate incentives to reform the micro-structures such as production and marketing. However there are two important factors that Turkish agriculture will face in near future. Turkey has already started negotiations with EU and agriculture will be one of the most important fields in negotiations. On the other hand WTO commitments will become more and more binding and Turkish agriculture will be more vulnerable to international competition.

These three pillars, i.e. government finances, EU negotiations and WTO commitments, are closely related to the efficiency of production, in one way or the other. To alleviate the burden of support programs on the budget and on the consumers, macro level institutions should be designed to create necessary incentives for producers to increase their efficiency, since supporting inefficient producers cannot be a sustainable policy. Secondly, to be a decent member of the EU, Turkey needs to increase the efficiency in production since EU is not likely to accept to bear the cost of inefficiency of Turkish farmers from the common budget. Lastly, Turkish producers cannot compete with foreign producers under increased market access in domestic markets and in the international markets. Thus, any reform program that claims to unravel major issues in Turkish agriculture should give priority to the measures that will increase the efficiency of farmers in the core of its policies.

To shed a light on the discussions about the inefficiency levels of Turkish producers, first the concept of efficiency needs to be clarified. Literature on the structure of agricultural production in Turkey focuses on partial efficiency measures such as productivity of labor and yield of land rather than efficiency. There is an extensive literature that uses different partial efficiency measures to analyze the state of efficiency in Turkish agriculture. Only a few work use partial efficiency measures by acknowledging the difference between partial and technical efficiency measures such as Zaim and Çakmak (1998), Çakmak (2004), Kepenek and Yentürk (2001) Lundell *et. al.* (2004) while most of the others do not mention any difference at all, such as Özkan *et. al.* (2004) and Uzunlu, *et. al.* (1999). Some authors use extensive statistical methods to analyze partial efficiency such as Toksoy and Ayyıldız (2004) or employ simple econometric methods to obtain partial efficiency measures such as Akçay and Esengün (1999). On the other hand, rare quantitative work that follows recently developed methods in efficiency measurement literature use aggregate data such as Akder *et. al.* (2000) and Mahmud and Demir (1999 and 2002). In short, the difference between efficiency and productivity is generally ignored in the literature. Yields calculated by various methods are considered as measures of efficiency. Although one can make partial efficiency analysis and comparisons by using yields, a complete picture about the efficiency posture of households cannot be accessed merely by depending on information about yields since these measures do not give any information about relative ability of producers to utilize inputs.

Farrell (1957) is accepted to break new ground for the efficiency analysis by giving a comprehensive understanding of efficiency (Fare et al., 1985). Farrell (1957) criticizes the employment of partial efficiency measures "…due to a pure neglect of the theoretical side of the problem" (Farrell, 1957). Farrell (1957) provided a measure of efficiency that "…takes account of all inputs" yet avoids the deficiencies of partial efficiency measures. To do this, he calculated a production frontier from the "most efficient" observations in the first place. Then, he measured the efficiency of each observation with its distance from the estimated production frontier.

Models that use econometric methods to estimate the efficient frontier of Farrell (1957) are given the general name of stochastic frontier analysis (SFA). SFA depends on the idea that "…there exists some efficient frontier from which all the observed points deviate randomly but in the same direction" (Farrell, 1957). Afriat (1972) has stated the statistical foundations that were based on the deterministic model of Aigner and Chu (1968). Richmond (1974) discussed the modified ordinary least squares (MOLS) model to estimate efficiency scores by conventional econometric methods. Gabrielsen (1975) developed the corrected ordinary least squares (COLS) while Greene (1980a) used maximum likelihood estimation (MLE) methods to estimate the efficient frontier (Kumbhakar and Lovell, 2000). The current SFA models depend on the idea of modeling efficiency scores as composed error terms and this approach is simultaneously developed by Aigner, Lovell and Schmidt (1977), Meusen and Broeck (1977) and Battese and Corra (1977). Aigner, Lovell and Schmidt (1977) decomposed the error term to an independently and identically distributed "noise" which stands for the '*deviations from efficient frontier due to the chance factors and a one-sided error term that stands for the deviation from efficient frontier because of inefficiency*" (Kumbhakar and Lovell, 2000).

Pitt and Lee (1981) extended cross-section analysis to panel data. Schmidt and Sickles (1984) applied panel data models by using fixed and random effects. Cornwell, Schmidt and Sickles (1990), Kumbhakar (1990) and Battese and Coelli (1992) introduced time-variable efficiency (Kumbhakar and Lovell, 2000). Lastly, technical efficiency effects models are introduced by Battese and Coelli (1995) to analyze the effect of factors that characterize the production process but are not among the arguments of production function. Battese and Broca (1997) has further developed technical inefficiency effects model to allow for non-neutrality between inputs and characteristic factors. A detailed survey about the topic can be found in Murillo-Zamorano (2004) while Kumbhakar and Lovell (2000) supply a comprehensive theoretical background.

In this paper, we attempt to figure out the general conditions under which Turkish agricultural sector operate. Section 2 will introduce a descriptive analysis of data that will be used in analysis. In Section 3 we will use stochastic frontier methods to analyze the efficiency structure of Turkish agriculture. The last chapter is reserved for concluding remarks.

