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Economic Efficiency Of Cotton Farms: A Case Study From Torbali, Turkey

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ECONOMIC EFFICIENCY OF COTTON FARMS: A CASE STUDY FROM TORBALI, TURKEY.

by

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DEDICATION

I dedicate this thesis to Nhialic Madhol kek Wende Jesu Kristo ku Wei Dheng (God, the Almighty, His Son, Jesus Christ, and the Holy Spirit) and to my loving parents and my ever-supportive family.

BIOGRAPHICAL SKETCH

Manoi Athiaan Manoi was born on August 25, 1982, in Warrap, South Sudan. He Received the Bachelor of Arts degree in Monetary Economic and Finance from the University of North Carolina at Asheville in 2006. He is a candidate for the Master's of Science in Agricultural Economics.

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ABSTRACT

Manoi, Manoi Athiaan. ECONOMIC EFFICIENCY OF COTTON FARMS: A CASE STUDY FROM TORBALI, TURKEY. (**Advisor: Dr. Kenrett Y. Jefferson-Moore**), North Carolina Agricultural and Technical State University.

Sustainable cotton production is inextricably linked to the efficient use of resources. Suboptimum use of resources incurs opportunity costs and can exacerbate damaging externalities. In the Torbali region of Izmir, Turkey, overexploitation of ground water for irrigation and high fuel oil consumption for tractor operation affect cotton farms' economic viability and the sustainability of cotton production in the region. Improving efficiency of resource use will improve enterprise viability, reduce harmful externalities and conserve ecological capital. This study explores technical, allocative and economic efficiency levels of cotton farms in the Torbali region of Izmir, Turkey by using Data Envelopment Analysis (DEA). The mean technical, allocative and economic efficiencies were measured to be 0.870, 0.880 and 0.766 respectively. These results exposed the existence of inefficiencies in cotton production in Torbali. Data on economic efficiency indicated that the farms could potentially decrease their cost of cotton production by 23.4 percent on average and still grow the same amount of cotton.

CHAPTER 1

INTRODUCTION

Cotton is one of the most important crops of Turkey. In 2007, nearly 976,000 tons of cotton lint were produced by 104,000 farmers on approximately 591,000 hectares of land (MARA, 2007). Since cotton lint production is 967,000 tons per year and consumption of cotton lint is 1.5 million tons per year, current levels of cotton production cannot meet the needs of the textile industry. Even with growing demand, many farmers have left cotton production as a result of increasing costs (Thomas, Gunden, Boyaci & Oktay, 2009). Improving efficiency can have a twofold positive effect. First, efficiency gains will enhance the viability of individual farms and the industry as a whole, leading to an improved socio-economic status of rural people in the Torbali region. Second, improved efficiency can lead to the conservation of resources, such as water resources, as well as reductions in the use of fertilizers, insecticides and fuel oil, leading to positive impacts on environmental health. Efficiency in production is a way to ensure that products of firms are produced in the best and most profitable way. To prevent waste of resources and maximize output, efficiency is of great importance for every sector of an economy, not just agricultural sector.

As such, determining the efficiency of cotton farms in Turkey is important for exposing potential opportunities for reducing costs and conserving resources. Generating efficiency data will also have the added benefit of providing policy makers with the research-based information they need to design agricultural policies with the appropriate mix of incentives that will encourage efficient resource use in cotton production in the Torbali region.

Therefore, the objective of this study is to measure technical, allocative and economic efficiencies in order to identify opportunities for improving the efficiency of resource use in cotton production. Ultimately, it is hoped that opportunities for improving efficiency will be leveraged to ensure the sustainability of cotton production in the Torbali region of Turkey.

Principles of Sustainable Production

There is a general agreement that conventional, industrial agriculture is not sustainable. For example, conventional agriculture depends increasingly on energy supplies from non-renewable sources, depends on a narrow genetic base, depends on intense use of chemical fertilizers and pesticides, and relies on subsidies and price supports. This pattern of dependency has led to a negative environmental impact as evidenced by the loss of species, habitat destruction, soil depletion, consumption of fossil fuels and water at unsustainable rates, air and water pollution and risks to human health (Hodge, 1993; Horrigan, Lawrence, and Walker, 2002). Cotton production in the Torbali region exemplifies many of the concerns noted here.

Ikerd (1993) proposed that a sustainable agricultural system should be "capable of maintaining its productivity and usefulness to society over the long run…it must be environmentally-sound, resource conserving, economically viable and socially supportive, and commercially competitive" (p.30). Given this definition, a sustainable cotton production system would be equitable and would meet the needs of current and future Torbali populations within the limits of Torbali's ecological endowment, and within boundaries delineated by existing scientific, political, economic and social parameters. In other words, a sustainable cotton production system should be economically feasible, socially desirable and ecologically viable. (See Figure 1.)

