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Privatization, Ownership, and Technical Efficiency: A Study on Turkish Cement Industry

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Abstract: This paper presents an empirical study on the effects of ownership and privatization on technical efficiency in Turkish cement industry. We first summarize the characteristics of Turkish cement industry and changes in industrial structure in the post-privatization period. The effects of ownership and privatization on technical efficiency are estimated in stochastic production frontier framework. The empirical tests presented, which use data on all cement plants in Turkey, suggest that neither ownership nor privatization had a significant impact on technical efficiency.

Keywords: Privatization, public sector, ownership, technical efficiency, cement industry, Turkey

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1 Introduction

Privatization of state-owned enterprises (SOEs) has been a major component of economic policy in many developed and developing countries since the late-1970s. One of the main arguments introduced to justify the drive for privatization is based on the belief that private firms are more efficient than state-owned firms. Privatization is supposed to enhance the efficiency of the economy, and, thus, to strengthen international competitiveness (Van De Walle, 1989).

All successive civilian Turkish governments since the military coup in 1980 have consistently advocated privatization of SOEs on a similar ground. Government officials and politicians themselves argued that SOEs in Turkey have become a burden on the state's budget because they are not operated efficiently and profitably. The inefficiency of public enterprises is explained by the lack of well-defined objectives, lack of competitive market conditions, and difficulties in enforcing and monitoring ownership rights. SOEs are blamed for many economic problems including poor quality in many services and products, and persistent inflation through their strain on the budget. Privatization is then presented as a necessary condition for the creation of a "free market economy" in which private firms, free from arbitrary political intervention, supply products and services efficiently.

Although there is neither any sound theoretical reason nor strong empirical evidence supporting the claim that private enterprises are more efficient than SOEs, the efficiency argument seems to hold the central position in the rhetoric of privatization. For example, the main Turkish law on privatization (No.4046) which finally came into effect in 1994, was adopted to lay down "the principles for privatization that will improve efficiency in the economy and reduce public expenditures."

Given the consistent emphasis on the efficiency argument as the main justification for the privatization process in Turkey, one expects to find empirical studies comparing the performance of public and private plants, and the effects of ownership change on efficiency. Although the privatization law stipulated that the Privatization Administration conduct research on the post-privatization performance, to the best of our knowledge, there is no extensive study on this topic. In this paper, we analyze the effects of privatization on technical efficiency in Turkish cement industry. We prefer to analyze the cement industry because of three factors. First, the privatization of SOEs has been so far concentrated in a few industries (cement, animal feed, etc.). The public sector had had a considerable share in cement production (about 40%) before the first group of public plants privatized in 1989. All state-owned and "mixed" plants (27 in total) in the cement industry were privatized in only seven years. It is thus possible to use econometric approach to control for plant-specific and random factors. Second, public plants were privatized quite earlier in the cement industry than in other industries so that we have a relatively long time span to observe post-privatization performance. For example, five cement plants were privatized in 1989. We expect that if ownership matters, its effects on performance should be observed in since 1989. In other words, we have enough observations for the post-privatization period. Finally, since the cement industry produces a homogenous product, it is easier to control for the effects of changes in product mix on plant performance.

There are a few studies on Turkish cement industry. In an earlier paper, Çakmak and Zaim (1992) compared the efficiency of private and public plants in 1985. They employed the stochastic production frontier approach to estimate the production frontier and technical efficiency at the plant level. Their findings suggest that private plants, on average, are not more efficient than public plants.

The effects of privatization on performance were investigated by Tallant (1993) and Suiçmez (1995). They used conventional ratio analysis (labor productivity, profit margin, etc.) to test the effects of privatization in the cement industry and found no clear improvement in performance.

In this paper, we use the stochastic production frontier approach to compare efficiency levels of private and public plants, and the post-privatization performance of public plants. This approach explicitly takes into consideration the fact that some plants may not operate efficiently, i.e., some plants, given the inputs they consume, do not reach to the potential output level which is defined by the "best practice technology". The factors that may explain inefficiency and the parameters of the stochastic production frontier can be simultaneously estimated thanks to the method developed by Battese and Coelli (see Battese and Coelli, 1995; Coelli, 1994). This paper extends an earlier study on the same topic (Saygili and

Taymaz, 1996). This study uses a longer panel (1980-95) than the one used in the previous study (1980-93), and exploits a number of new variables related to the composition of labor and the technology used in cement plants, like the share of technical personnel, the share of subcontract labor, and the use of pre-calcination in the production process. The effects of these factors deserve special treatment given the fact that privatized plants tend to shed labor and to employ subcontract workers.

The effect of privatization on market structure is another major concern in the privatization debate in Turkey. As will be seen in this paper, there is an obvious trend towards the formation of regional clusters in the cement industry. Public cement plants were usually sold to large private holding companies that prefer to acquire plants in specific regions. Although this is an important topic for policy makers, we limit our study to the effects of privatization on technical efficiency. We plan to investigate the extent of monopolist practices in the post-privatization period in another paper.

The paper is organized as follows. Section 2 summarizes the development of the cement industry, and the process of privatization. Section 3 is devoted to the analysis of the effects of privatization. After a brief presentation of the stochastic production frontier model and a discussion on the determinants of technical efficiency, estimation results are explained in detail. Major findings are summarized in Section 4.