2. Data

The data set used in this study is unique. It is based on Quantitative Household Survey (QHS) commissioned by the Treasury and implemented by the G.G. Consulting et al. (2002 and 2004) to observe the effects of Agriculture Reform Implementation Program (ARIP). Approximately 2700 variables are obtained from the survey results. Originally, 5508 households are participated in survey. The survey is conducted for the years 2002 and 2004.

We used the production section of the questionnaire for 3014 farm households[5]. The data set is classified using the NUTS-I definition of Turkish Statistics Institute. Table 1 gives the mean values of the variables used in estimation.

Total revenue from crop and livestock production is used as dependent variable. Labor expressed as days worked is used as labor data. The unpaid labor used in agricultural activities is not given in survey results for 2004. Thus, labor use per hectare for 2002 is used as a proxy for the same figure for 2004. This excludes any effect of introduction of labor saving technologies on efficiency. However, given the short span of time, this is not likely to introduce any serious bias in results. All observations that used zero labor (hence, zero land used in 2004) are excluded from the analysis. Land data consists of total dry and irrigated land used for field crops, dry and irrigated land used as orchards and fallow land in hectares. Livestock data is in Bovine Unit which is defined by ministry of Agriculture and Rural Affairs, and consists of the number of animals that the households own.

Table 1: Means of input variables used in analysis

	Regions	# of HHs	Income from (TL) Agriculture	Subsidies	Factor Use Labor Days	Livestock CBU	Land Ha.
2002	West Marmara	365	6940	666	72.2	2.7	11.6
	Aegean	505	5232	312	144.3	1.5	7.5
	East Marmara	272	5004	501	97.4	2.7	10.8
	West Anatolia	179	4363	1049	107.6	1.3	19.3
	Mediterranean	357	6201	418	133.0	1.2	10.9
	Central Anatolia	238	4155	964	43.7	2.3	24.8
	West Black Sea	363	2937	316	97.6	2.2	6.9
	East Black Sea	336	2105	155	73.5	1.2	4.5
	Northeast Anatolia	75	2763	650	48.0	4.2	20.3
	Cent. East Anatolia	94	3307	834	87.2	3.0	15.1
	Southeast Anatolia	230	5318	689	87.3	1.1	16.0
	Turkey	3014	4656	516	97.8	1.9	11.6
2004	West Marmara	365	8024	864	70.7	3.0	10.6
	Aegean	505	6392	498	137.2	1.7	6.8
	East Marmara	272	9112	863	84.1	2.1	9.8
	West Anatolia	179	6572	1477	109.2	2.7	20.9
	Mediterranean	357	8799	654	126.7	1.3	11.1
	Central Anatolia	238	5982	1391	40.2	2.5	20.6
	West Black Sea	363	3721	446	88.5	2.0	5.8
	East Black Sea	336	2805	241	75.4	0.9	2.4
	Northeast Anatolia	75	5246	983	44.4	3.8	20.5
	Cent. East Anatolia	94	3710	799	102.3	4.0	12.1
	Southeast Anatolia	230	5330	1310	76.9	1.7	15.2
	Turkey	3014	6184	771	93.0	2.0	10.5

Source: Author's calculations from G.G.C. *et. al.* (2003 and 2005)

[5] 1358 households which are replaced with the nearest neighbors and 1104 households, whose answers are contradicting, are excluded from the analysis.

Table 1(continued): Means of input variables used in analysis

	Money spent on (TL)								
Regions	Seed	Fertilizer	Pesticide	Water	Diesel	Electricity	Other	Feed	Total
West Marmara	312	997	206	48	1118	55	1085	1054	4875
Aegean	172	531	322	188	922	108	745	497	3484
East Marmara	269	747	236	143	1231	123	841	564	4155
West Anatolia	442	1180	184	408	1765	224	767	499	5469
Mediterranean	1063	1472	759	273	1214	58	721	418	5978
Central Anatolia	193	1348	149	67	1642	62	749	319	4531
West Black Sea	236	479	176	51	705	20	510	276	2455
East Black Sea	25	329	53	4	56	13	100	227	806
Northeast Anatolia	222	334	1006	86	903	13	762	252	3578
Cent. East Anatolia	104	314	59	26	386	25	650	346	1910
Southeast Anatolia	408	807	275	133	658	163	809	205	3459
Turkey	329	802	288	132	955	78	696	457	3738
West Marmara	152	1962	352	75	1064	44	950	1186	5785
Aegean	173	869	512	374	974	134	1227	636	4900
East Marmara	149	1425	571	248	1012	33	929	760	5127
West Anatolia	570	1640	295	679	1953	615	1429	747	7930
Mediterranean	717	1917	746	425	870	117	1318	344	6454
Central Anatolia	205	1720	319	267	1424	60	932	362	5290
West Black Sea	69	675	232	114	636	18	331	250	2325
East Black Sea	13	385	27	35	35	1	147	119	762
Northeast Anatolia	216	766	59	428	581	76	888	608	3622
Cent. East Anatolia	38	469	247	0	351	3	167	286	1561
Southeast Anatolia	249	1484	321	171	509	200	679	314	3927
Turkey	231	1243	376	247	860	106	854	524	4441

Source: Author's calculations from G.G.C. *et. al.* (2003 and 2005)

Expenditures on seed, fertilizers, pesticides, irrigation, diesel, electricity, animal feed and other operational costs are also included as explanatory variables. Survey results do not report any quantities for these inputs. Using these figures incorporates the information about input prices by ignoring the differences in prices paid by the households among regions. Though, prices of these items are not likely to vary much through out the country since there is no price difference among regions in diesel, electricity, fertilizers, animal feed and pesticides, apart from the transportation costs. Besides the markets of these inputs are integrated enough to assume a small deviation among regions in the prices of these items. There are many work in the literature that use money paid to inputs in similar cases. [6]

The inefficiency effects are incorporated by six groups of variables. The mean values of selected factors that affect the production structure are given in Table 2.

