12 The relative efficiency of the public manufacturing industry in Turkey

An intertemporal analysis using parametric and non-parametric production function frontiers

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Introduction

The wave of privatization in both developed and developing countries initiated a number of research projects which focused on the analysis of performance of public and private enterprises using the criterion of productive efficiency. The theoretical arguments which explain the relatively poor performance of public enterprises compared to their private counterparts based their approach on the incentive and monitoring structures faced by their respective managers. In their study, Domberger and Piggott (1986) claim that the incentives and the constraints provided by the market promote productive and technical efficiency in the private sector whereas the public sector may face a different set of incentive structures which may not be compatible with the pursuit of efficiency in production. A related argument is presented in the property rights literature which ties the inherent efficiency differences to the very nature of the ownership structure and its effects on monitoring the managers. In his pioneering work Alchian (1965) argues that while the broadly dispersed and non-transferable ownership rights of public enterprises reduces the incentive of the public owners (voters or taxpayers) to monitor the performance of the public sector manager, the more concentrated and transferable ownership structure of the private sector generates incentives for shareholders to monitor managerial performance.

The purpose of this study is twofold. One objective is to show that two alternative approaches in the production frontier literature, commonly referred to as the non-parametric non-stochastic production frontiers and the stochastic production frontiers yield consistent and complementary results. The second aim is to evaluate and compare the performance of the public and private manufacturing sectors in Turkey by using these competing methods. Specifically, we will start with a non-parametric non-stochastic production frontier methodology to establish a manufacturing sector frontier for Turkey for each year between 1974 and 1991 based on data on twenty-eight subsectors where public and private sectors are registered separately. Once these frontiers are constructed, then examination of each subsector's distance to the frontier at each year for both ownership types will show the developments in efficiency through time. The results obtained from this approach can further be examined by two other model specifications, namely the time-varying stochastic production frontier and the efficiency effects model, both utilizing panel data. While the first specification allows one to determine how efficiency varies in time, the latter model will test whether there are statistically significant differences between average technical efficiency levels of public and private sectors.

The chapter is organized as follows. The following section of the study gives a brief summary of the developments in Turkish manufacturing industry emphasizing the role of the public sector and summarizing the results of previous empirical studies. The model specification are presented in the following section, after which there is a discussion of data source and results.

The role of the public sector in Turkish manufacturing industry

Prior to the 1980s, the main feature of the development strategies pursued by successive Turkish governments was their reliance on strong interventionist policies. During the early 1920s the strong sentiment against foreign business after the War of Independence led the government to provide substantial incentives for the creation of a local entrepreneurial class. However, the disruption of agricultural export markets during the Great Depression and the ensuing foreign exchange shortages accelerated industrial import substitution and proved to be a decisive factor in the country's turn towards statism. Hence, starting from the mid-1930s the state assumed the role of the entrepreneur class through the creation of public enterprises in a broad range of manufacturing activities. The state maintained its role as an agent of industrialization even after the emergence of the private sector in the late 1940s and with the introduction of central planning during the 1960s, its intervention on the economy as a whole reached peak level.

The industrialization policy of the import substitution period, characterized by heavy protectionist measures created a favourable environment for manufacturing investment.[1] The growth of output averaging 7.5 per cent during the 1965–80 period, increased the share of manufacturing in gross domestic product (GDP) from 14.1 per cent in 1963 to 19.1 per cent in 1979. In the same period, an increased public sector activity in capital intensive sectors such as basic metals, fertilizer, paper and petrochemicals resulted in a structural shift from the production of consumption goods towards the production of intermediate and capital goods. With these developments, the share of value added generated by the public sector enterprises in the large manufacturing industry increased to levels as high as 35 per cent towards the end of 1980s.[2] The increased importance of public production is also reflected in its share of employment and investment in the total large manufacturing sector (see Table 12.1).

Table 12.1 Share of the public sector in large manufacturing

Percent share of public sector in manufacturing	*1976*	*1981*	*1986*	*1991*
Value added	29	46	40	32
Employment	35	34	29	25
Investment	32	27	32	9

Source: computed from various issues of *Annual Manufacturing Industry Statistics*, State Institute of Statistics (Turkey).