2. Privatization in the Turkish cement industry

2.1 The development of the cement industry

The first cement plant in Turkey was established by a private firm, Aslan Çimento, in Darica, Istanbul, in 1911 (for the history of the cement industry in Turkey, see Basaran and Turunç, 1995). Until 1950 four new plants in Ankara, Zeytinburnu (Istanbul), Kartal (Istanbul), and Sivas were built. The cement industry has developed on a large scale only after the 1950s. A public enterprise, ÇISAN (Turkish acronym for Turkish Cement Industry Co.), was established in 1953 to build 15 plants in various regions. Turkish Housing Credit Bank, Sümerbank, Is Bank, and public plants in Ankara and Sivas were the main shareholders in ÇISAN that owned 11 of 13 cement plants built in Turkey in the period 1950 to 1963.

During the "planned development" period (1963-80), the Turkey achieved historically high growth rates. As a consequence of rapid economic growth and the process of urbanization, the demand for cement increased rapidly, and 17 new plants were established in the period 1963-80. More than half of these (nine plants) were privately owned, and five state-owned. Three plants established in this period had "mixed" ownership (the state and OYAK, the Armed Forces Relief Institution, a "private" holding company). State-owned cement plants were established mainly in Central Anatolia in the 1950s, whereas they were mostly located in the Eastern and South-Eastern regions in the 1960s and 1970s (see Table 1). The governments that aim to pull out the state from the economy continued to build new cement plants (six in total) in the 1980s. It is interesting that the latest public plants are located in the Western regions (Denizli plant was established in 1987 and Lalapasa plant in 1991). It is, of course, not possible to explain the establishment of these plants with the "regional development" objective.[1] With the establishment of these cement plants, Turkey became the third major producer in Europe (after Germany and Italy) in the early 1990s (Ignebekçili, 1995).

2.2 Privatization process in the cement industry

A French company, Sema-Metra Conseil (SC), was contracted by the government and the World Bank to prepare two reports, one on the "Program for the Structural Regulation of the Cement Sector and Privatization" (February 1986) and the other on the "Plan for the Reorganization of ÇITOSAN" (April 1986).

Sema-Metra Conseil (1986b) suggested that the government should i) sell the plants in the Western part immediately (because Western plants can be as profitable as private plants, see SC, 1986b: 35), ii) restructure the plants in the East before being sold, and iii) reorganize ÇITOSAN (formely ÇISAN).

The privatization process in the cement industry started in 1989. Five cement plants, all in the Western and Central regions, were sold to a French firm, Ciments Français, for 105 millions USD. In 1990-91, minority holdings in "mixed" plants (controlled by private agents) were sold either through public offerings or sales on Istanbul Stock Exchange. These

[1] The western regions (especially the north-western, Marmara region) of Turkey are economically the most developed part of the country. Major transportation facilities (ports, highways, etc.) are concentrated in this region that has also a high population growth rate thanks to immigration from other regions. Therefore, the growth rate of demand for cement has been steadily at a high rate in the western regions. For the location of cement plants in Turkey, see the web site of the Association of Cement Producers in Turkey, http://www.tcma.org.tr/en/.

privatization methods are supposed to be used to disperse ownership to the public. However, the Public Participation Administration and later the Privatization Administration, agents in charge of privatization process, preferred "block sales" over other methods to privatize state-owned cement plants. Indeed, all state-owned cement plants were privatized by block sales.

In 1992-93, 10 plants were privatized, and five more were privatized in 1995-96. At the end of 1996, the cumulative proceeds from the privatization of cement plants reached 1047 millions USD. Total privatization revenue at that time was about 3058 millions USD. In other words, the cement industry alone contributed to nearly 35% of all privatization revenues. After the privatization of the last two plants, Ergani and Kurtalan, for 47 and 28 millions USD, respectively, the privatization in the cement industry was complete in 1997.

Privatization of state-owned cement plants triggered a shake-up in the industry. Another French firm, Lafarge Coppée took over a private cement plant in Istanbul in 1990. Incidentally, the Sema-Metra Conseil (1986b) report claimed, only a few years ago, that Lafarge Coppée would not consider to enter into the Turkish market. A year later, Vicat, a member of the French Parficim SA group, acquired a plant in Konya. Ciments Français, now known as the Set Cement Holding[2], after buying five privatized plants in 1989, bought a private plant in Kartal (Istanbul) and sold the Söke plant to Batiçim, a private Turkish firm, in September 1993, and opened a cement grinding plant in Ambarli (Istanbul) in 1997. Lafarge Coppée became a partner in Eregli and Ankara grinding plants and became a partner of Yibitas Holding. Lafarge and Yibitas group now owns cement plants in Yozgat, Çorum and Sivas, and cement grinding plants in Hasanoglan/Ankara, Nevsehir and Samsun. Lafarge formed with Asland SA and Aurelius BV a joint venture, Aslan Çimento. Vicat became a partner in Bastas (Ankara). Finally, Akçimento and Çanakkale merged into Akçansa, a joint venture between Sabanci Holding and CBR, a Belgian firm. As a result of all these acquisition and merger activities, foreign firms now control more than 30% of clinker capacity in Turkey.

Majority of private plants (seven out of 13 plants) were owned by independent firms before the privatization process. OYAK had majority of shares in all but one of the mixed plants. After privatization, a few holdings/business groups have established a dominant

[2] Italcementi, the fourth largest cement producer in the world, took over Ciments Français' majority shares in 1992. Italcementi's world-wide strategy is to integrate cement production towards ready-mixed concrete and aggregates. The Set Group, the affiliate of Italcementi in Turkey, operates five cement plants, 23 concrete plants, and four quarries.

position in the sector. Moreover, holding companies had a strong tendency to acquire close-by cement plants. Rumeli Holding, a company without any prior history in the cement industry, was very aggressive in acquiring plants in the Eastern region and along the Black Sea coast. OYAK and Sabanci Holding formed an alliance and focused on plants in the Central and Southern Anatolia and Marmara regions. Ciments Français has plants in the Central and Western regions whereas and Lafarge and Yibitas own cement plants in three neighbouring provinces in the Central Anatolia. These firms attempt to vertically integrate towards downstream activities[3], mainly towards the distribution of ready-mix concrete that is an expected move to achieve and to maintain regional monopolies.

