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The Effects of Trade Exposure on Technical Efficiency: New Evidence from the Turkish Rubber Industry

ÖMER GÖKÇEKUŞ
Department of Economics, Duke University, Box 90097, Durham, NC 27708-0097
gokcekus@econ.duke.edu

Abstract

When a country's foreign trade regime becomes more open, international trade theory suggests that domestic firms face more competition and start to operate more efficiently to reduce their production costs. This proposition is empirically examined by using plant-level data from the Turkish rubber industry during a period of substantial trade liberalization: technical efficiency levels improved significantly when Turkey's trade regime shifted from a restrictive to a more liberalized one. Incumbent plants located closer to international markets improved technical efficiency more than the other plants. These findings suggest that the improvement in technical efficiency was due largely to trade liberalization.

Key words. Trade liberalization, technical efficiency.

1. Introduction

This study attempts to provide new empirical evidence on the relationship between a foreign trade regime and an economy's performance. It examines the Turkish rubber industry during a period of significant trade liberalization. Two related questions are addressed. Was there any significant change in technical efficiency levels before and after trade liberalization? And were there any significant differences among plants' technical efficiency levels?

In the 1980s, many developing countries launched wide-ranging reforms in order to solve their dire economical problems. One of the most important reforms was the liberalization of highly protective foreign trade regimes. [For details, see Papageorgiou and Choksi (1991).] Despite the prominence of trade liberalization during the 1980s, there are a limited number of studies which analyze the effects trade liberalization had on the industrial competition and efficiency of developing countries [i.e., Tybout, de Melo, and Corbo (1990); Roberts and Tybout (1991); Levinsohn (1991)]. Moreover, there is little consensus on whether trade liberalization had a positive or a negative effect on economic performance or whether it had any effect at all [Rodrik (1992)].

This study quantifies technical efficiency levels for each plant in the Turkish rubber industry by using a stochastic frontier production function model. Since the data set, derived from the Annual Manufacturing Surveys of Turkey, includes very detailed plant-specific characteristics, this paper also provides new insights into plant-specific characteristics and their effects on technical efficiency.

The paper is divided into five sections. Section 2 gives a brief review of the channels through which trade liberalization affects technical efficiency levels. Section 3 describes the econometric models utilized in the estimation of technical efficiency and in the explanation of the technical efficiency differences within the industry. It also provides the rationale for dividing the data into different subgroups based on the location and age of the plants. Section 4 provides background information on Turkish trade reforms in the 1980s. Section 5 includes estimation results and their evaluations. Finally, Section 6 provides some concluding remarks.

2. Theoretical Background

According to international trade theory, there are three main channels through which a more liberal trade regime affects technical efficiency. First, in order to compete against international producers, domestic firms must adopt a newer and more efficient technology or use the same technology with less waste and less X-inefficiency to reduce cost whenever possible [Nishimizu and Robinson (1982, p. 179)].

Second, in the case of developing countries, imports of intermediate and capital goods may not be substitutable with domestically produced ones: the imported inputs may embody differentiated intermediates that are not available in the local economy. The increased availability of such imported intermediate and capital goods leads to a greater number of insights that local researchers gain from inspecting and using these goods, and this increase in knowledge leads to greater technical efficiency.

Third, increased volume of imports and exports augments international technical knowledge spillovers. This may happen through the suggestions of the foreign purchasers to improve the manufacturing process, by, for example, the recommendation that new intermediate inputs be used [Grossman and Helpman (1991, p. 167)].

3. The Econometric Model

Farrell (1957) defines technical efficiency as the ratio of actual output level to maximum potential output level obtainable from a given input with frontier technology. We derive technical efficiency from the following stochastic frontier production function model:

$$\begin{aligned}\ln VA_i = {} & \beta_0 + \beta_1 \ln K_i + \beta_2 \ln L_i + \beta_3 (\ln K_i)^2 + \beta_4 (\ln L_i)^2 + \beta_5 (\ln K_i)(\ln L_i) \\ & + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \epsilon_i, \qquad (1)\end{aligned}$$