By the late 1970s, Turkey's inward-oriented policies and continued reliance on the public sector as the engine of development caused growing fiscal and current account deficits. These shortfalls led to unsustainable levels of debt which resulted in the announcement of the 1980 stabilization and adjustment programme. The market-oriented adjustment programme, with an outward-looking development strategy, had the objective of liberalizing the economy. In this framework, autonomy given to public enterprises in price setting improved their financial position for a short period. However, this did not decrease their reliance on the government's budget. The initial guidelines for the reform programme stated that the government would abstain from expanding the public sector and hence, with this objective at hand, public investments were channelled away from manufacturing industry towards infrastructural sectors such as communication, transportation and energy. With the intention of alleviating the pressures on the government's budget, public enterprises in the manufacturing sector were directed towards commercial channels to borrow for their day-to-day financing requirements. This, increasing the debt service requirements of the public sector, led to even lower levels of investments in an attempt to reduce the public enterprise borrowing requirements.

The poor record of public sector investment was not compensated by the private sector. As one can follow from Table 12.2, total manufacturing investment reached its peak level prior to the debt crisis of 1977 and from then on it deteriorated significantly. Private–public breakdown of this declining total manufacturing investment shows that public manufacturing investment decreased faster than private sector investment. The reasons behind the decline in private investment were increasing interest rates, which resulted from financial liberalization and the crowding-out effect of government borrowing. Furthermore, heavy real currency depreciation and macroeconomic instability prevented private sector investment from sustaining the levels it reached during the previous decade, which had featured a heavy reliance on foreign borrowing.

The recent debates on privatization coupled with the poor financial performance of public enterprises initiated an academic curiosity on the sources of growth in the Turkish manufacturing sector, which resulted in a series of works on total factor productivity growth.

Earlier studies, inspired by the virtues of the outward oriented growth strategy of the liberalization episodes, attempted both to establish the links

Table 12.2 Index numbers for manufacturing investments (1988 prices, 1980=100)

	Total manufacturing investments	*Private manufacturing investments*	*Public manufacturing investments*
1974	88	125	49
1975	122	153	89
1976	134	174	92
1977	138	175	97
1978	116	155	74
1979	105	114	95
1980	100	100	100
1981	92	96	88
1982	82	95	68
1983	74	90	57
1984	70	92	47
1985	75	95	54
1986	75	104	44
1987	63	95	29
1988	59	94	23
1989	54	89	17
1990	84	146	19
1991	82	157	3

Source: computed from various issues of *Main Economic Indicators*: Turkey, State Planning Organization (Turkish Republic Prime Ministry).

between total factor productivity and trade regimes and also to evaluate relative performance of the public sector. In this respect one can cite the studies by Krueger and Tuncer (1982) and Nishimuzu and Robinson (1984). These studies, concentrating on the period from the mid-1960s to mid-1970s, reported significant trade policy effects on total factor productivity performance with the positive impact of export expansion and the negative impact of import tightening (Celasun 1994). Furthermore, Nishimuzu and Robinson, by comparing growth rates of total factor productivity in manufacturing for the period 1963–76 in Japan, Korea, Turkey and Yugoslavia found that they were lower in Turkey than in Korea and Japan but higher than in Yugoslavia (Nishimuzu and Robinson 1984). In addition, contrary to their expectations, Krueger and Tuncer (1982) detected relatively higher total factor productivity growth in the public sector, which is a finding supported by Yildirim (1989) and Uygur (1990) for approximately the same period.

The drawback of the total factor productivity methodology used in these studies is that, in this approach each economic identity (firm, sector or country) is compared to only itself in previous periods and not to an explicit common benchmark which makes it difficult to conduct direct multilateral comparisons. One other deficiency of the methodology is its inability to distinguish between technological progress and improvements in technical efficiency. The techniques used in this chapter, which are the subject of the next section, will provide alternative approaches.

Model

To investigate the intertemporal efficiency variations in Turkish manufacturing industry in general and the comparative position of the state in particular we will employ both non-parametric non-stochastic and stochastic techniques. Among the various approaches, we will particularly utilize:

- The Farrell output-based measure of technical efficiency
- The Time-varying Efficiency model of Battese and Coelli (1992) and
- The Technical Efficiency Effects model of Battese and Coelli (1995).

While the first model is a non-parametric non-stochastic technique, the other two are the applications of the stochastic production frontiers that use panel data. An appealing feature of using alternative specifications is the convenience it provides in checking for the robustness of the results and also in extracting complementary knowledge about the nature of the inefficiencies in public and private manufacturing sectors.