3 Effects of privatization in Turkish cement industry

3.1 Modelling the production structure: Stochastic production frontier approach

In comparing the performances of private and public establishments, all factors that contribute to technical efficiency should be taken into account. The effects of ownership and ownership change can be determined only after controlling for the effects of other variables. The stochastic production frontier approach offers us the possibility to isolate the effects of ownership in a unified framework where both the production frontier itself and the efficiency effects are estimated simultaneously. The use of panel data techniques allows the researcher to estimate a stochastic production frontier that incorporates specifications for technical change and plant-specific efficiencies (for studies on the cement industry, see Hjalmarsson *et al*. 1996; Cotfas, 1997; Kumbhakar *et al*., 1997; Taymaz and Saatci; 1997).

In this study we use data on a panel of all cement plants for the years 1980 to 1995 (for the list of cement plants, see Table 1). The stochastic frontier production function we estimate is a translog model defined by

$$\begin{aligned} y_{ft} &= \alpha_0 + \sum_i \alpha_i x_{ift} + \alpha_t t + \beta_{TT} t^2 + \sum_i \beta_{Ti} t x_{ift} + \sum_{i \le j} \sum \beta_{ij} x_{ift} x_{jft} \\ &+ \alpha_{TP} Type_{ft} + \alpha_{BG} Bag + \varepsilon_{ft} - \nu_{ft} \end{aligned} \qquad [1]$$

[3] The financial advisor to Lafarge, the Turk Merchant Bank which is a subsidiary of Bankers Trust, states that the company seeks to expand its operations in Turkey through horizontal and vertical integration (see the

where the subscripts *f* and *t* index plant (*f*=1,…,F) and time (*t*=1,…,T); *y* is the output; x_i variables are inputs (the output and all inputs are in logarithmic form); and *t* is the time variable. Subscripts *i* and *j* index inputs (*i*, *j* = L, R, E, and K, representing labor, raw materials, energy and capital inputs, respectively). The ε-random errors are assumed to be independently and identically distributed as $N(0,\sigma^2_\varepsilon)$ and independent of the ν-terms which account for plant-specific technical inefficiency in production.

Although the cement industry produces a relatively homogenous product, there are nevertheless some heterogeneity that needs to be incorporated into the model. The most important difference is related to raw materials. Some plants add pozzolan, a natural cement-like material, to clinker to produce different types of cement. The pozzolan content is regulated by cement standards. It is claimed that the variable cost for blended cement that contains 20-40% natural pozzolan is about 10% lower than that of portland cement (Sema-Metra Conseil, 1986a: 48). We add a variable, *Type*, that measures the share of blended cement in total output as a control variable. Cement is sold either in bags or as a bulk material. Since packing cement in bags is expected to be costly, we add the share of output sold in bags, *Bag,* as another control variable.

The technical inefficiency effects, ν_{ft}, are assumed to be independently distributed, such that ν_{ft} is the non-negative truncation of the $N(\mu_{ft}, \sigma^2_\nu)$ distribution, where μ_{ft} is defined by

$$\mu_{ft} = \delta_0 + \sum_{k=1}^{m} \delta_k z_{kft} \qquad [2]$$

where *z*s are plant-specific factors (*k*=1,…,*m*) that influence technical inefficiency. The technical efficiency of a plant *f* at time *t*, EFF_{ft}, is defined by

$$EFF_{ft} = e^{-\nu_{ft}} \qquad [3]$$

The parameters of the stochastic production frontier and the efficiency effects model are simultaneously estimated by the Frontier 4.1 program (Coelli, 1994). Note that, the

company's home page, http://www.bankerstrust.com/corpcomm/country/turkey.html).

coefficients of efficiency variables (the *z* variables) as defined here show the effects of these variables on technical *in*efficiency. Therefore, a positive coefficient for an efficiency variable implies a negative effect on technical efficiency.

The output is measured by the volume of cement production. Trade in clinker can distort cement output measure because there is considerable amount of clinker trade between plants. Cement producers usually stockpile clinker throughout the year, and operate cement grinders only part of the year to meet demand that fluctuates seasonally. Thus, in this study, the output is defined in "cement equivalent": net clinker and cement outputs are aggregated by using the clinker/cement price ratio.[4]

Four categories of inputs are used: labor (total number of production workers and administrative personnel, including the subcontract workers), raw materials (expenditure for raw and intermediate materials, adjusted for stock changes, in 1993 prices), energy (expenditures on electricity, coal and oil in 1993 prices), and capital (clinker capacity in tons). The efficiency effects variables are discussed in detail in the next section.