[6] To count a few, Batesse, Rao and O'Donnell (2004), Batesse and Coelli (1995), Chavas, Petrie and Roth (2005) use money spent on inputs instead of quantity in the estimation of frontier.

Table 2: Mean values for some factors that characterize the production structure

		Number of Households							
		Producing				Receiving			Member
	Region	Crops	Ind. Crp.	Veg.	Fruit	DIS	Credit	Tech. As.	of ASC
2002	West Marmara	317	280	52	27	248	50	28	145
	Aegean	303	364	58	150	298	111	21	102
	East Marmara	182	90	56	145	162	37	22	85
	West Anatolia	172	65	36	5	119	11	9	3
	Mediterranean	326	107	78	53	157	38	25	58
	Central Anatolia	237	64	21	5	170	14	15	5
	West Black Sea	331	146	109	91	201	44	8	28
	East Black Sea	80	124	15	236	168	22	9	70
	Northeast Anatolia	73	17	8	1	35	1	4	0
	Cent. East Anatolia	88	29	4	9	37	2	5	0
	Southeast Anatolia	206	80	20	18	135	6	2	5
	Turkey	2315	1366	457	740	1730	336	148	501
2004	West Marmara	317	278	69	49	292	92	14	144
	Aegean	351	349	91	153	386	148	26	79
	East Marmara	189	88	86	160	219	55	14	77
	West Anatolia	178	52	30	12	163	54	7	3
	Mediterranean	327	89	79	53	229	52	15	45
	Central Anatolia	238	50	17	7	205	20	0	0
	West Black Sea	338	125	224	104	267	32	1	3
	East Black Sea	135	130	46	190	251	21	1	47
	Northeast Anatolia	69	22	16	7	57	1	4	0
	Cent.East Anatolia	82	25	9	12	57	2	0	6
	Southeast Anatolia	212	84	29	22	170	10	2	4
	Turkey	2436	1292	696	769	2296	487	84	408

Source: Author's calculations from G.G. et. al. (2003 and 2005)

The first group is composed of five variables related to land. The share of irrigated land, orchards, fallow, rented land and land taken for sharecropping in total land are included in this group of variables. The second group consists of four dummy variables for the production pattern of household. These variables take the value one if the household is producing the related crop. The third group consists of dummy variables for DIS receiving, credit access, technical support access and Agricultural Sales Cooperative Union membership status of households.

The fourth group consists of three dummy variables about the education status of household chief. The first variable takes value one if household chief is illiterate and zero otherwise while the second variable takes value one if the household chief has a primary school degree and zero otherwise. For the households of which chief has a higher education the third variable takes the value one. The fifth group of variables are related to the farm size and consists of six dummy variables respectively for 0-2 Ha., 2-5 Ha., 5-10 Ha., 10-20 Ha., 20-50 Ha. and more than 50 Ha. of land area owned. The variables take value one if the total area of land owned by the household is in the related size group. The last group of variables consists of region dummies at NUTS-I level. If household is in the relevant NUTS-I region then the variable takes value one and zero otherwise.

Table 2 (continued): Mean values for some factors that characterize the production structure

		Number of Households								
		head's education level is			owns a farm size of (ha):					
	Region	Illit.	Primary-	Primary+	0-2	2-5	5-10.	10-20	20-50	50+
2002	West Marmara	41	303	21	45	82	101	81	47	9
	Aegean	63	425	17	94	155	153	73	24	6
	East Marmara	59	201	12	48	69	79	42	24	10
	West Anatolia	27	139	13	7	18	35	58	48	13
	Mediterranean	48	275	34	64	109	82	56	35	11
	Central Anatolia	46	179	13	2	23	50	67	66	30
	West Black Sea	77	278	8	50	132	106	56	18	1
	East Black Sea	72	231	33	178	108	36	8	2	4
	Northeast Anatolia	14	58	3	7	7	12	22	21	6
	Cent. East Anatolia	26	62	6	11	18	15	25	18	7
	Southeast Anatolia	63	160	7	21	45	54	63	30	17
	Turkey	536	2311	167	527	766	723	551	333	114
2004	West Marmara	38	304	23	47	94	101	75	40	8
	Aegean	47	437	21	94	163	155	65	25	3
	East Marmara	39	220	13	53	75	69	43	23	9
	West Anatolia	31	137	11	3	20	35	62	43	16
	Mediterranean	61	258	38	71	104	74	55	39	14
	Central Anatolia	51	171	16	4	30	43	72	69	20
	West Black Sea	66	285	12	78	139	89	42	13	2
	East Black Sea	67	228	41	192	111	26	6	1	0
	Northeast Anatolia	9	59	7	5	10	15	19	20	6
	Cent. East Anatolia	28	62	4	16	22	14	27	11	4
	Southeast Anatolia	105	117	8	20	58	55	50	32	15
	Turkey	542	2278	194	583	826	676	516	316	97

Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

3. Model and Estimations

Stochastic frontier models are applied to the data described above. The deviation from the efficient frontier is modeled by a compound error term. The compound error term is sum of a normally distributed noise term and an asymmetrically distributed "inefficiency" component, which is always negative. The negative component represents the deviations of the firms from the efficient frontier due to inefficient structure of production while the normally distributed term stands for the random deviations from the efficient frontier due to reasons such as data measurement errors.

The most general form of the stochastic frontier model can be written as

$$Y = F\left(X;\beta\right)\exp\left(v-u\right) \tag{1}$$

where,

$$v \sim N\left(0,\sigma_v^2\right) \tag{2}$$

$$u \sim \left|N\left(0,\sigma_u^2\right)\right| \tag{3}$$

Normally distributed component of composite error term, v, and the inefficiency component of the error term, u, are distributed identically and independently from each other and regressors. Y is a one by ixt vector of output level. $F(.)$ is the imposed functional form of frontier and it takes X as argument. X is a $k+1$ by i x t matrix and composed of a column of ones and k input variables. β is a one by k+1 vector of parameters. u and v are one by i x t vectors of inefficiency and random components, respectively.

Production technology is assumed to follow a translog functional form. To obtain input elasticities at the sample mean directly from the estimated coefficients, input data is transformed to deviations from the geometric mean.

The model used in this paper is originally introduced by Batesse Coelli (1995). The model depends on a former modification of (1) developed in Batesse and Coelli (1992) to allow for time-varying efficiency to incorporate the change in firm level efficiency over time in quite elastic way as follows

$$u_{it} = u_i.\theta(t) \tag{4}$$

and

$$\theta(t) = \exp(\gamma(t-T)) \tag{5}$$

The distributional assumptions are same as in (2) and (3). The major contribution of the model in Batesse and Coelli (1992) is the introduction of time dimension for firm level efficiency in a quite simple way. Only one extra parameter, namely γ, is estimated to find varying efficiencies over time. The details of the model and estimation process can be found in Battese and Coelli (1992).

Estimation of technical inefficiency does not have much policy implications by itself. The model developed in Batesse and Coelli (1992) estimates the relationship between input utilization of firms and their output. However, they do not give any explanation about the reasons of inefficiency. Unraveling the factors underlying inefficiency is as important as estimating inefficiency for policy design. The early work on efficiency analysis has incorporated such factors into the analysis by running a second step regression. In this second step, efficiency scores are regressed on these exogenous variables by using OLS. However, this approach turns out to be problematic since when estimating the efficiency scores one assumes identically distributed u (Battese and Coelli, 1995).

Battese and Coelli (1995) employ a single step approach that will not contradict with the identical distribution assumption about u while explaining the technical inefficiency effects. They modify the model developed in Battese and Coelli (1992) by making the following assumption:

$$u_{it} = \sum_{i=1}^{k} \delta_i z_{it} + w_{it} \tag{6}$$

where z_{it} s are exogenous variables, δ_i s are parameters to be estimated and w_{it} is identically and independently distributed as $N(0,\sigma_w)$. To be compatible with the model of Battese and Coelli (1992) we need to impose the following condition on u_{it}

$$u_{it} = \sum_{i=1}^{k} \delta_i z_{it} + w_{it} \geq 0 \tag{7}$$

which in turn implies

$$w_{it} \geq -\sum_{i=1}^{k} \delta_i z_{it} \qquad (8)$$

and this implies

$$u_{it} \sim \left| N\left(-\sum_{i=1}^{k} \delta_i z_{it}, \sigma_w \right) \right| \qquad (9)$$

The parameters of the model defined by equations (1)-(3) and (6)-(9) can be estimated by using maximum likelihood estimation techniques (Battese and Coelli, 1995). The δ coefficients show the marginal effect of exogenous variables on technical efficiency[7].

4. Findings

The results of the tests that are conducted using the findings of these models are summarized in Table 3. The paremeters σ^2 and γ are statistically significant at 1 percent significance level that implies to the existence of a significant technical inefficiency among the households. Time invariant technical inefficiency is also rejected since the coefficient of time dummy is statistically significant for both models.