The foundations of the first methodology go back to Farrell (1957), where he showed how one can measure productive efficiency and its components allocative and technical efficiencies within a theoretically meaningful framework. His initial approach has been adopted and extended by Farrell and Fieldhouse (1962), Seitz (1970) and Afriat (1972). The methodology is based on the concept of output distance which is due to Shephard (1970) and is defined relative to the production technology S^t ($S^t = \{(X^t, Y^t)$: X^t can produce $Y^t\}$) as $D^t_0(X, Y) = \min\{\Theta : (X^t, Y^t/\Theta \in S^t)\}$. Here Y^t refers to the vector of outputs and X^t refers to the vector of inputs at period t. In other words, the distance function measures the reciprocal of the maximal ray expansion of the observed outputs (Y) given inputs (X). One advantage of the output distance function is its ability to provide Farrell measure of technical efficiency directly. Specifically:

$$\begin{aligned} D^t_0 &= \min\{\Theta : (X^t, Y^t/\Theta) \in S^t\} \\ &= [\max\{\Theta : (X^t, Y^t/\Theta) \in S^t\}]^{-1} \\ &= 1/F^t_0(X^t, Y^t) \end{aligned} \quad (1)$$

where $F^t_0(X^t, Y^t)$ is the Farrell output-based measure of technical efficiency.

The output based productivity index may be computed by solving a linear programming problem for each year. Suppose that for each t, there are $k = 1, \ldots\ldots, K^0$ observations on inputs, $X^{k,t} = (X^t_{k,1}, \ldots\ldots, X^t_{k,N})$ and outputs $Y^{k,t} = (Y^t_{k,1}, \ldots\ldots, Y^t_{k,M})$. By imposing constant returns to scale and strong disposability on the technology, for observation k^t we compute:

$$[D^t_0(X^{k,t}, Y^{k,t})]^{-1} = \max \Theta$$

subject to

$$\sum_{k=1}^{K^0} z_k Y^t_{k,m} \geq \Theta Y^t_{k',m} \quad m = 1,\ldots,M \tag{LP1}$$

$$\sum_{k=1}^{K^0} z_k X^t_{k,n} \leq \Theta X^t_{k',n} \quad m = 1,\ldots,N$$

$$z_k \geq 0 \quad k = 1,\ldots,K^0$$

where z_k is an intensity variable. This linear programming problem measures the output based Farrell technical efficiency of observation k' relative to the constant returns to scale reference technology of the same period, namely period t. However, by imposing additional restrictions on the intensity variable z_k one can construct production frontiers that satisfy different scale assumptions. For example, the additional constraint,

$$\sum_{k=1}^{K^0} z_k = 1$$

if imposed on the linear programming problem (LP1), will yield efficiency scores relative to a variable return to scale production frontier.

One important pitfall of this method is that it assumes all the deviations from the frontier are due to inefficiency alone. However, if any noise is present (e.g. due to measurement error, weather, strikes and so on) then this may influence the placement of the production frontier and may result in exaggerated inefficiency scores. Nevertheless with the introduction of the stochastic production frontier approach, which is independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) these deficiencies are alleviated. In this approach, the error structure that is assumed to be composed of two different components, one which captures the variation in output due to the factors which are not under the control of the firm and the other which represents the pure technical efficiency, provided a means to isolate the impact of random factors. The stochastic production frontiers, which are initially introduced for estimation of technical efficiency using cross section firm data, have been extended in various ways regarding both specification and estimation (see Greene 1993 for a recent survey of the frontier model literature). Particularly, realizing the potential advantages of panel data over a single cross-section data in stochastic frontier estimation, Pitt and Lee (1981) specified a panel data version of the Aigner, Lovell and Schmidt (1977) model. The initial panel specification, which is built on the assumption of fixed inefficiencies over time, is further extended by Cornwell, Schmidt and Sickles (1990), Kumbhakar (1990), Battese and Coelli (1992, 1995) and Lee and Schmidt (1993), so as to incorporate varying technical efficiency over time. Among the time-varying efficiency models we will employ Battese and Coelli (1992, 1995) specifications.

The time-varying model of Battese and Coelli (1992) is defined by:

$$Y_{it} = f(x_{it}; \beta)e^{(V_{it}-U_{it})} \tag{2}$$

and

$$U_{it} = \eta_{it}U_i = \{e^{[-\eta(t-T)]}\}U_i, \quad t \in \Im(i); \; i = 1, 2, \ldots, N$$

where Y_{it} represents the production for the i'th producing unit at the t'th observation period; $f(x_{it}; \beta)$ is a suitable function of a vector x_{it} of factor inputs associated with the production of the i'th producing unit in the t'th observation period; and β a vector of unknown parameters. The V_{it}'s are assumed to i.i.d with $N(0,\sigma_v^2)$; U_i's are also assumed to be i.i.d. but non-negative truncation of the distribution $N(\mu,\sigma^2)$ where η is an unknown parameter to be estimated. Finally $\Im$ represents the set of T_i time periods among the T periods involved for which observations for the i'th producing unit are obtained. This model is constructed such that the non-negative observation specific effects U_{it} decrease, remain constant or increase as t increases, if $\eta > 0$, $\eta = 0$ or $\eta < 0$ respectively. That is, with the exponential character of the model technical efficiency must either increase at a decreasing rate ($\eta > 0$), decrease at an increasing rate ($\eta < 0$) or remain constant ($\eta = 0$).