3.2 Determinants of technical efficiency in the cement industry

As explained in the preceding section, the first group of state-owned cement plants was privatized in 1989. Minority shares in "mixed" plants were sold mostly in 1990. The rest of state-owned plants were privatized in two waves, first in 1992-93, then in 1996-97. Since we have data about cement plants for the period 1980 to 1995, we group cement plants into four categories (see Table 1 for plant names, and Table 2 for plant characteristics):

1° State-owned plants that were privatized after 1995, i.e., state-owned throughout

[4] Cement production technology is a process-type, capital intensive technology. There are three distinct phases in the production process: i) preparation of the raw material (limestone) for the kiln, ii) production of the intermediate product, clinker, and iii) mixing clinker with other materials to produce the final product, cement. In the first phase, limestone, transported from the quarry, is crushed and ground into fine powder for the "dry process" or (after adding water) into slurry for the "wet process". The slurry or fine powder is then fed into the kiln, which is basically a slightly inclined rotary cylinder. The kiln is the main component of a cement plant, and its size determines clinker production capacity. In this phase, the slurry or powder is heated, burned and calcined in the kiln to form clinker. The final phase is to cool the clinker and to grind it together with gypsum or pozzolan to produce different types of cement. Cement plants are usually integrated towards all those three phases. Since the clinker capacity of a plant is the main determinant of cement production, it is usually used to measure the capacity level of cement plants. In this study, we do not analyze grinding plants (there are seven grinding plants in Turkey) because they are not operationally comparable to integrated cement plants. Portland cement which was invented by a British stone mason, Joseph Aspdin in 1824, is the most widely used type of cement made with a combination of calcium, silicon, aluminum, and iron. Different types of portland cement are manufactured to meet various physical and chemical requirements that are defined by various national and international standards.

the period under investigation[5]

2° State-owned plants that were privatized during the sample period. These firms are divided into two sub-groups: those privatized in 1989 and 1992/93.

3° Plants privately owned throughout the period

4° Mixed plants owned by the state and private agents until 1990 (public shares were sold in 1990-91)

To test the effects of ownership on technical efficiency, we introduce a number of dummy variables that indicate the type of ownership. For example, the value of the Private variable is equal to 1 for a plant under private ownership throughout the period 1980 to 1995. The variable for first group (state-owned throughout the period) is the omitted ownership dummy. Thus, the coefficients of all other ownership variables will reveal the efficiency of plants relative to this group.

The effect of privatization on technical efficiency is tested in an analogous way by using a dummy variable for the *post-privatization* period. If privatization leads to higher efficiency levels, the coefficient of the post privatization variable will have a negative value. Since the effects of privatization could be different in various groups of public plants, we also introduce different post-privatization dummy variables for all three groups of privatized firms (privatized in 1989, 1992/93, and the "mixed" group).

There are two critical technological factors that may determine the efficiency of cement producers: the process technology (wet or dry), and the existence of pre-calcination. In dry process, preheating of the grounded raw material takes place in cyclones before it is fed into the kiln. Since the hot gases discharged from the kiln are used for preheating, the dry process saves energy. Pre-calcination technology was innovated by Japanese producers in the late 1960s. In this system, almost all of the calcination takes places before the kiln so that the size of the kiln can be reduced. Although the dry process and pre-calcination could be more efficient, the choice of technology depends on the moisture content, and the presence of certain substances (especially alkalis like nitrium and potassium) in the raw materials (Carlsson, 1978).

We use two variables to incorporate the effects of process technologies on technical efficiency: *technology type* variable takes the value 1 if the plant has adopted dry technology,

[5] Includes Adiyaman and Askale plants whose 1994-95 data are not available.

and 0 if the plant uses wet technology. *Pre-calcination technology* variable is defined similarly: it takes the value 1 if the plant has adopted pre-calcination technology, and 0 otherwise. To control for the effects of the vintage of technologies, another variable, technology age is used. Technology age is defined as the age of investment that is used to upgrade the original kiln technology of the plant. Since we suppose that new technologies are more efficient, the technology age variable is expected to have a positive coefficient.

The share of subcontract labor has increased dramatically in privatized plants immediately after their privatization. It could be important to test if privatized plants rely on subcontract labor to improve efficiency or to reduce labor costs by employing unorganized/informal labor. If subcontracting improves the efficiency of the plant, the variable measuring *the share of subcontract labor* in the efficiency effects model will have a negative coefficient. *The share of technical personnel* (engineers and technicians) is also used as a control variable to incorporate the effects of differences in the composition of the work force.

We assume that an increase in regional demand will lead to higher capacity utilization and better use of resources. Thus, a demand variable that measures *the annual growth rate of regional cement demand* is included in the model. This variable is expected to have a negative coefficient. In addition to the growth rate of regional demand, we expect that regional market power is important for efficiency. If the plant enjoys the market power (as measured by the share of the plant in regional sales), it can smooth output and benefit more from increases in regional demand. In other words, *the regional market share* variable is expected to have a negative impact on technical inefficiency.

Export oriented firms could be more efficient because they can maintain high utilization rates through exports. Therefore, the share of exports in total sales is used as an explanatory variable in the efficiency effects model.

The age of the plant may affect technical efficiency in opposite directions. On the one hand, we may expect lower efficiency in older plants because of depreciation and obsolescence. On the other hand, older plants may attain higher efficiency if learning-by-doing is important. Therefore, the effect of this variable on technical efficiency is ambiguous. If the second effect is dominant, the *plant age* variable will have a negative coefficient.

The location of the plant is related with the availability and type of raw materials used. Two dummy variables are used to control for the location of the plant. *Location –East* is a dummy variable that takes the value 1 if the plant is located in the Eastern and South-Eastern regions, and *Location West* is defined in the same way for those plants located in the Western, Southern, and Marmara regions. These two variables compare the efficiency of plants located in the Eastern and Western regions relative to those located in the Central and Black Sea regions. In other words, the variable for the Central region is the omitted dummy variable.