where ϵ_i, the composed error term, captures the random effects and technical inefficiency [Aigner, Lovell, and Schmidt (1977); Meusen and Van den Broeck (1977)].[1] In this study, technical inefficiency is measured as the shortfall of output from its maximal possible value given by the stochastic frontier.[2] Value added is used as the measure of output. Capital and labor are the inputs. In addition to capital and labor, X_6, X_7, X_8, and X_9 are also included as explanatory variables to capture qualitataive variations among the plants. X_6 is the ratio of technical workers (engineers and technicians) to the total production workers and differentiates skilled and unskilled labor. X_7 is the ratio of administrative and managerial workers to the total labor force and distinguishes production from nonproduction workers. X_8 is the share of the aggregate output of the province where a plant is located in the industry's aggregate output and is a proxy to the spillover effects among the neighboring plants. Finally, X_9 is the ratio of total electricity consumption to the total installed machinery (in terms of kilowatt hours per horsepower) and captures the capacity utilization differences among the plants.

By employing the procedure suggested by Jondrow et al. (1982), the technical efficiency level for each plant is computed. Having calculated the technical efficiency for pre- and post-trade liberalization periods, we can investigate changes in technical efficiency levels following trade liberalization. Then, in order to calculate the effects of the other plant-specific factors, in addition to the trade regime, the following equation will be used:

$$TE_i = \alpha_0 + \alpha_1 TRADE + \alpha_2 FINAN_i + \alpha_3 PORT_i + e_i, \tag{2}$$

where *TRADE* is the total protection rate in 1980 and 1985 for the entire industry and explains the trade regime differences. *FINAN* is the ratio of external funds to internal funds and is included to see if decision makers differentiate between internal and external finances. *PORT* is a dummy variable and takes the value of one for the plants which were located in a province with a commercial seaport and zero for the others.

Finally, the sample is divided into three subgroups in order to derive more detailed information on the effects of trade exposure on technical efficiency.

1. port-city plants (i.e., plants located in the Istanbul and Izmir provinces) and others.[3] Distance and transportation cost are highly correlated. That is, the plants which are located away from international markets and sell at the nearby markets will be exposed to less international competition.
2. incumbents (i.e., plants which were active both in 1980 and 1985) and others. If the policy changes are perceived as permanent, then the incumbents, provided that they have room to improve technical efficiency levels are going to make necessary adjustments.
3. incumbent-port-city plants (i.e., incumbents located in Istanbul and Izmir) and others. Under the assumption that both to be incumbent and to be located at a port-city have positive effects on technical efficiency, it is expected that there will be a magnified change in technical efficiency levels for the incumbent-port-city plants.

4. Turkish Trade Liberalization in the 1980s and Data

Responding to the devastating economic situation during the second half of the 1970s, the Turkish government introduced a radical economic reform package in January 1980. Throughout the 1980s, the foreign trade regime was liberalized. For example, the overall impact of import duties and quantiative restrictions in average (as a percentage of c.i.f. price) declined by 57.4 percent from its level of 129 percent in 1980 to 55 in 1987.[4]

The rubber industry is selected for this study because of the drastic cuts in protection levels and the resulting dramatic changes in export, import and production levels in this sector. The rubber industry was a typical import substitution industry: in 1980, the share of exports and imports together in domestic production was only 6.5 percent, and the rate of protection was 84 percent. In 1985, after the trade liberalization attempts, the share of trade in domestic production became 38.4 percent, and the total protection rate became 44 percent [Krueger and Aktan (1992)]. 1980 and 1985 are chosen as the benchmark years to represent pre- and post-trade liberalization periods.

The oberservations used in this study are drawn from the Annual Survey of the Turkish Rubber Industry. From the survey, 65 percent of the plants for 1980 and 67 percent for 1985 were deemed to have sufficiently accurate data to be included in the sample: a number of plants did not report capital and labor hours; some had negative value added; there were also some editing errors. Summary statistics are presented in Table 1.[5]

5. Empirical Results

At the first step of the estimations, we checked if the technology stayed the same from 1980 to 1985. We could not reject that there was no structural change in technology from 1980 to 1985. We also examined the Cobb-Douglas functional form and constant returns to scale restrictive forms. We rejected both Cobb-Douglas and constant returns to scale.[6] The result from the estimation of the production frontier is presented in Table 2.