The technical efficiency effects model of Battese and Coelli (1995) is similar in character to equation (2), except that the U_{it} are assumed to be random variables which are independently distributed as truncations at zero of a normal distribution with mean m_{it} and variance σ_u^2 where $m_{it} = g(z_{it}, \delta)$. Here z_{it} is a vector of variables which may influence the efficiency of a producing unit; δ is a vector of parameters to be estimated; and g(.) is a suitable functional form usually assumed to be linear.

Data model specification and results

The methods outlined are applied to construct manufacturing sector frontiers for Turkey for the period 1974–91 using data on twenty-eight subsectors (defined at three digits according to International Standard Industrial Classification) where public and private sectors are registered separately. In all the applications, one has to recall that the best practice is a common manufacturing sector frontier which is defined over subsectors in the manufacturing industry. Note however that, while constructing the best practice frontier, public and private production in each subsector are considered as separate observations. The implicit assumption that all industries utilize the same production frontier and that this frontier can be constructed from the observations on subsectors is similar in nature with ones employed by Caves (1992) and Torri and Caves (1992). In their approach to find the productivity differentials between the subsectors of two countries, the observations on outputs and inputs of subsectors of these countries are used together while constructing a stochastic production frontier.[3] A similar approach at a different aggregation level is employed by Fare *et al.* (1994) where a common best-practice world (production) frontier is constructed using the inputs (aggregate capital and labour) and outputs (GDP) of seventeen Organization of Economic Cooperation and Development (OECD) countries in the sample.

The data are compiled from *Annual Manufacturing Industry Statistics* (State Institute of Statistics 1974–91) which cover all establishments in the public sector and those establishments with ten or more employees engaged in the private sector. All three digit industries, except ISIC390 (other manufacturing industry) are included in the analysis. A nice feature of the data is that, except in few cases, both government and private activity coexist in all subsectors allowing for a comprehensive analysis of relative efficiency between public and private enterprises during the period 1974–91.[4] Table 12A.1 gives the list and the definition of these sectors included in the model.

Our measure of the aggregate output of a subsector is the real value of the output of the industry.[5] The three input proxies chosen are: number of individuals engaged in production, real value of the raw materials, fuel and electricity, and total capacity of power equipment installed at the end of the year in terms of horse power.[6] The usual difficulties associated with computation of the capital stocks at this disaggregate level forced us to use total capacity of power equipment installed as a proxy for the capital stock.

First a non-parametric non-stochastic frontier methodology is employed and linear programming problem (LP1) is solved to construct a manufacturing sector frontier for all the years between 1974 and 1991 under constant returns to scale (CRS) and variable returns to scale (VRS) assumptions. Then, geometric averages of the output distance functions are computed for each year across all the sectors and for different ownership types. These averages, which actually show the efficiency levels, are shown in Figures 12.1 and 12.2.

On the basis of these figures it is evident that technical efficiency in the Turkish manufacturing industry is in a declining trend.[7] Note that both diagrams show the same trend with higher efficiency scores in the VRS case compared to the CRS case. This is theoretically expected since the CRS frontier envelops the data most loosely of all scale assumptions and hence results in lower efficiency (higher inefficiency) scores compared to other scale assumptions. With respect to the level of technical efficiency for different ownership types, both diagrams are in agreement that there are two distinct periods: before and after 1982. Note that while until 1982 the public sector performed better than the private sector, the reverse is the case for the years after 1982 resulting in almost equal average efficiency scores when the entire sampling period is taken into account.[8]

The results reached from the non-parametric non-stochastic methodology

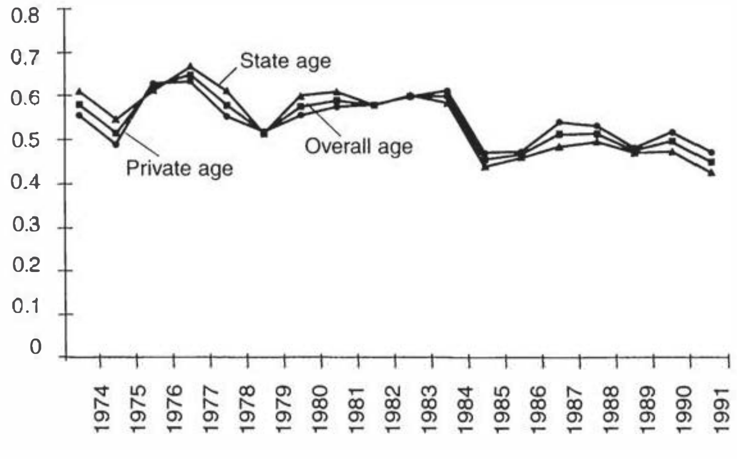

Figure 12.1 Geometric means of the efficiency scores obtained from non-parametric, non-stochastic methodology (CRS)