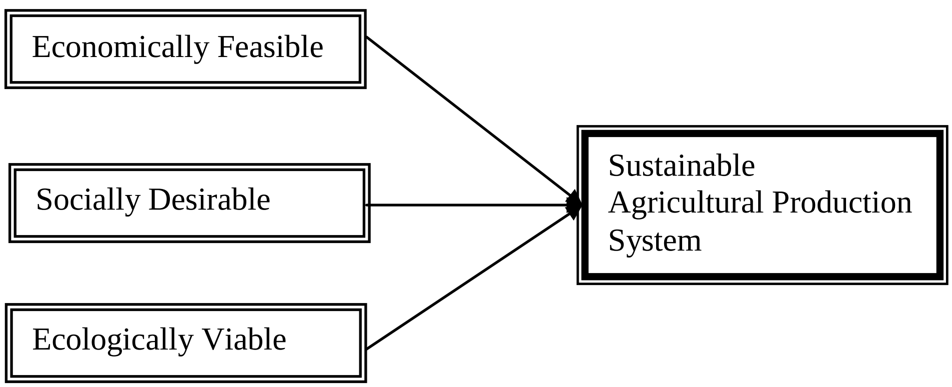

Figure 1. Sustainable Agricultural Production System as Adopted and Modified from Wright (2005)

Horrigan, Lawrence and Walker (2002) drew attention to the salience of integrating social concerns into the design of sustainable agricultural production systems. They reject approaches to sustainability that focus on the description and development of sustainable farming practices without regard for the socio-productive characteristics of the farming systems in which they will be applied. To bring a sustainable cotton production system to fruition following the precepts depicted in Figure 1, the agents of such a system must act according to the framework illustrated in Figure 2.

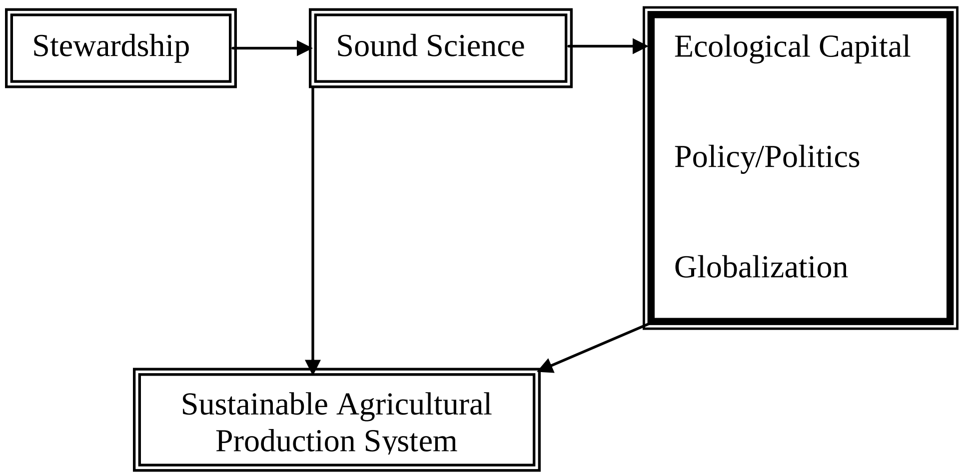

Figure 2. Stewardship as Adopted and Modified from Wright (2005)

Stewardship as depicted in Figure 2, entails employing ethical principles and values in choosing how sustainability is achieved. For example, sound science provides knowledge about the ecosystem and the possibilities for supporting sustainable cotton production. It also informs us about how to make good decisions through policies and the political process that support sustainable cotton production. Science generates knowledge about specific sustainable practices and their efficacy; it tells us about the impact of globalization, including the functioning of international markets and the spread of pollutants and diseases. In sum, science tells us what is and what is not possible. Therefore, good stewards must apply ethical standards and values in choosing from among the possibilities that science generates as they design and implement a sustainable cotton production system, and evaluate and adjust the system to meet sustainable objectives as conditions evolve. Good stewardship supports the attainment of sustainable cotton production in at least two ways: (1) applying sound science to develop production procedures or protocols that increase output per unit of input or decrease input per unit of output, thereby achieving overall economic efficiency, and (2) directing political and policy processes to design policies that support efficient use of resources and foster a culture of conservation and sustainable use of resources.

Background

The population of Torbali province is about 124, 580 people. Of this, only 9.13 percent lives in the rural area. Regardless of the rural population being significantly smaller compare to urban population, farming in general and cotton production in particular is a big deal here. The total land area in hectares is 56, 500 hectares, and agriculture covers 30, 170 of the land. Under agricultural land, crops occupy about 14, 000 ha or 46 %. In addition, about 19, 630 ha or 65% of agricultural land is irrigated. 1333 ha or 9.5% of crop land is under cotton, which yields 45, 000 kg/ha or 5, 999 (ton) annually. Other major agricultural commodities are olive and vegetables with 24% and 20% of agricultural land, respectively. In Turkey, cotton farming and processing constitute a large sector of employment in the country. As one of the most important agricultural commodities in Turkey, there are about 104, 000 cotton farmers producing an average of 976, 000 tons of cotton lint on approximately 591, 000 hectares of land (Ministry of agriculture and Rural affairs, 2007). Cotton production occupies 48% of industrial crops arable land. Turkey produces 4, 310 kg/hectares of raw cotton, and 1, 650 kg/hectares of lint cotton, making it the 6th largest cotton producer in the world. However, consumption of cotton lint is 1, 500, 000 tons per year. At this rate of consumption, cotton production cannot meet the needs of domestic textile industry. Therefore, Turkey imports cotton to make up for the deficit in local production, which makes it the 2nd largest importer of cotton in the world. In Turkey, cotton farmers are supported by the government using three agricultural tools - deficiency payments, direct income support, and irrigation water, fertilizer, and fuel subsidies. In recent years, cotton farmers have used chemical inputs, such as pesticides and fertilizers, in their attempt to increase yields and farm incomes. Of all the total insecticides used worldwide, around 23% was applied to cotton (Krattiger, 1997). Excessive use of chemicals has sown negative effects on the environment and human health (Lichtenberg and Zimmerman, 1999). The environmental effects include damage to agricultural land, fisheries, and fauna and flora. Increased mortality and morbidity of humans due to exposure to pesticides are also recorded especially in several developing countries (Wilson and Tisdell, 2001). Studies conducted in Turkey implied that production costs have increased with overuse of pesticides without any effective monitoring procedure (Tanrivermis, 2000). However, the area sown to cotton shrunk by 15% from 2002 to 2006, regardless of the government support to cotton farmers and the farmers overuse of chemicals.