The *Size* variable is used to test if the size of a plant (measured in terms of the log number of employees) affects its technical efficiency. A positive coefficient will support the hypothesis that small plants are more efficient than large plants. Finally, a *Time* variable is included into the inefficiency effects model to capture changes in average efficiency level over time.

3.3 Characteristics of public and private cement plants: A descriptive analysis

Table 2 summarizes the data on the characteristics of cement plants in 1995. As shown in the table, state-owned cement plants are much smaller that their private counterparts. The average clinker production capacity for those plants privatized after 1995 was only about 374,000 tons per year while an average private plant is three times as large as a public plant. The plant capacity is, of course, related to the size of the regional market where the plant is located. Private plants were built close to large markets (metropolitan areas and urban regions) while public plants spread all over Turkey to satisfy local demand in remote markets. None of the private plants are located in the Eastern part of the country. Most of the private plants (10 of them) are located in the "Western" regions (including the Mediterranean coast), whereas almost all plants in the Eastern region were established by CITOSAN. It is also interesting to observe the fact that privatization of public plants started with those in the Central and Western regions, as suggested by the Sema-Metra Conseil report (1986b).

Production technology differs significantly among these groups. All private and mixed plants use "dry" technology in 1995. Moreover, most of the private firms adopted pre-calcination process by 1995. Incidentally, state-owned plants privatized after 1995 and their technologies are much younger since most of these plants were established in recent years. Given the data on the age of plants and technologies, the use of "advanced" technology (dry process and pre-calcination) can be explained either by the characteristics of raw materials used in the production process or the effectiveness of private plants in selecting the appropriate technology.

Private and mixed plants have a larger market share on average than other groups. Export intensity is also higher among private and mixed plants, because most of these plants are in the coastal region and are located close to major harbors. Privatized plants employ proportionately less technicians than private plants and depend more on subcontract labor. The share of subcontract labor was very low for all groups in the late 1980s, and rapidly increased afterwards. The increase in the use of subcontract labor is much higher in privatized plants than in the public and private plants. It seems that privatized plants were able to "restructure" labor relations on their benefit after the change in ownership (for an analysis of labor relations in privatized plants, see Sugur, 1997).

3.4 Efficiency effects of privatization: Estimation results

First, a model without any efficiency effect is estimated by OLS as the simplest case (Model 1). Then, a number of stochastic production frontier models were estimated for the cement industry. The estimations results of four models that include all efficiency effect variables are reported in Table 3 (Models 2a, 2b, 3a, and 3b). A series of hypotheses tests for restricted models was performed to check the robustness of the preferred models. Test results indicate that Model 3a is the best model (Table 4).[6]

The effect of privatization is measured by the "post privatization" variable in Model 2a. In model 2b, three post-privatization variables (for state-owned plants privatized in 1989 and 1992/93, and mixed plants privatized in 1989/90) are used. The effect of privatization is tested by using the likelihood ratio test. If privatization does not have any impact on technical efficiency, the coefficient(s) of the post privatization variable(s) should be equal to zero. In that case, the likelihood values of the unrestricted model (the one that includes the post-privatization dummies), and the restricted model (the one that does not include) should not differ. The χ^2 statistic is used to test if the difference in likelihood values is statistically significantly different from zero. The log-likelihood values for the unrestricted and restricted

[6] The model was estimated in restricted forms (no efficiency effects, Cobb-Douglas functional form, without technology variables, etc.), but likelihood ratio tests summarized in Table 4 reject all these restrictions. Estimation results for restricted models that are not reported in Table 3 are available from authors upon request.

models and χ^2 statistics are given in Table 3.

In Model 2a, the coefficient of the post privatization variable is not significantly different from zero (see the t-value and χ^2 statistic). In Model 3a, all but the coefficient of the post privatization 1992/93 variable are not statistically different from zero. The hypothesis that the coefficients of all three post-privatization variables are equal to zero can be rejected at only 10% level (see the χ^2 statistic).

The differences among groups of plants reveal a remarkable pattern. Estimation results show that the most efficient state-owned plants were privatized in 1989. Those privatized in 1992-93 were somewhat less efficient. The least efficient state-owned plants are those privatized after 1995. In other words, the privatization agencies started the privatization process with the most efficient state-owned plants, and the post-privatization performance of these plants did not show any significant improvement. These results clearly contradict the argument that state-owned enterprises were to be privatized to improve efficiency.

Private plants were clearly more efficient than state-owned plants privatized after 1995, but when we compare average technical efficiency of private plants and public plants privatized in the first round (in 1989), no statistically significant difference is found. That means a group of state-owned plants are as efficient as their private counterparts (see Figure 1).

The estimates of other coefficients in the efficiency effects model conform with our prior expectations. The growth rate of demand, share in regional demand, export share, location (West) and the Time variables all have negative and statistically significant coefficients. The pre-calcination technology variable has a negative coefficient and it is statistically significant at the 5% level in Model 3a. The plant size, age of technology, and location (East) variables have positive and statistically significant coefficients. Interestingly, the share of subcontract labor has a positive but insignificant coefficient. That means the use of subcontract labor does not at all improve technical efficiency of cement plants.

To test the robustness of our results, Model 2a and 3a were reestimated by dropping five variables that are used to reflect technological and organizational characteristics, because one may claim that these variables are controlled by the firm, and these variables differ considerable among private and state-owned plants. For example, private firms are faster in adopting pre-calcination technology that improves technical efficiency. Thus, we can get better estimates for ownership and post-privatization effects if the pre-calcination technology variable is dropped from the model.