can be further verified by stochastic specifications. The stochastic production frontier for the panel data on the three digit subsectors of the Turkish manufacturing industry is defined by

$$\begin{aligned}\log Y_{it} = {} & \beta_0 + \beta_1 \log(lab_{it}) + \beta_2 \log(raw_{it}) + \beta_3 \log(cap_{it}) + \beta_4 [\log(lab_{it})]^2 \\ & + \beta_5 [\log(raw_{it})]^2 + \beta_6 [\log(cap_{it})]^2 + \beta_7 \log(lab_{it}) \log(cap_{it}) \\ & + \beta_8 \log(lab_{it}) \log(raw_{it}) + \beta_9 \log(cap_{it}) \log(raw_{it}) + \beta_{10} t \log(lab_{it}) \\ & + \beta_{11} t \log(cap_{it}) + \beta_{12} t \log(raw_{it}) + \beta_{13} t + \beta_{14} t^2 + V_{it} - U_{it}\end{aligned}$$

where:

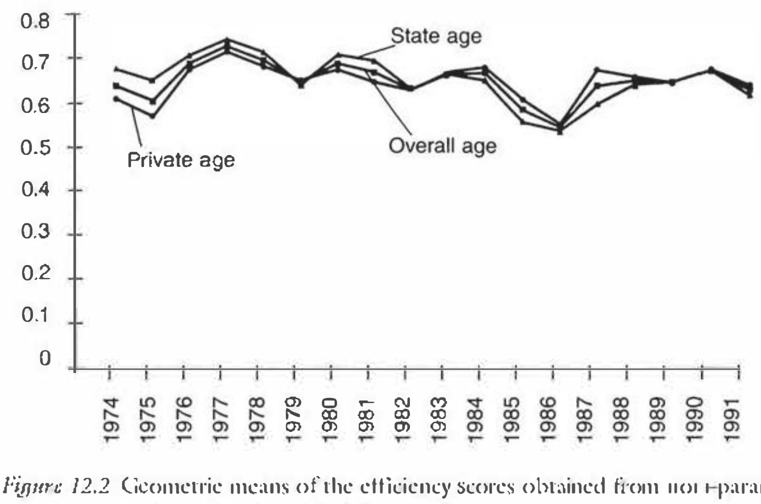

Figure 12.2 Geometric means of the efficiency scores obtained from non-parametric, non-stochastic methodology (VRS)

Y represents the real value of the aggregate output of a subsector;
raw represents the real value of raw materials fuel and electricity used by a subsector;
lab represents the number of individuals engaged in production in a subsector;
cap represents a proxy variable for capital stock which is defined as the total capacity of power equipment installed at the end of the year in terms of horse power; and
V and *U* are random variables whose properties we defined earlier for two alternative model specifications, namely the time-varying efficiency model of Battese and Coelli (1992) and the technical efficiency effects model of Battese and Coelli (1995).

The maximum likelihood estimates of the parameters of both the models are presented in Table 12.3. The first column shows the parameter estimates of the time-varying efficiency model and the second column is reserved for the parameter estimates of the technical efficiency effects model.

Table 12.3 Parameter estimates

Parameters	*Time-varying Efficiency model*	*t-values*	*Technical efficiency Effects model*	*t-values*
β_0	0.1467	(4.60)	0.025	(0.69)
β_1	0.0535	(2.09)	0.0870	(2.73)
β_2	0.8266	(38.34)	0.8438	(34.03)
β_3	0.0324	(2.25)	0.0041	(0.19)
β_4	0.0941	(6.04)	0.1009	(6.39)
β_5	−0.0075	(−1.32)	0.0112	(1.62)
β_6	−0.0024	(−0.58)	−0.0050	(−0.94)
β_7	−0.0810	(−7.14)	−0.0774	(5.60)
β_8	−0.1017	(−6.89)	−0.1340	(−9.39)
β_9	0.0843	(7.54)	0.0840	(6.22)
β_{10}	0.0067	(3.57)	0.0055	(1.99)
β_{11}	−0.0042	(−3.21)	−0.0024	(−0.46)
β_{12}	−0.0004	(−0.27)	−0.0008	(−0.47)
β_{13}	−0.0129	(−2.27)	−0.0151	(−2.37)
β_{14}	0.0011	(4.84)	0.0011	(3.37)
$\sigma_s^2=\sigma_v^2=\sigma^2$	0.2329	(8.84)	0.0490	(2.05)
$\gamma\_\sigma^2/\sigma_s^2$	0.9040	(90.41)	0.0023	(0.20)
μ	−0.7788	(−5.27)	—	—
η	−0.015	(−2.52)	—	—
δ_0	—	—	0.0116	(0.86)
δ_1	—	—	−0.0933	(−2.73)