Problem Statement

Production and consumption of cotton has been part of The Turkish textile and apparel industry and economy. Turkey used to be a leading producer of cotton in the past, but recently cotton production has fallen sharply, while consumption is rising, turning Turkey into a net importer of cotton (Tanriverdi, 2010). In 2007, nearly 976,000 tons of cotton lint were produced by 104,000 farmers on approximately 591,000 hectares of land (Ministry of Agriculture and Rural Affairs, Turkey, 2007). Since cotton lint production is 967,000 tons per year and consumption of cotton lint is 1.5 million tons per year, current levels of cotton production cannot meet local consumption despite the presence of the government's farm support programs for cotton farms, and the farmers' overuse of chemicals (Thomas, et al., 2009). Turkey is seeking admission to the European Union, and this requires an alignment of its agricultural policies with the European Union's Agricultural policies. As a result, its farm support program policies have come under review. In addition, the World Trade Organization rules require member countries to reduce their trade barriers, including their custom level. These policy changes are likely to exacerbate the dire cotton production and consumption realities in Turkey. Worse still, the real cotton price has fallen noticeably, and the input-output price parity of cotton has been in favor of input. Consequently, even with growing demand, many farmers have left cotton production because of increasing costs, while cotton consumption has increased 11 percent in the last five years. Since the Turkish textile industry is a key component of the Turkish economy, a decline in cotton production at a time when cotton consumption is increasing poses a serious problem for the industry and the Turkish economy (Thomas, et al., 2009). Therefore, improving the cotton sector economic and environmental efficiency competitive capacity and improving its chances to survive the competition not only from China, but also from all other significant cotton producers around the world, is imminent.

Purpose of Study

The objectives of the study are threefold:

1. To assess the technical, allocative, and economic efficiency of the cotton farms in Torbali, Turkey, in order to identify opportunities for improving the efficiency of resource use in cotton production;
2. To highlight consequences of efficient production implications on the environment; and
3. To highlight implications of inefficient production practices, and provide alternative recommendations to policy makers, national civic organizations, and/or farmers' unions for their future decisions on improving cotton farms' efficiencies with respect to the impacts of the excessive use of pesticides on the environment and general public health.

CHAPTER 2

LITERATURE REVIEW

The severe economic stress confronting cotton producers today has prompted research efforts in production and marketing risk management strategies. Yet, it is equally important to assess the production efficiency of specific farming units, which can help producers focus on necessary adjustments within their operations and improve productivity. Compared with the number of studies devoted to measuring production efficiency of other agricultural crops, studies on cotton farmers are limited. Although Brooks (2001) analyzed production and cost estimates for cotton-producing farms in the United States, and Helmers, Weiss, and Shaik (2000) measured regional efficiency and total factor productivity of the U.S. cotton-producing regions, there has been no study measuring farm-level technical efficiency for cotton farmers in Torbali, Turkey, known to this author.

Nevertheless, the technical efficiency of cotton growing has been estimated by various studies. For instance, Shafiq and Rehman (2000) used a Data Envelopment Analysis to identify sources of resource use inefficiency for cotton production in Punjab, Pakistan. There were a considerable number of resources that were both technically and allocatively inefficient. The use of Data Envelopment Analysis shows that the technique provides a clear identification of both the extent and the source of technical and allocative inefficiencies in cotton production. However, both the interpretation of the farm level results generated and the projection of these results to a higher level require care, given the technical nature of the agricultural production processes.

Wossink and Denaux (2006) use Data Envelopment Analysis (DEA) to identify the quantification of pesticide use efficiency for producers of transgenic cotton versus conventional cotton in order to test for the improvement promised by the genetically engineered crop. The data were from a survey of cotton growers in North Carolina, USA. Differences in environmental efficiency were found to be significant between herbicide tolerant and stacked gene (herbicide tolerant and insect resistant) cotton and between stacked gene and conventional cotton. In contrast, no statistically significant differences were found for the efficiency of pest control cost. In the follow-up Tobit regression, differences in production environment and farm, farmer and field characteristics are accounted for so that the contribution of seed type to efficiency can be observed. The regression results confirmed the importance of stacked gene cotton for improving the environmental efficiency of pesticide use in cotton. In contrast, seed type was not significant in explaining differences in cost efficiency.

Güden (1999) estimated technical efficiency of cotton production in Menemen, Turkey, using Data Envelopment Analysis (DEA) and determined production and input losses caused by inefficiency. The researcher found that technical efficiency score was 0.677 in the province, which implies that current production could be increased by 32.3 percent. Binici et al. (2006) investigated the technical efficiency of cotton production on the Harran Plain in Turkey. Compared with results from other studies of farm production, in developing countries, the study founded that the sample of 54 cotton farmers located in

Harran Plain are producing at a high level of efficiency. Nevertheless, 72 percent of the farms are using inefficient levels of inputs. The results showed a positive and significant relationship between a farmer's education and a farm's technical efficiency, which implies that technical efficiency, underscores the need for public investment in rural education. This team of researchers also concluded in their study that chemicals, tractor, and labor inputs are mostly used inefficiently in Harran Plain, Turkey.