The estimation results for the models without technology decision variables (Model 2b and 3b) are shown in Table 3. There seems to be no significant change in estimation results even when technology and organization related variables are omitted. In other words, the low diffusion of "new" technologies in state-owned plants seems to be explained by local conditions (raw material characteristics, plant size, etc.) in which these plants operate.

Marginal effects of explanatory variables on expected output can be calculated from estimation results for all groups of firms. Following Battese and Broca (1997), marginal effects can be defined as follows:

$$\partial E(y_{ft}) / \partial x_{ift} = \left[\alpha_i + 2\beta_{ii} x_{ift} + \sum_{i \leq j} \beta_{ij} x_{jft} \right] - C_{ft} (\partial \mu_{ft} / \partial x_{ift}) \qquad [4]$$

where μ_{ft} is defined in Equation 2. The first component in Equation 4 is the elasticity of mean production with respect to the ith variable. The second term is the elasticity of the technical efficiency effect. If the variable is not included in the efficiency effects model (production frontier), the second term (the first term) will disappear. C_{ft} is defined by

$$C_{ft} = 1 - \frac{1}{\sigma_v} \left[\frac{\phi(\frac{\mu_{ft}}{\sigma_v} - \sigma_v)}{\Phi(\frac{\mu_{ft}}{\sigma_v} - \sigma_v)} - \frac{\phi(\frac{\mu_{ft}}{\sigma_v})}{\Phi(\frac{\mu_{ft}}{\sigma_v})} \right] \qquad [5]$$

where ϕ and Φ represent the density and distribution functions of the standard normal random variable, respectively. In our estimations, we use the deviations of input variables from their geometric mean in the production frontier. Therefore, the estimated coefficients in Table 3 show marginal effects (output elasticities) of inputs for an average plant.

Marginal effects of the efficiency effect variables are calculated for all groups in Table 5. Marginal effects are calculated at the means of the variables in 1989 (the time when privatization started) for all groups. The effect of privatization on efficiency is shown in the first row. State-owned plants privatized in 1989 and mixed plants did not experience any change in efficiency after privatization, but those privatized in 1992/93 show a slight improvement. All other marginal effects are somewhat stronger for the state-owned plants privatized after 1995 because this group of plants is relatively inefficient so that there is a scope for efficiency improvement.

Figure 1 depicts average technical efficiency levels for five groups of cement industries. It is shown that private (the Private group) and state-owned plants that were privatized in 1989 (Priv89) have achieved almost the same level of technical efficiency throughout the period. Mixed and other state-owned plants were somewhat less efficient. The Priv95 group (those privatized after 1995) has the lowest average efficiency level but had been quite successful in raising efficiency *before* they were privatized in 1995-97.

Although it is beyond the scope of this paper, the stochastic production frontier estimation results can be used to analyze the rate and direction of technical change in Turkish cement industry. Our results indicate that the average annual rate of technical change in the period 1980 to 1995 was about 3.0%, and it gradually decelerates 0.2 percentage points per year. Moreover, there seems to be capital using and labor saving technical change in the cement industry (see the coefficients of the Time*Capital and Time*Labor variables in Table 3).

4 Conclusions

Privatization of state-owned establishments has been a major aim of economic policy in many developed and developing countries in the last couple of decades. The large-scale privatization of state-owned plants has been justified by the argument that private plants are more efficient than state-owned plants. The performance of privatized establishments is principally an empirical issue, because economic theory does not suggest any firm prediction on this question. Despite privatization of a large number of state-owned establishments, our empirical knowledge is quite limited. This paper aims to analyze the effect of privatization in Turkish cement industry by using stochastic production frontier method. Our findings on the analysis of all cement plants in Turkey can be summarized as follows:

1. Private plants are not necessarily more efficient than state-owned plants. Some state-owned plants are as efficient as private plants. Efficiency differences among state-owned plants can be explained by their geographical location and the size of regional markets they

aim to serve. These findings convey further support for a cross sectional study by Çakmak and Zaim (1992) who found no difference between the average efficiency levels of private and state-owned cement plants.

2. There is not any evidence that supports the hypothesis that privatization improves technical efficiency. Our analysis does not find any significant improvement in the efficiency of privatized plants.

3. Turkish governments seem to adopt the policy that gives priority to the privatization of efficient and profitable plants. This is precisely the case in the cement industry: the most efficient public plants were privatized first, in 1989, and the least efficient plants the latest, in 1995-97.

4. All public plants wholly owned by the state were privatized through block sales. This policy contradicts the aim to disperse ownership to the public.

5. Privatization has led to the creation of regional monopolies in the cement industry. Existing cement producers and new entrants have acquired cement plants in certain regions to establish or to maintain regional monopolies.

This study is focused on the effect of privatization on technical efficiency. The analysis can be extended to consider the effects on the allocation of resources (allocation efficiency), labor relations and the use of subcontract labor, pricing behavior of privatized plants, and vertical integration towards ready-mixed concrete production activities. These extensions remain as a part of our future research agenda.