Source: author estimates.

Starting with the time-varying efficiency model, several hypotheses are tested to determine whether the structural production model and distributional assumptions on the error term are appropriate. The likelihood ratio testing procedure which simultaneously tests the significance of a group of coefficients is used. The structural tests include a test of null hypothesis of Hicks-neutral technical change; a test of null hypothesis that there is no technical change and a test of null hypothesis that the Cobb-Douglass production is the appropriate model. The tests on the distributional assumptions on the error terms included a test of the null hypothesis that the traditional average production function is a better representation of the data; that the test of the null hypothesis that time-invariant model applies; and finally a test of the null hypothesis that U_i's have half normal distribution. The log-likelihood function values of the restricted and that of unrestricted models together with the relevant test statistics are presented in Table 12A.2. As one can easily follow from this table, all null hypotheses are rejected, leading us to conclude that translog time-varying production frontier with non-Hicks-neutral technical change is the appropriate choice.

Before focusing on the efficiency issue, one also has to assess the economic plausibility of the estimated coefficients. Thus in Table 12A.3, the values of the production elasticities of the three inputs, returns to scale and the annual change in production due to technical change are listed, all evaluated at the sample means.[9] Most of the production elasticities have the expected positive signs. The production elasticity for labour is 0.1172 and for raw materials is 0.9326. The only exception is the capital elasticity which takes the value of −0.0075, which is not significantly different from zero at the 5 per cent significance level.[10] The estimated scale elasticity of 1.08 indicates a mildly increasing return to scale. Finally the last figure in Table 12A.3 denotes that the industry has experienced a rate of technical progress over the sample period of 0.81 per cent per year.

Now turning our attention to the parameters associated with the inefficiency error term U_{it}, namely γ, μ and η listed towards the bottom of the second column in Table 12.3, we see that all with t-ratios larger than 1.96 in absolute value are statistically significant. These significant t-ratios are not surprising, given the conclusions of the likelihood ratio test mentioned earlier. While validating the conclusions reached from the non-stochastic non-parametric methodology, a parameter which is of particular interest is η. Since the estimated value of η (−0.015) is negative and significant, this indicates that technical efficiency in the Turkish manufacturing industry decreases at an increasing rate. Then, one can easily conclude that both non-parametric non-stochastic and stochastic production frontier models are in coherence in showing that the technical efficiency is in a declining trend in the Turkish manufacturing industry.

To show the association between the efficiency estimates of the non-parametric non-stochastic methodology and the time-varying efficiency model, the efficiency rankings obtained from alternative models are compared. For the time-varying efficiency model, given the specification of truncated normal distribution of the error term relating to inefficiency, technical efficiencies of each subsector are estimated using a panel variant of Jondrow *et al.*'s (1982) formula for all the years between 1974 and 1991. Then, Spearman's Rank Correlation of the efficiency scores derived from non-parametric non-stochastic model and time-varying efficiency model are computed and reported in Table 12.4. A conclusion that emerges from rank correlations is that both methods are not only in coherence in showing the general trends but are also in agreement while ranking individual efficiency scores of different subsectors.[11]

The technical efficiency effect model is specifically formulated to incorporate the factors that influence the efficiency of the producing units and to test their significance. In this study the emphasis is on the efficiency effect of ownership structure in Turkish manufacturing industry. A dummy variable is introduced (which takes the value of 1 if the production takes place at the state-operated enterprises and zero otherwise) as a subsector specific variable in an attempt to identify the differences in predicted efficiencies between the subsectors of the manufacturing industry and the results are reported in the second column in Table 12.3.[12]