5.1. Technical Efficiency

The frequency distribution of the technical efficiency levels for 1980 and 1985 are presented in Table 3. There is a big variation in the frequency distribution and the average of technical efficiency in the rubber industry both within 1980 and from 1980 to 1985. The big variation within 1980 supports the proposition that: "There are very weak incentives for engineering or economic efficiency in private or public sector . . . High cost and low-cost firms coexisted in many industries with very weak market pressures for expansion of the latter and contraction of the former." [Krueger (1993, p. 15)]. On the one hand, 32.3 percent of the plants were above an 80 percent technical efficiency level. On the other hand, 21.5 percent of the plants were below a 60 percent technical efficiency level.

There is also an improvement in the plants' technical efficiency over time: (1) the average technical efficiency was 66.7 percent in 1980 and 76.1 percent in 1985: in other words, the average technical efficiency was 14.2 percent higher in 1985 than it was in 1980; (2) the number of plants below the 60 percent technical efficiency level declined from 21.5 percent in 1980 to zero percent in 1985, and the number of plants above the 80 percent technical efficiency level increased from 32.3 percent in 1980 to 59.6 percent in 1985; and (3) the mode range is 75–79 percent in 1980 and 85–89 percent in 1985.

Table 1. Summary statistics of the data set.

Variable	output[a]	capital	material	labor-hour	electricity	ELHOP	FINAN	MANAG	SPILL	TECH
Year: 1980										
Mean	38,766	17,964	25,347	60,700	147,466	1,399	1.54	0.11	0.36	0.04
Minimum	2,855	406	475	10,000	2,800	11	0	0	0	0
Maximum	447,932	232,777	299,267	306,176	1,036,740	34,558	22.98	0.60	0.66	0.79
Std. Dev.	56,856	30,343	39,591	57,576	206,378	3,863	3.09	0.15	0.31	0.13
Year: 1985										
Mean	121,928	81,427	70,768	137,493	438,554	2,058	1.48	0.15	0.26	0.08
Minimum	13,915	1,428	4,241	31,360	35,063	112	0	0	0	0
Maximum	782,987	619,892	488,810	564,000	1,882,130	22,896	11.24	0.75	0.57	0.65
Std. Dev.	176,623	124,248	106,469	122,030	413,230	4,856	2.09	0.14	0.23	0.15

[a]Except labor hours and electricity, the variables are in terms of 1980 prices and million Turkish lira. ELHOP = electricity consumption/installed machinery (in terms of kilowatthours per horsepower); FINAN = external funds/internal funds; MANAG = (managerial & administrative) workers/total labor force; SPILL = province's output/total domestic output; TECH = (technical/production) workers. (For details see Note 5.)

Table 2. Maximum likelihood estimate of the stochastic production frontier.

dependent:	ln(VA)		
observ. no:	140		
Variable	Coefficient	Std. Error	t-ratio
constant	0.673	0.522	1.287
$\ln(K)$	0.589	0.084	7.030
$\ln(L)$	0.515	0.106	4.880
$[\ln(K)]^2$	0.076	0.030	2.553
$[\ln(L)]^2$	0.071	0.082	0.863
$\ln(K).\ln(L)$	−0.142	0.083	1.720
X_6: (tech/prod.) workers	0.393	0.460	0.856
X_7: (prod./total) workers	−0.841	0.472	1.782
X_8: spillovers	0.098	0.090	1.082
X_9: electricity/horsepower	0.008	0.024	0.347
σ_u/σ_v	0.883	0.922	0.858
$\sqrt{(\sigma_u^2 + \sigma_v^2)}$	0.472	0.148	3.449
Log-L	70.690		

Table 3. Frequency distribution of technical efficiency.

Technical Efficiency (percent)	1980		1985	
	Total	Frequency	Total	Frequency
above 90	2	2.15	1	2.12
85–89	14	15.05	16	34.04
80–84	14	15.05	11	23.40
75–79	21	22.58	11	23.40
70–74	9	9.68	3	6.38
65–69	9	9.68	3	6.38
60–64	4	4.30	2	4.26
55–59	6	6.45	0	0.00
50–54	4	4.30	0	0.00
below 50	10	10.75	0	0.00
total	93	100.00	47	100.00
average	66.65		76.08	
(std. dev.)	(10.92)		(6.94)	