Wadud (2003) used DEA model to compare the results with a stochastic frontier model to assess estimates of technical, allocative, and economic efficiency of rice farms using farm-level survey data for rice farmers in Bangladesh. The mean values of technical, allocative and economic efficiency were 86, 91 and 78 per cent for CRS DEA frontier and 91, 87 and 79 per cent for VRS DEA frontier. Thus the results of DEA analysis revealed substantial inefficiencies in production. There was scope for reducing cost in production and hence obtaining output gain through efficiency improvement. In terms of scale economies, 94 farms were characterized by decreasing returns to scale, 25 farms had constant returns to scale and 31 farms had increasing returns to scale. The DEA results showed that there was substantial technical, allocative, and economic inefficiency in production and that analysis of technical, allocative, and economic inefficiency in terms of land fragmentation, irrigation infrastructure, and environmental factor were robust. The paper study concluded that policies leading to reduction of land fragmentation and improvement of irrigation infrastructure and environmental factors could promote technical, allocative, and economic efficiency, reduce yield variability, and enhance farm incomes and household welfare.

CHAPTER 3

METHODOLOGY

This paper used the Data Envelopment Analysis method to measure cotton production efficiencies. This method measures a firm's position relative to an efficient frontier, which results in firm's efficiency score. The efficiency score is always between zero and one, where a score of one indicates full efficiency and deviations from the frontier are assumed to be inefficient. DEA is a technique of estimating a firm's relative position to the frontier. Modern efficiency measurements, as used today, begins with Farell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs. Farrell proposed that the efficiency of a firm consists of two components: *technical efficiency*, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and *allocative efficiency*, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. These two measures are then combined to provide a measure of total *economic efficiency*.

Since then, numerous studies have utilized this efficiency measurement methodology. The use of DEA has been applied to efficiency measurement in Turkey over the last decade. The technical efficiency of cotton production was calculated by Günden & Miran (2001). Similarly Abay, Miran & Günden (2004) analyzed the efficiency measures of tobacco farms, and Günden, Miran & Unakıtan (2006) determined the efficiency levels of the resources used in sunflower production by using Data

Envelopment Analysis. The economic efficiency of organic and conventional cotton farms was measured by Tzouvelekas et al. of the university of Crete, Greece (2001), and the environmental and cost efficiency of transgenic and conventional cotton production (Wossink & Denaux, 2006), as well as the allocative efficiency of cotton farms in Punjab, Pakistan (Shafiq & Rehman, 2000) and the technical efficiency of cotton farms In Vehari, Pakistan (Battese & Hassan 1998; Chakraborty et al., 2002), have also been calculated. However, no studies have measured the economic efficiency of cotton farms in Turkey.

The problem of measuring the productive efficiency of an industry is important to both the economic theorist and the economic policy maker. If the theoretical arguments as to the relative efficiency of different economic systems are to be subjected to empirical testing, it is essential to be able to make some actual measurements of efficiency. Equally, if economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources (Farrell, 1957). When one talks about the efficiency of a firm, one usually means its success in producing as large an output from a given set input. Efficiency is generally measured using either parametric or non-parametric methods. Parametric methods include deterministic frontier production functions, stochastic frontier methods, and panel date models (Battese, 1992).

Measurement of Efficiency via Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric mathematical programming method widely used in efficiency measurement studies and it is based on the views of Farrel (1957) on efficiency. It involves the use of linear programming methods to construct a surface around the date or an efficiency frontier (piecewise). The frontier that denotes the efficient farm is the expected target for other farms that are inefficient. In other words, efficiency is measured relative to this frontier, where all deviations from the frontier are assumed to be inefficient. This is to say that the standard methodology for measuring farm level production efficiency is to estimate a production frontier that envelopes all the input/output data available for the analysis. Within this context, the technical efficiency of a farm is measured relative to the input/output performance of all other farms in the sample (Fraser and Cordina 1999). Farms that are located on the production frontier are considered perfectly efficient, while those located inside or below the frontier are considered inefficient because they are generating less output than what is feasible given the level of inputs. Production efficiency of inefficient farms is measured as the relationship between the observed output and the output that could be obtained if the farm produced on the frontier, given its observed level of inputs.

Data Envelopment Analysis compares efficiency from two points of view: output-expansion and input-contraction. The output-expansion model poses the question as to how much more output could be produced with given levels of inputs. In contrast, the input-contraction model evaluates how much a decision-making unit (DMU) could reduce inputs without lowering its output (Coelli, 1995). Data Envelopment Analysis first estimates an envelopment surface using data from all farms in the data set. Two basic types of envelopment surfaces can be estimated. One is referred to as a Constant Return to Scale surface (CRS), and the other is referred to as a Variable Return to Scale (VRS) surface (Charnes et al. 1978). The performance of each farm is evaluated relative to the envelopment surface. The measure of the relative farm performance is called the Overall (Global) Technical Efficiency, if the CRS surface is estimated (Iraizoz et al. 2003), and the Pure Technical Efficiency (PTE), if the VRS surface is estimated (Llewelyen and Williams 1996; Iraizoz et al. 2003). When estimating a CRS surface, farms are assumed to be operating at their optimal level of scale. However, it is widely recognized that several factors, including imperfect competition and financial constraints, can cause farms to operate at less than their optimal scale (Coelli 1995). A lack of scale efficiency will likely result in the Global Technical Efficiency being measured with an error (Coelli 1996).