Table 3: Test Results

Test	H_0		Test Statistic	Result
Existence of technical inefficiency across farms	$\sigma^2 = 0$		-3.65	Reject
	$\gamma = 0$		3.91	Reject
Time Invariant Efficiency	$\delta_t = 0$		171.59	Reject
Significance of Technical Inefficiency Variables	$\delta_i = 0$ for all *i*	**Wald**	415.50	Reject
		LR	629.697	Reject
Constant Returns to Scale	$\sum \beta$		1.32	
	$\sum \beta = 1$		30.2	Reject

Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

Significance of technical inefficiency effects variables is tested for both models by Wald test and likelihood ratio test. Both test statistics for N-TIEM are larger than the critical value of $\chi^2_{31} = 44.99$. The critical value for NN-TIEM is $\chi^2_{341} = 385.062$, and it is smaller than the test statistics. Thus, null hypothesis is strongly rejected by both tests for both models. Accordingly, it can be concluded that technical inefficiency is explained by the technical inefficiency effects variables and TVDM is not an appropriate specification to measure the technical inefficiency. Significance of cross terms is tested by a Wald test. Test statistic turns out to be 445.27 while the critical value is $\chi^2_{341} = 379.75$. Thus, the Wald test statistic rejects the null hypothesis of insignificant cross terms. CRS is strongly rejected in N-TIEM. Sum of coefficients of inputs is 1.32 and this implies increasing returns to scale. Test statistic for CRS is 2.19 which is smaller than $\chi^2_1 = 3.94$. Thus, NN-TIEM model fails to reject CRS. Sum of coefficients of input variables is 1.12 and it is not statistically different from one.

[7] We have also estimated the model in Batesse and Coelli (1992) to test the significance of the efficiency effect variables and the model developed in Batesse and Broca (1997) is also estimated but not presented. The results of two models are consistent and the latter are reported in Dudu (2006) and Çakmak et al. (2008).

Coefficients of input variables are reported in Table 4. Coefficients of inputs are positive and statistically significant except for labor in N-TIEM model. Insignificance of labor can be explained by measurement problems described afore. Besides, many authors report insignificant coefficients of labor for various countries. To count a few, work of Xu and Jeffrey (1998) for Chinese rice production, Coelli, Rahman and Thirtle (2003) for Bangladeshi crop production and Mahmud and Demir (2002) for Turkish agricultural sector, report insignificant coefficients for labor. Xu and Jeffrey (1998) relate insignificance of labor to the extension in modern input usage while Coelli, Rahman and Thirtle (2003) explain the same fact with labor surplus in these economies. Mahmud and Demir (2002) explain their finding by excessive usage of labor in Turkish agriculture. Both explanations are appropriate for Turkish case since descriptive statistics depicts the extension in modern input usage and the existence of excess labor in Turkish agricultural sector is a well-known fact (Çakmak *et. al*. 2004).

Table 4: Estimated coefficients for input variables

Variable	Coefficient	Std. Error	
Constant	7.92	0.10	***
Labour	0.07	0.04	
Livestock	0.05	0.01	***
Land	0.38	0.04	***
Seed	0.03	0.01	***
Fertilizer	0.33	0.04	***
Pesticides	0.15	0.02	***
Water	0.02	0.01	***
Diesel	0.17	0.02	***
Electricity	0.02	0.00	***
Other Costs	0.04	0.02	**
Animal Feed	0.07	0.01	***

***: 1% significance, **: 5% significance, *: 10% significance,
Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

Land turns out to be the most important factor of production with an output elasticity of 0.38. Underlying reason for land being the most important input to affect the agricultural production can be insufficiency of modern infrastructure and technological progress. Accordingly, agricultural production has remained to be crucially dependant on land. Agricultural policies followed since the establishment of the Republic has always considered extension of cultivated area as the most important source of agricultural output growth in Turkey (Çakmak and Akder, 1999). Governments had supported the cultivation of even marginal areas with limited potential yield.

Fertilizer, diesel and pesticides follow the land as inputs with significantly higher elasticities. This offers that fertilizer, diesel and pesticides are the most important source of increase in the yield of land. Agricultural policies followed after 1960s confirms this conclusion. After agricultural land has reached its feasible frontier in terms of area, governments had focused on increasing the yield of land by encouraging farmers to use modern inputs more extensively (Çakmak and Akder, 1999). Several input subsidy programs are held for this purpose.

Second group of inputs that are relatively more effective on agricultural output is animal feed, livestock and other costs that mainly consist of expenditure on fodder. Output elasticities of these inputs are much smaller than that of the land and land related inputs. This points out that dairy production does not contribute as much as vegetal production to the agricultural revenue. Besides, the output elasticity of number of livestock is smaller than that of animal feed. Therefore, one can characterize households in two groups according to livestock ownership. Households that use animal feed are likely to be more market oriented while others are likely to consider livestock holding as a kind of investment. Thus, animal feed turns out to be more important for agricultural revenue. This turns out to be rational when the insufficiency of social security network that covers the rural households is taken into account. Since most of the small farmers are left outside the social security system, they invest on livestock in order to use it in “bad days”. The financial instruments can be quite problematic for households. One possible problem may be prohibition of interest bearing assets by the religion. Secondly, the financial instruments are complicated for most of the household chiefs who does not have an education further than primary school. The last but not the least, the availability of financial intermediaries is quite limited in the rural areas (Çakmak *et. al.* 2004). Lower output elasticity of other costs supports this hypothesis since fodder is the main component of other costs and it is the “cheaper” way of feeding livestock. Naturally, there is a trade off between the yield of livestock and cost of feeding. Since the households that do not care much about the amount of dairy production are also likely to use fodder instead of animal feed.