5.2. *Plant-specific Factors*

In order to quanify the effects of plant-specific characteristics together with the trade regime variable, we estimate the equation (2). The estimation results are as follows:

$$TE_i = .868 - \underset{(3.915)}{.231}\ TRADE - \underset{(.311)}{.002}\ FINAN_i - \underset{(.441)}{.010}\ PORT,$$

$$R^2 = .110.$$

The numbers in parentheses are the absolute values of t-statistics, and R^2 is the goodness-of-fit measure. This estimation result also supports the previous finding that the trade regime has a significant effect on the efficiency level: the coefficient of the trade regime variable is negative and it is statistically significant. That is, a decline in protection has a positive effect on the technical efficiency level.

On the other hand, the ratio of external to internal finances and the location of a plant do not have a statistically significant effect on technical efficiency.

5.3. Distance from International Markets and Incumbency

In 1980, with the three subgroups (i.e., incumbent plants and others, port-city plants and others, and incumbent-port-city plants and others) technical efficiency levels do not show big variations. This finding is not surprising because of the minimal level of export and imports and the relatively very high protection level in 1980.

In 1985, the port-city plants improved their technical efficiency a little bit better than the others; still, there was no substantial difference among the plants within this subgroup. Yet, the differences within the following two subgroups became wider. Incumbent plants' average technical efficiency level was 3.1 percent higher than the others. Similarly, incumbent-port-city plants had a 5.4 percent higher average than the others: these two groups improved their technical efficiency levels 14.3 and 53.7 percent above the industry's average improvement rate respectively. These numbers also support the main finding that trade exposure has a positive effect on technical efficiency.

6. Conclusion

This study reveals that the decisions and the resulting performances at the production side of the economy are sensitive to changes in the trade regime.

We measured the technical efficiency levels attained by each plant in the Turkish rubber industry by using a stochastic production frontier for the years before and after trade liberalization. The results indicate that the improvement in technical efficiency levels was comprehensive: the average and the mode range of the industry went up; and the number of plants operating at low technical efficiency levels declined. Apparently, the inefficient plants either decided to stay in business, but with higher technical efficiency levels, or were not able to improve their technical efficiency levels and therefore went out of business. Contributing to this change was an increase in international competition, which created the needed market pressure for the expansion of low-cost firms and the contraction of high-cost firms.

It is found that the way a plant financed itself and its location did not have a significant effect on technical efficiency based on a regression analysis. However, the effect of international competition was made clearer by dividing plants on the bases of both their age and their distance from international markets. Doing this provided supporting evidence that trade exposure had a positive effect on technical efficiency: the incumbent plants which were located closer to international markets improved their technical efficiency levels more than the other plants.

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Notes

1. It is assumed that the correlation between random effects and technical efficiency components equals zero, and the distribution of the technical inefficiency is half-normal.
2. For a detailed definition of two different technical efficiency measures, namely input saving and output increasing, see Fϕrsund and Hjalmarsson (1979, pp. 296–298).
3. Istanbul, Izmir and Mersin are the three main commerical seaport cities of Turkey. However, no rubber plant is located in the Mersin province.
4. Krueger and Aktan (1992, pp. 64–65) provides a detailed account for the calculation of total charges on imports.
5. **Output** is derived by subtracting the changes in inventories of semi-finished and finished products from the total sales; **capital** includes items such as machinery and equipment, motor vehicle, building, improvement to land and other construction, office equipment and furniture; **material** includes the expenditure on raw materials, primary inputs, packaging and other variable inputs. The changes in inventories of raw-material and intermediate inputs are also taken into consideration. The output, capital, and material are all in terms of 1980 prices and million Turkish lira; **labor** is calculated as (average number of production workers) $*$ (number of working days in a year) $*$ (number of hours in each shift) $*$ (number of shifts in a day): the production workers include technical personnel, foremen, and the workers; **electricity** comprises the quantity of electricity used by the plant (in terms of kilowatt/hour).
6. The calculated F-statistics and critical F-values at 5 percent significance level are the following: for structural change: $F = 0.427$, $F(10, 150) = 1.89$; for Cobb-Douglas functional form: $F = 2.963$, $F(3, 150) = 2.66$; for constant returns to scale: $F = 6.469$, $F(1, 150) = 3.90$.

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