The Constant Return to Scale DEA

The purpose of Data Envelopment Analysis (DEA) is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. DEA is commonly used to evaluate the efficiency of a number of farms or Decision Making Units (DMUs). The first DEA model for estimating technical efficiency was suggested by Charnes, Cooper & Rhodes (1978), and was based upon the assumption of constant returns to scale. Constant returns to scale assume that the farms are operating at their optimal scale. In this study, an input-oriented Charnes, Cooper &

Rhodes model (CCR model) was used to measure efficiency of cotton production. The technical efficiency (TE) measure under the assumption of constant returns to scale (CRS) can be formulated as follows:

$$\begin{aligned} & Min_{\lambda,\theta}\theta \\ & st \quad -y_i + Y\lambda \geq 0 \\ & \qquad \theta x_i - X\lambda \geq 0 \,, \\ & \qquad \lambda \geq 0 \end{aligned} \tag{1}$$

Here, θ is a scalar and λ is a vector of constants in Nx1. θ is the ith unit's efficiency score (i=1,2,…,91). The estimated θ will satisfy the restriction θ≤1 with a value θ=1, indicating a technically efficient farm in cotton production. The yi in the equation set is the amount of cotton production of the ith farm, and Y is the matrix of covering the amounts of cotton production for all farms. The xi is the ith farm's level of input use. Banker, Charnes & Cooper (1984) redeveloped the first DEA model considering the variable return to scale (VRS) by adding the convexity constraint N1'λ =1.

The technical efficiency (TE) score shows how efficiently the farm uses the available inputs to produce a given output. In other words, technical efficiency determines whether the farm achieves maximum output using a given bundle of factors of production. It measures the extent to which production can be affected by factors not related to the (dis)advantage of farm size and other aspects of the farm's production process. The overall technical efficiency (OE) measure obtained from the constant return to scale DEA is decomposed into pure technical efficiency (TEVRS) and scale efficiency

(SE). The purpose of the decomposition is to determine the source of inefficiency. The overall technical efficiency (OE) score includes the combined influence of the technical and scale effects. An overall efficiency is a gross measure of relative productivity as it captures all sources of variation in the ratio of output to input, including TE (Coelli, 1998). On the other hand, the scale efficiency (SE) measures the extent to which overall efficiency can be affected as the size of operation changes (i.e., SE = OE/TE). Under input-contraction, the level of the technical efficiency score is always greater than or equal to the overall efficiency score. If the two scores are identical, OE efficiency is fully explained by TE. If TE is higher than OE, overall efficiency is partly determined by the effect of scale (Battese & Broca, 1997). If the price of input and a suitable behavioral objective such as cost minimization are taken into account, allocative efficiency can be measured. First, two linear programming problems are solved for measuring technical and economic efficiency. Then, allocative efficiency is calculated residually (Coelli et al., 1998).

$$\begin{aligned} &\min_{\lambda x_i^*} w_i^{'}, x_i^* \\ &st \quad -y_i + Y\lambda \geq 0, \\ &\qquad x_i^* - X\lambda \geq 0, \\ &\qquad N1^{'}\lambda = 1 \\ &\qquad \lambda \geq 0, \end{aligned} \quad , \qquad (2)$$

Here, wi is a vector of input prices for the i-th farm and xi* is the cost-minimizing vector of input quantities for the i-th farm calculated by the LP, given the input prices wi and the output levels yi. Economic efficiency (EE) is determined for the i-th farm with the following equation:

$$EE = w_i^{'} x_i^{*} / w_i^{'} x_i \; . \qquad (3)$$

For the i-th farm, Economic Efficiency (EE) is the ratio of possible minimum cost to actual observed cost.

Allocative efficiency is calculated residually by using a Farrell (1957) decomposition relationship based on the assumption of a variable return to scale:

$$AE = EE / TE \qquad (4)$$

Allocative efficiency measures show far the farm is from the point of maximum profitability given the existing market prices for inputs and products. Thus, allocative efficiency determines whether the factors of production are used on proportions that ensure maximum output at given market prices.

In the technical efficiency model, total cotton production in (kg) was used as the output in the Data Envelopment Analysis model. The primary inputs were land measured in hectares of the cotton plot. The total amount of hired labor used in cotton production was measured in man-days. Tractor use was measured in hours. Planting material was measured as quantity of cotton seed in kilograms. Fertilizer, pesticide and irrigation were measured as the estimated total cost. In economic efficiency measurement we used land rent ($/ha), labor wage ($/man-days), tractor cost ($/hours) and seed price ($/kg). For other inputs we used the prevailing real interest rate as the input price.

Data

The data used in this study was collected through a questionnaire study 2002 from cotton farmers in Torbali, Turkey. The data were collected for the purpose a collaborative project between North Carolina Agricultural and Technical State University, Greensboro, North Carolina, USA and Ege University, Bornova, Izmir, Turkey. A structured questionnaire was developed to collect the input-output quantity and price data from a random sample of cotton farmers in eight villages in the Torbali region. The appropriate sample size was determined following procedures outlined by Newbold (1995). Data were collected in 2002 from 91 farmers using personal interviews. The data were collected from cotton farmers in the region by face to face interviews.

The sample size was found as 91 farmers using the following equation:

$$n = \frac{Np(1-p)}{(N-1)\sigma_{\hat{p}x}^{2} + p(1-p)} \tag{5}$$

at 95% confidence level and 10% error level with p: 0.50 and (1-p): 0.50 for getting the maximum sample size (Newbold, 1995).

Variables:

n: Sample size

N: Total number of farmers

p: Proportion for the cotton farmers (for maximum sample size, 0.5 was accepted).

$\sigma^2_{\hat{p}x}$: Variance

CHAPTER 4

DATA ANALYSIS AND RESULTS

This chapter presents the data analysis and results of the various efficiency models developed in this study. Table 1 gives basic descriptive statistics of output and input quantities and prices used in the analysis.