The last group of inputs that are less effective on agricultural revenue is composed of seed, water and electricity. Since money spent on seed is used as independent variable, importance of seed usage in production process can be underestimated. The seed variable does not comprise any information about seed usage in view of the fact that households are likely to use self-produced seeds, especially for cereal production where seeds are among the main inputs. Despite the underestimation problem, low output elasticity of money spent on seeds reveals and important fact. Money spent on seeds covers the cost of buying high-qualified seeds. Low output elasticity of this variable recommends that high quality seeds are not as effective as other inputs in increasing the production.

Underestimation problem also prevails in water and electricity usage that are mainly used for irrigation. There is a registration and pricing problem in irrigation from the water channels managed by the state institutions or irrigation associations. In most cases, farmers are let to use these facilities at low fees to encourage irrigation that results in the overuse of water. Similar problems also exist in electricity usage. Descriptive statistics for money spent on water and electricity and share of irrigated land substantiate these conclusions.

Coefficients of inefficiency effects variables are as expected and most of them are significant at conventional levels of significance (Table 5). Coefficient of share of irrigated land and orchards is negative and significant indicating a positive effect of irrigation on efficiency. This result is in line with expectations since irrigation is expected to increase the yield of land and products of orchards have higher value added. Share of fallow land is positive and significant indicating a negative effect on efficiency. This is also expected since the model considers that the alternative cost of fallow land is not cultivating some part of land and thus giving up some output.

Coefficients of dummy variables which designate the dominant products of the farm households are all in expected signs and significant at the conventional levels of significance. Being a producer of cereals affects efficiency negatively. This is not surprising especially under the production technology prevailing in Turkey. Another possible explanation can be made by considering the long lasting distortions of price support policies that has weaken the sensitivity of producers to market signals. Hence, efficiency has not been a criterion for survival of cereal producers and all kinds of investments both on physical capital and technological progress are ignored for a long time. Reforms made by ARIP turn out to be ineffective in increasing the efficiency of cereal producers.

Table 5: Estimated coefficients for technical efficiency effects variables

Variable	Coeff.	Std. Error		Variable	Coeff.	Std. Error	
Constant	1.59	0.15	***	West Anatolia	0.09	0.08	
Irrigated	-0.08	0.01	***	Mediterranean	-0.34	0.07	***
Orchard	-0.06	0.01	***	Central Anatolia	0.05	0.07	
Fallow	0.05	0.01	***	West Black Sea	0.05	0.07	
Rented	0.04	0.01	***	East Black Sea	-0.14	0.09	
Sharecropper	0.01	0.00	***	Northeast Anatolia	0.19	0.10	*
Cereals	0.27	0.05	***	Central East Anatolia	0.07	0.09	
Ind. Crops	-0.34	0.04	***	Illiterate	0.35	0.08	***
Vegetable	-0.08	0.04	**	Literate or Primary	0.17	0.07	**
Fruit	-0.08	0.05	**	Size 2-5 Ha.	-0.12	0.05	**
DIS	-0.02	0.03		Size 5-10 Ha.	-0.23	0.07	***
Credit	-0.04	0.05		Size 10-20 Ha.	-0.40	0.09	***
Tech. Sup.	-0.05	0.08		Size 20-50 Ha.	-0.54	0.11	***
ASC	-0.10	0.05	*	Size 50+ Ha.	-0.73	0.15	***
West Marmara	-0.40	0.08	***	Time	-0.52	0.04	***
Agean	-0.14	0.07	**	$ln\sigma^2$	-0.14	0.04	***
East Marmara	-0.27	0.08	***	$ln\gamma$	0.55	0.14	***

***: 1% significance, **: 5% significance, *: 10% significance,
Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

Being in one of the other producer groups effects efficiency positively. Effects of vegetable and fruit production are close to each other while the effect of industrial crops is considerably higher.

Coefficients of DIS receiving status, credit access and technical support receiving status are negative but insignificant. Insignificance of these variables offers that these factors cannot explain the variation in efficiency. Thus, it may reasonable to question the success of DIS program and quality of credit access and technical support services. The implementation period of DIS was too short (only three years) to give final verdict. Nevertheless, one would expect farmers to move closer to the efficient frontier as the distortionary price support and other production based subsidy programs are cancelled. Another factor that limited the impact of DIS is the fact that the distortionary support picked up in 2003 and 2004, hence limiting its expected impact. Moreover, DIS program, by itself, is not designed to create any incentive for inefficient farmers to be more efficient. The program is introduced to compensate the revenue losses of farmers due to the cancelled subsidy programs. So any efficiency improvements that occurred because of ARIP cannot be observed in the coefficient of DIS variable. Insignificance of effect of DIS variable on efficiency depicts that households who received support did not or could not use this money to improve their efficiency, or they used it for this purpose but its effects cannot be observed yet. Both are possible when the irregularities and delays in payments are taken into account. Farmers cannot finance their investments, especially the long-term investments that are likely to be more effective on efficiency, by relying on frequently delayed DIS payments.

Coefficient of being a member of agricultural sales cooperative unions (ASCUs) is negative and significant at 10 percent level. This is something expected since members of ASCUs are still likely to have a better access to the market even during the restructuring period of the ASCUs.