This model specification, as described in the model section, permits certain sector specific factors to shift the mean of the technical inefficiency error term U_{it}. For example the negative (and significant) sign of the coefficient related to the dummy variable (d_1= –0.0933) which represents state production, indicates that the change in the ownership from private to state production will result in a decrease in the value of technical inefficiency effect and hence an increase in technical efficiency. However, a test of null hypothesis $\gamma = d_0 = d_1 = 0$ if failed to be rejected would mean that stochastic production function is not statistically different from an average response function where U_{it} is omitted. Thus a test of hypothesis that $\gamma = d_0 = d_1 = 0$ is conducted and the likelihood ratio test statistic is calculated to be 0.6423 which is less than the χ^2_4 critical value of 9.49. This means that all the observations are equally efficient and the deviations from the average response function can only be attributed to random effects implying that government ownership does not

Table 12.4 Spearman's rank correlation coefficients

Time-varying efficiency model	*Non-parametric non-stochastic model*					
	Variable returns to scale			*Constant returns to scale*		
	1977	*1986*	*1991*	*1977*	*1986*	*1991*
1977	0.614			0.529		
1986		0.661			0.636	
1991			0.614			0.629

Note: all values are significant at the 0.05 level.
Source: authors' computations.

contribute to inefficiency on the average. Note further that this conclusion is also consistent with the findings obtained from the non-stochastic non-parametric methodology where almost equal efficiency scores are obtained for both ownership sizes when averaged over time.

Conclusion

This study by using stochastic and non-stochastic non-parametric techniques of production frontier literature focused on issues such as how efficiency in the manufacturing sector changes in time and if public and private enterprises show different performances in their pursuit of efficiency. A non-parametric non-stochastic frontier methodology employed led to the conclusion that technical efficiency in the Turkish manufacturing sector is in a declining trend and that public and private enterprises, by differing in efficiency levels before and after 1982, averaged around the same efficiency level over the entire sampling period. This empirical result is re-examined by stochastic specifications, namely by time-varying efficiency model and efficiency effects model. The conclusion from the time varying efficiency model is that the technical efficiency of the Turkish manufacturing industry decreases at an increasing rate. However, the impact of government ownership on the average efficiency level is not found statistically significant in the technical efficiency effects model, mainly because of the relative poor performance of the private sector prior to 1982 which was compensated for in the years following when the private sector performance was superior relative to the public sector.

Notes

We wish to thank the editor and the participants of the ERF workshop on 'The Changing Size and Role of the State-Owned Enterprise Sector' held at Amman, Jordan, May 1996 for their helpful comments and suggestions.

1 The policies ensued carried typical elements, such as overvalued exchange rate under a system of strict exchange rate control, strict import controls through tariffs, quantitative restrictions, guarantee deposits on imports and generous tax and credir incentives for manufacturing investments.
2 Large manufacturing industry covers all establishments in the public sector and establishments with ten or more employees engaged in the private sector.
3 Compared to these studies our approach is appreciably less restrictive in the sense that we neither use a tightly-specified functional form such as Cobb-Douglass nor force matched industries from another country to share the same common production frontier. Furthermore, the alternative strategy of estimating production frontiers separately for each subsector using micro level data, that is, firm data, would have made within industry-comparisons possible at the expense of inter-industry comparisons. In this case this approach would suffer from the same shortcomings of the Total Factor Productivity approach where each industry is evaluated according to its own performance in the past without allowing for inter industry comparisons.
4 No government activity exists in the following sectors: manufacture of products of leather and leather substitutes ISIC(323), manufacture of furniture and fixtures

ISIC(332), manufacture of rubber products ISIC(355), manufacture of plastic products not elsewhere classified ISIC(356), manufacture of glass and glass products ISIC(362), manufacture of professional and scientific equipment not elsewhere classified ISIC(385). Also, in our data set, no private activity exists for petroleum refineries ISIC(353). This provides a balanced panel data with forty-nine observations for each year.

5 All nominal figures are deflated using two-digit manufacturing price index and are expressed in 1988 prices.

6 Since there is no price index for purchased inputs, nominal values are deflated by two-digit manufacturing price index.

7 The oscillations around the trend may be partly due to deflating both inputs and outputs by the same two-digit manufacturing price index. For example, the sharp drop in efficiency from 1984 to 1985 seems to be the result of deflating inputs (especially imported raw materials) with a price deflator which underscores the effect of real currency depreciation that exist during that period. Since this will overstate the real cost of raw materials, it will reflect itself as increased inefficiency in our indexes. Also, one should note that the declining trend in the levels of technical efficiency does not necessarily imply a declining trend in productivity growth. Nevertheless, it will have a dampening effect on the productivity growth that stems from technological progress. We thank Professor Merih Celasun who brought these points to our attention.