Table 1. Basic Descriptive Statistics of Cotton Output, Major Inputs Used and Prices

Description	**Unit**	**Mean**	**STD**[k]	**Minimum**	**Maximum**
Cotton yield	kg/ha	3928.99	561.87	2710.00	5400.00
Land (plot size)	Ha	4.77	4.35	.85	21.00
Labor	man-days/ha	76.16	11.03	36.08	95.38
Tractor use	hours/ha	21.15	2.13	17.50	28.57
Seed	kg/ha	41.10	10.40	17.98	80.00
Other inputs	$/ha	300.65	87.64	140.23	606.06
Irrigation cost	*$/ha*	*140.55*	*57.62*	*44.15*	*374.86*
Fertilizer cost	*$/ha*	*120.65*	*39.99*	*45.53*	*258.61*
Pesticide cost	*$/ha*	*39.45*	*30.03*	*4.26*	*217.88*
Price of input					
Land rent	$/ha	368.92	95.46	132.45	562.91
Labor wage	$/man-days	6.10	0.66	4.42	7.95
Tractor cost	$/hours	3.72	0.47	2.68	4.71
Seed price	$/kg	0.77	0.54	0.26	3.97

[k] standard deviation

Table 2, below, illustrates the percentage share of each input in the total cost of production. It shows that labor has the highest average cost share among the five inputs, at 35.88 percent, which is to be expected. This is followed by land rent, with a mean of 29.16 percent to the total cost. This implies that 29.16 percent of total inputs is devoted to or allocated to land rent. The budget allocated for the tractor use is the second lowest at an average of 6.49 percent of total inputs, but it is the seeds that cost the least as only about 2.43 of the total production cost is appropriated for that portion of inputs. The share of other inputs is 26.04 percent. This means that a little over one-quarter of the total cost of inputs is dedicated to the cost of irrigation, fertilizers, and pesticides. One-quarter of the total cost of inputs is a huge budget. This implies that since over usage of these inputs doesn't generate more outputs, but only adds to environmental and ecological problems that are harmful to human health and biodiversity in general, the Torbali's cotton farmers could save some of their input resources, while producing the same amount of cotton. This savings could also be allocated to another sector or purpose that would earn them more income. Even better, the cotton farmers could use their savings in the environmental and biodiversity conservation and preservation.

Table 2. Percentage Share of Each Input in Total Cost

Description	Mean	STD[k]	Minimum	Maximum
Land rent	29.16	6.35	12.64	44.51
Labor	35.88	5.82	21.07	51.22
Tractor use	6.49	1.37	3.77	9.89
Seed	2.43	1.17	1.15	8.37
Other costs	26.04	6.02	16.05	47.11

[k] standard deviation

Table 3 presents technical and scale efficiency measures for the Torbali region's cotton farmers. Technical efficiency analysis indicated that the overall technical efficiency of sample cotton farms ranged from 0.576 to 1. The average was 0.816, with a standard deviation of 0.104. This measure indicates that the same amount of cotton can be obtained even if the inputs used for production are decreased by 18.4%. The average pure technical efficiency and scale efficiency measures were 0.870 and 0.937, respectively. This implies that inefficiency was primarily the result of poor pure technical efficiency, which was 13 percent below optimum production efficiency. Pure efficiency means that a firm's or farmer's efficiency or inefficiency to increase outputs while keeping the inputs constant cannot be blamed on an entity's size or scale, but solely on a technical ground. Scale efficiency was less of a problem, falling below the optimum level of efficiency by 6.3%. Technical efficiency measures obtained in this study are higher than those obtained by Günden & Miran (2001) in 1998 in Menemen, a cotton growing area adjacent to Torbali. Ten plots were on the efficiency frontier. In other words, current cotton production in these plots was obtained by the use of minimum-level inputs. Twenty percent of the plots showed pure technical efficiency, while 13 percent of the plots showed scale efficiency.

Table 3. Technical and Scale Efficiency Measures for Torbali Cotton Farms

Efficiency measures	Mean	STD[k]	Median	Min.	Farms	Percentages
Overall technical efficiency (TE_{CRS})	0.816	0.104	0.814	0.576	10	10.99
Pure technical efficiency (TE_{VRS})	0.870	0.097	0.884	0.598	18	19.78
Scale efficiency (SE)	0.937	0.073	0.963	0.676	12	13.19

[k] standard deviation

The sources of scale inefficiency and corresponding cotton production levels were determined and summarized in Table 4. Under constant returns to scale (CRS) model, a firm or the Decision Making Unit (DMU) is considered to be operating at an optimal status or scale for the combination of input factors and production scale. In other words, there is no need for any adjustment or improvement when a firm or DMU is at this stage. But when a firm or DMU is at DRS stage, it means that the firm is using more inputs in the production that returns fewer outputs than the inputs utilized in the production. At this stage, a firm is advised or suggested to decrease their inputs and production scale in order to improve its overall operational efficiency. Meanwhile, IRS is just the opposite of DRS. A firm that produces more outputs per a given input cannot only expand its production scale, but also should be able to improve its operational efficiency. The results indicated that approximately 19 percent of the sample cotton farms had decreasing returns to scale (DRS), and that 68 percent of the farms showed increasing returns to scale (IRS). The share of the farms that had constant returns to scale (CRS) was nearly 13 percent. If these farms remove scale inefficiency, they can increase their overall technical efficiency level from 0.816 to 0.870 on average. The cotton output of the 12 scale efficient farms is statistically different from DRS and IRS farms. Scale-efficient farms produced more cotton per hectare.