Region dummies compare the effect of being at the designated region compared to being in Southeast Anatolia. Thus, smaller coefficients imply a better effect on efficiency weighed against the effect of being in Southeast Anatolia. In line with expectations, being in the western and southern parts of the country has a significant and positive effect on efficiency. The coefficients of other regions are insignificant suggesting that effect of being in these regions is not statistically different from being in Southeast Anatolia.

Coefficients of education level variables compare the effect of being illiterate and being literate or having a primary school degree with that of having a degree higher than primary school. Both coefficients are significant and positive indicating a negative effect on efficiency. As education level falls efficiency gets worse off.

Coefficients of size dummies compare the effect of corresponding farm size with that of 0-2 Hectares size group. Coefficients depicts that the efficiency of household increases as their farm size grows. This is consistent with the test results that depict increasing returns to scale on the efficient frontier.

Lastly, the time dummy recommends that the efficiency has increased over time. Although time dimension of data is small, this can be taken as implication of positive effect of ARIP and macroeconomic stability that persist since 2002.

To sum up, estimated frontier reflects the many characteristics of agricultural production in Turkey. The output elasticities of input variables reflect a conventional production function in which land and the inputs that are used to enhance the yield of land play a major role. The coefficients of technical inefficiency effects variables are in line with expectations and justify most of the conventional standpoints. The interactions between inputs and technical inefficiency effects variables reveal some important facts such as the efficiency impeding effect of irrigation by electrical pumps or low quality of technical support or significance of livestock production for the efficiency of different household groups.

Descriptive statistics for estimated efficiency scores for NUTS-I regions are given in Table 6. There is a significant increase in the efficiencies from 2002 to 2004. This increase offers an increased integration of households to market. The increase is highest in western and southeastern parts of the country. East Marmara leads the increase with 22.78 percent. It is followed by Northeast Anatolia with 16.09 percent, West Marmara with 14.11 percent, Aegean with 13.34 percent and East Black Sea with 13.25 percent. Increase in the central parts of the country is around 10 percent while it is lowest with 8.31 percent in Central East and 5.42 percent in Southeast Anatolia.

Agricultural production in the western parts of the country is more efficient. Ranking of regions changes from 2002 to 2004. West Marmara, Aegean and East Marmara regions are in the first three ranks in both in 2002 and 2004. Mediterranean and East Black Sea regions share the 4th and 5th place in both years. Ranking of regions in central parts of the country, namely West, Central, Central East Anatolia and West Black Sea also did not change significantly. However, there has been a significant change in the ranking of Northeast and Southeast Anatolia. Northeast Anatolia has soared to sixth position from 11, and Southeast Anatolia has felt to 11 in 2004 while it was 6th in 2002. This drastic change can be explained by increasing protection in meat that is the main product of Northeast Anatolia, as suggested by descriptive statistics of number of livestock. On the other hand, the plummet of Southeast Anatolia is probably due to the rigidity of the region to the changes in the macro and agricultural policy environment.

Table 6: Mean efficiency scores

Region	Average		Std. Dev.	
	2002	2004	2002	2004
West Marmara	37.9	50.6	16.2	16.8
Agean	34.8	45.4	18.3	17.4
East Marmara	32.3	52.4	17.4	18.2
West Anatolia	24.0	33.3	13.2	16.5
Mediterranean	34.1	46.8	18.1	19.4
Central Anatolia	22.6	32.8	13.2	15.3
West Black Sea	23.4	34.4	13.3	15.1
East Black Sea	33.4	46.5	14.5	17.2
Northeast Anatolia	19.8	33.7	10.6	17.4
Central East Anatolia	24.6	32.6	13.4	17.1
Southeast Anatolia	27.4	33.2	16.6	17.2
Turkey	30.5	42.3	17.4	18.3

Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

Standard deviation of the efficiency for the whole sample is around 18-20 percent. Standard deviation is higher in western regions while it increases significantly in eastern parts of the country from 2002 to 2004. Increase is highest in Northeast and Central East Anatolia. Standard deviation in central parts of the country is lower in both periods.

Mean efficiencies for several groups of households defined by technical inefficiency effects variables are given in

Table 7.

Table 7: Mean efficiencies for groups of households defined by technical inefficiency variables

		Average		Std. Dev.	
		2002	**2004**	**2002**	**2004**
Cereal Producer	No	39.6	53.9	18.7	20.0
	Yes	30.8	43.5	18.4	20.7
Industrial Crop Producer	No	27.2	39.8	16.6	20.4
	Yes	39.6	53.1	19.2	19.2
Vegetable Producer	No	32.5	45.4	18.7	21.3
	Yes	34.8	45.9	19.7	19.7
Fruit Producer	No	32.0	43.9	18.9	20.9
	Yes	35.4	50.4	18.5	20.4
Technical Support Receiver	Received	32.4	45.3	18.6	20.8
	Not Received	42.4	55.0	21.8	23.0
Credit User	Used	32.0	44.2	18.5	20.8
	Not Used	39.7	52.4	20.6	20.6
ASC Member	Member	30.6	43.7	17.8	20.5
	Not Member	44.4	57.4	19.9	20.1
Education Level	Illeterate	26.4	37.8	16.5	20.5
	Lit. And Pri.	33.7	46.7	18.8	20.6
	Primary +	42.3	54.1	20.3	19.9

Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

Figures in Table 7 justify our findings and comments on the coefficients of technical inefficiency variables. However, there are some important conclusions that could not have been reached by merely considering the coefficients. First of all, although the coefficients of

DIS recipients, credit access, taking technical support and ASCU membership status were found to be ineffective on efficiency, one can observe that households that receive credit, take technical support or are ASCU members are considerably more efficient. Households that receive DIS are also more efficient even if the difference is not that noteworthy. Moreover, the gap between DIS receivers and the others has increased from 2002 to 2004.