8 Geometric average of efficiency scores across all the years are 0.67 for the private sector and 0.68 for the public sector for the variable returns to scale case. The constant returns to scale frontier resulted in an almost equal efficiency score of 0.55 for both ownership types.

9 In empirical studies it is common to express variables as deviations around their means because of the convenience it provides in obtaining output elasticities at the mean level of inputs. In estimating the parameters of the translog production frontier we also adopted such a strategy. Hence $\beta_1 + \beta_{10}t$ for example directly provides labour elasticity.

10 This may have stemmed from using total capacity of power equipment installed as a proxy for the capital stock. During a period where energy prices are increasing, the energy-saving policies adopted by firms may have caused a low variation in power equipment installed in the time component of the panel data.

11 To give an example, both the time-varying efficiency model and the CRS non-stochastic non-parametric model are in coherence in depicting nine subsectors out of most successful fifteen subsectors consistently in 1974. The sectors which are found among the most efficient fifteen subsectors by both models in 1974 are: private manufacture of basic industrial chemicals (ISIC 351), private manufacture of other chemical products (ISIC 352), private manufacture of petroleum and coal derivatives (ISIC,354), both public and private manufacture of portery china and earthware (ISIC, 361), public beverage industries, (ISIC 313), public tobacco manufactures (ISIC, 314), public petroleum refineries (ISIC 353) and public iron and steel basic industries (ISIC 371). A very similar ranking applies for the year 1991. For the year 1991 both models are in complete agreement in depicting ten out of fifteen most successful sectors. All subsectors that are listed as the most successful sectors in 1974 are also found among the most successful sectors in 1991 with the exception of public iron and steel basic industries (ISIC 371). However private beverage industries (ISIC 313) and private manufacture of electrical machinery apparatus (ISIC 383) are included among the successful sectors by both models.

12 The maximum likelihood estimates of the stochastic production frontier have been tested for all possible structural restrictions and the translog form with the non-neutral technical change is found to be the most appropriate form.

Appendix

Table 12A.1 Description of International Standard Industrial Classification codes

311	Food manufacturing
312	Manufacture of food products not elsewhere classified
313	Beverage industries
314	Tobacco manufactures
321	Manufacture of textiles
322	Manufacture of wearing apparel (except footwear)
323	Manufacture of leather and leather products (except footwear and wearing apparel)
324	Manufacture of footwear
331	Manufacture of products including furniture
332	Manufacture of furniture and fixtures
341	Manufacture of paper and paper products
342	Printing, publishing and allied industries
351	Manufacture of basic industrial chemicals
352	Manufacture of other chemical products
353	Petroleum refineries
354	Manufacture of petroleum and coal derivatives
355	Manufacture of rubber products
356	Manufacture of plastic products not elsewhere classified
361	Manufacture of pottery china and earthware
362	Manufacture of glass and glass products
369	Manufacture of other non-metallic mineral products
371	Iron and steel basic industries
372	Non-ferrous metal basic industries
381	Manufacture of fabricated metal products
382	Manufacture of machinery (except electrical)
383	Manufacture of electrical machinery apparatus, appliances and supplies
384	Manufacture of transport equipment
385	Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified

Table 12A.2 Hypothesis tests on time-varying efficiency model

Restriction	*Model*	*Log-likelihood*	χ^2	*Critical value (5%)*	*Decision*
None	translog	325.76			
$\beta_{10}=\beta_{11}=\beta_{12}=0$	translog (hicks-neutral)	315.26	21.00	7.81	Reject H_0
$\beta_{10}=\beta_{11}=\beta_{12}=\beta_{13}=\beta_{14}=0$	translog (no-tech. change)	292.70	66.12	11.07	Reject H_0
$\beta_4=\beta_5=\beta_6=\beta_{10}=\beta_{11}=\beta_{12}=\beta_{13}=\beta_{14}=0$	Cobb-Douglas	265.35	120.82	18.31	Reject H_0
$\gamma=\mu=\eta=0$	translog (OLS)	76.95	497.62	7.81	Reject H_0
$\mu=\eta=0$		320.04	11.44	5.99	Reject H_0
$\mu=0$		323.15	5.22	3.84	Reject H_0
$\eta=0$		322.54	6.44	3.84	Reject H_0

Source: authors' calculations.

Table 12A.3 Key estimates derived from time-varying efficiency model

Description	*Estimate*
Labour elasticity	0.1172
	(0.0214)
Capital elasticity	−0.0075
	(0.0116)
Raw material elasticity	0.9329
	(0.0166)
Returns to scale	1.08
Technical change	0.0081

Note: numbers in parentheses are standard errors.
Source: authors' estimates.

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