Table 4. Summary of Return to Scale Results

Return to scale	Farms	Percentages	Cotton production (kg/ha)		
			Mean	Min.	Max.
CRS	12	13.19	4440.09[a]	3500.00	5400.00
DRS	17	18.68	3810.82[b]	2710.00	5125.00
IRS	62	68.13	3849.42[b]	3000.00	5000.00

[a, b] Significant by Mann-Whitney U test for $p<0.05$

In the second step of efficiency analysis, the economic efficiency (EE) and allocative efficiency (AE) estimates under variable return to scale (VRS) were obtained (Table 5). The first DEA model depended on upon the assumption of CRS. But the CRS assumption is only appropriate when all DMU's are operating at an optimal scale. However, some factors such as imperfect competition, financial constraints, technology, and among others, may cause a DMU to be not operating at optimal scale. Hence, Banker, Charnes, and Cooper (1984) redeveloped the DEA model to account for variable returns to scale (VRS) situations. The use of the CRS specification when not all DMU's are operating at the optimal scale results in measures of technical efficiency (TE) which are confounded by *scale efficiency* (SE). Therefore, the use of VRS specification permits the calculation of these SE effects (Coelli et al, 1998).

The allocative efficiency ranged from 0.659 to 1. The average was 0.880, and the standard deviation was 0.074. As a result of technical (TE_{VRS}) and allocative efficiency measures, the average economic efficiency of the farms was 0.766, with a low of 0.428 and a high of 1. These results exposed the existence of allocative and economic inefficiencies of cotton production in the province under conditions of VRS. The economic efficiency measure implies that the farms could potentially decrease their cost of cotton production (or the cost of purchased inputs) by 23.4 per cent on average while still producing the same amount of cotton. While some farms were technically efficient, they did not achieve allocative efficiency. Consequently, only 4.4 per cent of farms were rated as economic and allocative efficient (See Table 5.).

Table 5. The Results of Economic, Allocative and Technical Efficiencies Under Variable Return to Scale

Efficiency measures	Mean	STD[k]	Median	Min.	Farms	Percentages
Economic Efficiency (EE)	0.766	0.107	0.765	0.428	4	4.40
Allocative Efficiency (AE)	0.880	0.074	0.896	0.659	4	4.40
Technical Efficiency (TE_{VRS})	0.870	0.097	0.884	0.598	18	19.78

[K] standard deviation

The comparison between efficient and inefficient farms exposed the fact that economically efficient farms have higher cotton production and larger plot sizes. They also used fewer tractor hours, and seed and other input costs were lower than those of the inefficient farms (See Table 6).

Table 6. The Differences Between Economically Efficient and Inefficient Farms

Description	Unit	Economic Efficiency	
		Efficient farms (n=4)	Inefficient farms (n=87)
Cotton production *	kg/ha	4415.55	3890.72
Land (plot size)	Ha	7.91	4.63
Labor	man-days/ha	77.28	76.07
Tractor use	hours/ha	19.73	21.26
Seed	kg/ha	39.53	41.22
Other inputs	*$/ha*	228.92	306.29
Irrigation cost	$/ha	115.61	142.52
Fertilizer cost	$/ha	88.22	123.20
Pesticide-growth reg. cost	$/ha	25.10	40.58

* Significant by Mann-Whitney U test for p<0.05

The economically optimal input usages were calculated for an average cotton farm in the province using the efficient reference set for each farm. (Table7). The difference between actual and optimal input levels indicates the adjustment that is required in inputs in order to achieve overall economic efficiency. One could reduce the input used by the percentage change presented in the last column of Table 7 without decreasing cotton production in the Torbali region. For example, at the farm level, farmers were using inputs such as irrigation, fertilizer and pesticides at levels that were 30.45% in excess of the optimum level. The use of land, labor and tractors above optimum levels amounted to 19.08, 18.55 and 21.04 percent respectively. It can be said that farms would reduce costs and increase profitability of cotton production by achieving overall economic efficiency.

Table 7. Actual and Economically Optimum Input Usages

Description	Actual	Optimum	Adjustment	Change (%)
Land (ha)	4.77	3.86	0.91	19.08
Labor (man-days/ha)	76.16	62.03	14.13	18.55
Tractor use (hours/ha)	21.15	16.70	4.45	21.04
Seed (kg/ha)	41.10	33.42	7.68	18.69
Other inputs [1] ($/ha)	300.65	209.09	91.56	30.45

[1] irrigation, fertilizer and pesticides

CHAPTER 5

IMPLICATIONS AND CONCLUSION

This thesis assesses the patterns and sources of technical, allocative, and economic efficiency of cotton farms in Torbali, Turkey, using Data Envelopment Analysis (DEA) model. The results show that farmers can reduce their cost of irrigation, fertilizer, and pesticides by 30.45% and still produce the same quantity of cotton. Farmers in the Torbali region can also use less land (19.08%), labor (18.55%), tractor hours (21.04%) and seeds (18.69%), which will further reduce production costs without reducing the quantity of cotton produced. There is mounting evidence in the literature on the negative impact on water resources from fertilizer and pesticide runoff from crop land, and the negative effect of pesticides on wild fauna. There is also a public health issue with bioaccumulation and biomagnification from exposure to pesticides over time through the food chain. More efficient use of pesticides can reduce environmental and public health risks. In some areas of the world, excessive diversion of rivers for irrigation and ground water overdraft has resulted in severe environmental problems. For example, the Aral Sea in Kazakhstan has declined in area by more than 50%, leading to severe environmental and health problems. In the United States, there is concern that large portions of the land now being irrigated from the Ogallala aquifer will return to dry-land farming (Raven and Berg, 2006), reducing the productive capacity of these lands. In the Torbali region of Turkey, as farmers increase their use of irrigation in cotton production, the cost of irrigation increases as ground water becomes less accessible. Wells have to be sunk much deeper and, as a result, pumping costs escalate. Furthermore, overdraft of ground water could eventually lead to depletion of ground water reserves as rates of withdrawal from aquifers exceed renewal rates.