Table 8 compares the mean efficiencies of DIS receivers that are in different land size groups. Two results are worth highlighting. Households that did not received DIS payments in less than 2 Hectares group are more efficient than the ones that received DIS payments, in 2002. Note that difference is greater than the sample average. Secondly, households that received DIS in the 20-50 Hectares group are drastically more efficient than those that did not receive DIS. The situation is reversed in 2004. DIS receivers of 20-50 Hectares group turn out to be less efficient, while less than 2 Hectares group became more efficient. The percentage of households that received DIS in each group explains these findings. Percentage of households that receive DIS increases by farm size. It is the highest for 20-50 Hectares group in 2002, while the gap is moderately closed in 2004. Share of households that received DIS is lowest in less than 2 Hectares group in both periods. Thus even if DIS receiving has a positive effect on efficiency, it is hard to observe this effect from mean efficiency of size groups.

Table 8: Mean efficiencies of DIS receivers and others according to farm size

		Not Receiving DIS		Receiving Dis		All Producers	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
2002	0-2 Ha.	33.8	19.8	31.8	17.1	33.1	18.9
	2-5 Ha.	31.0	17.9	31.5	16.9	31.3	17.4
	5-10 Ha.	31.2	18.2	32.9	18.5	32.2	18.4
	10-20 Ha.	31.7	19.6	32.8	19.4	32.5	19.4
	20-50 Ha.	32.1	20.7	38.5	20.2	36.4	20.5
	50+ Ha.	37.8	20.5	37.6	21.9	37.7	21.5
2004	0-2 Ha.	44.9	20.8	45.2	20.7	45.1	20.7
	2-5 Ha.	41.6	20.6	43.4	20.5	42.9	20.5
	5-10 Ha.	40.4	18.9	47.0	20.7	45.9	20.6
	10-20 Ha.	41.9	23.0	47.9	21.2	47.1	21.5
	20-50 Ha.	52.4	20.1	47.2	21.4	47.8	21.3
	50+ Ha.	44.1	26.2	54.1	21.0	52.8	21.8

Source: Author's calculations from G.G. *et. al.* (2003 and 2005)

5. Conclusion

The efficiency levels put forward an important integration problem across the country. The problem is more serious in the Eastern parts of the country. Besides, the gap between east and west works out to be increasing.

Secondly, sectors that have been subsidized historically by distortionary measures turn out to be inefficient. There seems to be slight but inadequate adjustments after the implementation of ARIP, especially when one considers the necessity, exigency and urgency of transformation in agricultural sector in the context of EU accession negotiations and Millennium Round of the WTO Negotiations.

The problems in the implementation of ARIP are reflected in results. First of all, ARIP could not reach small farmers and cereal producers, if DIS receiving are taken as an indicator of this. A drastically small percentage of small farmers are enrolled in DIS program compared the other farm groups. Secondly, the least developed parts of the country also cannot enjoy the benefits of ARIP sufficiently. Although DIS is revealed as being a better way of subsidizing farmers, it needs to be developed to reach the poorer farmers.

Although outcomes of N-TIEM model support the need to increase the average farm size, the results of NN-TIEM model, which suggests that 2-5 Hectares size group is more efficient than the mid-sized farms, should be kept in mind. Besides, average farm size does not look like an urgent and serious problem for agricultural production.

The positive effect of irrigation on efficiency is another important conclusion derived from out analysis. However, we found that using electricity for irrigation hinders the effect of irrigation. Thus, canal irrigation increases the efficiency of irrigation.

Our findings supports that there is an excess employment of labor in agriculture. This is not surprising for a country where 33 percent of the employed labor force is in the agricultural sector in 2004. It is obvious that this situation cannot be sustained especially under the increased competition that will be imposed by multilateral agreements and EU accession in future. However as interactions of labor with technical inefficiency variables offers, rather than trying to "exile" people from agriculture, introducing policies that will create incentives for labor to move to the more efficient areas inside the agricultural sector would be both less costly and more productive.

A similar argument is also valid for land. Land is found to hinder the positive effects of most of the technical inefficiency variables on efficiency. The problem with land can be more challenging since it cannot be moved to the more efficient areas. The solution is likely to lie in making long term investments, to increase the quality of the land which will diminish the climate dependency of the crop production.

Modern inputs are found to be dominating the production process. In addition, this had been encouraged by governments in the past, especially by distorting the prices paid by the farmers. However, this can create serious environmental problems in the future. Although our analysis cannot exactly identify the magnitude of the problem, negative interactions of pesticides and fertilizers suggest that excessive use of these inputs may not only harm the environment, but also affects the productivity of the basic factors of production.

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