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Table 1 Cement plants in Turkey, 1995

	Established in	Production in 1994		Clinker capacity	Privatized in	Buyer
		Clinker	Cement			
			State-owned			
Ankara	1926	654	694	800	1989	Ciments Français
Sivas	1943	346	279	350	1992	Yibitas
Elazig	1954	319	284	310	1996	OYAK-GAMA
Afyon	1954	243	387	350	1989	Ciments Français
Söke	1955	180	412	210	1989	Ciments Français
Gaziantep	1955	417	543	500	1992	Rumeli Holding
Nigde	1957	414	351	450	1992	Oyak-Sabanci
Balikesir	1958	208	378	350	1989	Ciments Français
Pinarhisar	1958	612	639	600	1989	Ciments Français
Çorum	1959	457	311	450	1992	Yibitas
Bartin	1962	251	302	240	1993	Rumeli Holding
Van	1966	154	184	190	1996	Rumeli Holding
Trabzon	1966	332	411	355	1992	Rumeli Holding
Askale	1968	201	339	300	1993	Ercimsan
Kars	1969	203	183	215	1996	Cimentas
Kurtalan	1976	246	205	510	1997	Canlar Otomotiv
Adiyaman	1983	302	365	510	1995	Teksko
Ladik	1983	521	557	525	1993	Rumeli Holding
Ergani	1984	350	201	510	1997	Rumeli Holding
Sanliurfa	1986	317	265	500	1993	Rumeli Holding
Denizli	1987	552	630	600	1992	Modern
Lalapasa	1991	472	520	510	1996	Rumeli Holding
			Mixed ownership			
Konya	1953	487	617	530	1990	
Adana	1954	1495	1222	1490	1990	
Bolu	1968	962	875	1200	1989	
Mardin	1969	500	387	525	1990	
Ünye	1969	560	626	560	1990	
			Private ownership			
Aslan	1911	930	1153	1080		
Anadolu	1929	350	523	435		
Çimentas	1950	1520	1412	1500		
Eskisehir	1954	440	509	500		
Bursa	1966	787	996	840		
Bastas	1967	625	600	620		
Akçimento	1967	1820	2059	1850		
Göltas	1969	904	870	1200		
Nuh	1969	1301	1856	1350		
Bati	1969	1400	1701	1400		
Yibitas	1973	626	395	700		
Çimsa	1973	1480	1248	1400		
Çanakkale	1974	1792	2004	1815		

Sources: Sencan (1995), Kamu Ortakligi İdaresi Baskanligi (1997), and our database.

Table 2 Characteristics of cement plants in Turkey, 1995
(number of plants and mean values)

	State-owned plants privatized before 1995	State-owned plants privatized after 1995	Private owned	Mixed owned
Number of plants	14	6	13	5
Number of observations				
Total	189	100	157	80
After privatization	55	-	-	26
Production (000 tons)	536	311	1436	1055
Capital (clinker capacity, 000 tons)	455	374	1188	922
Employment	226	286	396	380
Energy (billion TL, 1993 prices)	93.3	60.5	238.9	175.3
Raw materials (billion TL, 1993 prices)	30.8	10.6	124.1	50.5
Type (share of blended cement)	22.5	16.3	44.8	25.2
Bag (share of bulk output)	79.2	82.5	68.7	82.0
Demand growth (%)	14.8	12.7	10.5	19.4
Share in regional sales (%)	11.7	15.2	18.5	22.5
Exports/sales ratio (%)	0.8	1.1	13.1	8.0
Plant age (year)	34.7	21.7	35.7	32.4
Location				
East	2	5	0	1
Center	8	0	3	3
West	4	1	10	1
Share of technical personnel (%)	6.7	4.2	10.5	8.1
Share of subcontract employees (%)	21.9	12.0	10.2	28.3
Pre-calcination technology				
No	12	6	5	3
Yes	2	0	8	2
Technology age (year)	26.6	17.3	23.2	25.0
Technology				
Wet	7	1	0	0
Dry	7	5	13	5
Type of owner**				
Holding/Group	13	6	6	4
Independent	1	0	7	1

* Excludes Adiyaman and Askale plants whose 1994-95 data are not available.
** "Type of owner" shows the type of owner who has acquired the state-owned plant after privatization.

Table 3 Stochastic production frontier estimation results

Variables	Model 1 (OLS)		Model 2a		Model 2b		Model 3a		Model 3b	
	coeff	std.dev.	coeff	std.dev.	coeff.	std.dev.	coeff.	std.dev.	coeff.	std.dev.
Production frontier										
Constant	-0.245*	0.077	0.223*	0.058	0.296*	0.053	0.222*	0.058	0.325*	0.055
Capital	0.275*	0.042	0.504*	0.047	0.453*	0.048	0.519*	0.042	0.453*	0.048
Labor	0.561*	0.068	0.242*	0.054	0.256*	0.056	0.253*	0.057	0.260*	0.059
Energy	0.345*	0.044	0.221*	0.031	0.241*	0.029	0.211*	0.029	0.236*	0.029
Raw materials	0.171*	0.021	0.044*	0.017	0.043*	0.017	0.041*	0.017	0.042*	0.016
Time	0.046*	0.004	0.027*	0.004	0.029*	0.004	0.029*	0.004	0.030*	0.005
Time*Time	-0.001^{+}	0.001	-0.002*	0.001	-0.002*	0.001	-0.002*	0.001	-0.002*	0.001
Time*Capital	0.021*	0.011	0.026*	0.010	0.031*	0.009	0.027*	0.009	0.033*	0.010
Time*Labor	-0.075*	0.019	-0.038*	0.014	-0.045*	0.013	-0.031*	0.014	-0.045*	0.013
Time*Energy	0.012	0.009	-0.002	0.008	-0.003	0.007	-0.008	0.008	-0.006	0.008
Time*Raw mat	0.001	0.006	0.005	0.005	0.006	0.004	0.004	0.005	0.006	0.004
Type	0.002*	0.000	0.001*	0.000	0.001*	0.000	0.001*	0.000	0.001*	0.000
Bag	0.003*	0.001	0.000	0.001	-0.001	0.001	0.000	0.001	-0.001	0.001
All other interaction terms										
Efficiency effects variables										
Constant			-1.794*	0.466	-1.060*	0.483	-1.686*	0.460	-1.025*	0.451
Private			-0.627*	0.094	-0.596*	0.092	-0.606*	0.091	-0.587*	0.092
Privatized in 1989			-0.548*	0.103	-0.419*	0.095	-0.566*	0.100	-0.428*	0.093
Privatized in 1992/1993			-0.190*	0.060	-0.159*	0.054	-0.187*	0.059	-0.148*	0.055
Mixed			-0.372*	0.075	-0.359*	0.071	-0.381*	0.073	-0.385*	0.075
Post privatization			-0.084	0.104	-0.028	0.073				
Post privatization, 1989							-0.002	0.157	0.097	0.121
Post privatization, 1992/93							-0.256*	0.121	-0.145	0.109
Post privatization, mixed							0.005	0.122	0.076	0.106