If farmers were to use water resources, land, labor and tractor hours more efficiently, resources would be available for growing other crops, which could increase the diversity of the agro-ecological system. Other options for the investment of savings from more efficient use of resources would include improving the quality of the land with such practices as grading to improve water flow and percolation in surface irrigation, building the organic matter content of soil to improve retention and availability of water to crops, investments in developing more efficient irrigation technologies such as drip irrigation, and more efficient use of tractor hours which would lead to less fuel consumption, less pollution and less soil compaction. These changes would put cotton production on a more sustainable path.

In the short run, instead of pursuing new cotton production technologies developed by research institutes and universities, research and extension programs should focus on improving Tarboli cotton farmers' efficient use of resources in cotton production. Additionally, policy options that provide incentives for conservation and efficient use of resources along with education programs on the merits and benefits of adopting sustainable production practices should be developed and implemented.

To meet the local and national high demand of cotton, the cotton farms in Torbali, Turkey, are using chemical inputs, especially pesticides to increase yields and farm income. According to Krattiger (1997), around 23% of the total insecticides used worldwide was applied to cotton. Resorting to inorganic agro-chemicals to boost production is counterproductive. Excessive use of pesticides has shown negative effects on the environment and human health (Lichtenberg and Zimmerman, 1999). It is very clear from the study results that most of the cotton farms in Torbali, Turkey, are inefficient. Farmers here tend to overuse their cotton input production resources, yet the majority of the farms are economically, technically, and allocatively inefficient. The results indicated that the cotton farmers can produce the same amount of cotton, while reducing their inputs by 19.08% of land, 18.55% of labor, 21.04% of tractor usage, 18.69% of seeds, and a combined 30.45% of irrigation water, fertilizer, and pesticide. Escalating cotton production cost, heavy-reliance on non-renewable resources breed a range of important environmental problems. These include pollution, land and soil degradation and erosion, water contamination, chemical residues in foods, adverse effects in human health, and a reduced biodiversity of wild species of fauna and flora. These negative implications of manufactured farm chemicals coupled with inefficient production modes bring into question the sustainability of cotton farming in Torbali.

With a 65% of its 30, 170 hectares of agricultural land under irrigation, Torbali cannot sustain its cotton production operation profitable for so long. The province is already producing cotton inefficiently, and its excessive use of factors of production and inputs is not resulting in more benefits, but in serious negative health and environmental externalities. This situation needs to be corrected immediately. If not checked and the course reversed, more and more cotton farmers may quit their farms. Such a scenario may not only lead to lost income for the cotton farmers, but may also affect the textile industry, which is a very vital part of Turkey's economy. Besides, the farmers who have abandoned their cotton farms may migrate to urban areas to look for jobs. This could lead to congestion in the cities and lack of enough opportunities to go around as over 90% of the residents in Torbali lives in urban areas. Worse still, the farmers, in their quest for high cotton yields, may decide to move and convert other natural ecosystems to agricultural land, which could negatively impact the environment and ecological diversity even more at a time when there is need for wetland conservation.

Therefore, it is important that we find solutions to conflicts that arise between agriculture and the environment or biodiversity. The parties concern or policymakers must do something before it is not too late to remedy the situation. First, the right course to take to salvage the situation would be to inform the cotton farmers of their inefficient production activities. They need to be told that they are overusing their resources and that they can scale back on inputs use, but still produce equivalent amount of output. In other words, farmers need to be educated that what they need to increase their cotton yields is not more land, labor, irrigation water, fertilizers, and pesticides, but efficiency and effectiveness. This could be done through training, farm cooperative extensions, or through the ministry of agriculture. Second, the farmers need to know or be educated that over employment of pesticides does not mean or necessarily result in over production. And that doing so actually hurts. The Torbali cotton farmers need to reduce the plot sizes of the land they are currently overusing, shrink their labor amount, cut back on tractor use (fuel oil), decrease the amount of pesticides and continue to produce the same amount of output. If they scale back on their inputs and inefficient farming practices, it would have a positive consequence on the environment. In other words, the few inputs or alterations into our soil, rivers, air, wetlands, and all forms of biodiversity, the few problems we have in our surroundings. After all, pesticides, which comprises of insecticides, fungicides, herbicides, and others, are designed to kill something somewhere. Therefore, pesticides affect species diversity at least in the area where they are applied and beyond, if application is imprecise (McLaughlin and Mineau, 1995). Third, the government may set up come a subsidy as well as insurance program for these cotton farmers as well as against their unintended production operation adverse impacts or externalities. Fourth, the cotton farmers could be encouraged to form cotton farmer-cooperatives. This would help them not only by share information and any loss in their farming operations, but also in their daily farming activities from farmland to the points of sales. Above all else, cotton farmers must be mindfully of the consequences of their operations on the environment within which they operate by. This entails efficient and sustainable farming. To be sustainable, a farm must produce adequate yields of high quality, be profitable, protect the environment, conserve resources, and be socially responsible in the long term (Reganold, et al., 2001).

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