Table 3 Continued

Variables	Model 1 (OLS)		Model 2a		Model 2b		Model 3a		Model 3b	
	coeff	std.dev.	coeff	std.dev.	coeff.	std.dev.	coeff.	std.dev.	coeff.	std.dev.
Demand growth			-0.314*	0.123	-0.337*	0.125	-0.292*	0.121	-0.330*	0.114
Share in regional sales			-3.246*	0.403	-3.011*	0.336	-3.082*	0.361	-2.961*	0.316
Exports/sales ratio			-0.581*	0.134	-0.604*	0.147	-0.540*	0.132	-0.595*	0.141
Plant age			-0.002	0.002	-0.000	0.001	-0.002	0.002	-0.000	0.002
Location - East			0.413*	0.065	0.418*	0.064	0.379*	0.064	0.408*	0.061
Location - West			-0.144*	0.068	-0.153*	0.069	-0.140*	0.064	-0.162*	0.066
Size (log employment)			0.506*	0.083	0.384*	0.088	0.492*	0.080	0.375*	0.085
Time			-0.049*	0.009	-0.043*	0.009	-0.044*	0.009	-0.039*	0.009
Share of technical personnel			0.287	0.859			-0.144	0.872		
Share of subcont. employees			0.076	0.432			0.291	0.338		
Pre-calcination technology (1=yes)			-0.323	0.191			-0.308*	0.148		
Technology age			0.009*	0.004			0.008*	0.003		
Technology type (1=dry)			0.046	0.058			0.021	0.051		
Log-likelihood value										
Unrestricted model	18.6		267.1		260.5		270.2		263.2	
Restricted model[a]			266.7		260.4		266.7		260.4	
χ^2 statistic			0.8		0.2		7.0+		5.7	
σ^2			0.039*	0.006	0.036*	0.005	0.038*	0.005	0.035*	0.005
γ			0.762*	0.077	0.668*	0.092	0.789*	0.061	0.648*	0.108
Number of plants	40		40		40		40		40	
Number of observations	526		526		526		526		526	

* (+) means statistically significant at the 5% (10%) level. [a] Restricted model excludes dummy variables for the post-privatization period ('Post privatization 1989', 'Post privatization 1992-93', and 'Post privatization mixed' variables).

Note: $\sigma^2 = \sigma^2_{\varepsilon} + \sigma^2_{\nu}$ $\gamma = \sigma^2_{\nu} / \sigma^2$

Table 4 Statistics for tests of hypotheses

Null hypothesis[a]	log-likelihood value[b]	Test statistic, λ[c]	df	Test result (5% level)
H_0: Model 1 (OLS) [d]	18.6	503.2	22	Reject H_0
H_0: No efficiency effects	72.1	396.2	20	Reject H_0
H_0: Cobb Douglas frontier	232.2	76.0	15	Reject H_0
H_0: Only ownership and privatization effects	165.0	210.4	13	Reject H_0
H_0: Only ownership, privatization and location effects	170.6	199.2	11	Reject H_0
H_0: Only ownership, privatization, location, size and time effects	175.6	189.2	9	Reject H_0
H_0: Model 2a	267.1	6.2	2	Reject H_0
H_0: Model 2b	260.5	19.4	7	Reject H_0
H_0: Model 3b	263.2	14.0	5	Reject H_0

[a] Model 3a is the alternative in all tests.
[b] Log-likelihood value under null hypothesis
[c] The likelihood ratio statistic, λ, is defined by $\lambda = -2ln(L_r/L_u)$ where L_r and L_u are the maximum values of the likelihood function under the null and alternative hypotheses, respectively. If the null hypothesis is true, λ is asymptotically distributed as χ^2 with *df* degrees of freedom where *df* is the number of restrictions imposed by the null hypothesis.
[d] The test statistic has a mixture of χ^2 distributions because the alternative for the null involves an inequality constraint, $\gamma \geq 0$ (see Coelli and Battese, 1996; for critical values, see Kodde and Palm, 1986).

Table 5 Marginal effects of efficiency variables

	State-owned plants privatized in			Private	Mixed
	1989	1992/93	after 1995		
Post privatization	0.000	0.079			-0.002
Demand growth	0.058	0.090	0.282	0.030	0.134
Share in regional sales	0.612	0.947	2.985	0.314	1.418
Exports/sales ratio	0.107	0.166	0.523	0.055	0.249
Plant age	0.000	0.001	0.002	0.000	0.001
Location - East	-0.075	-0.117	-0.367	-0.039	-0.174
Location - West	0.028	0.043	0.135	0.014	0.064
Size (log employment)	0.120	0.067	-0.213	0.005	-0.059
Time	0.009	0.014	0.043	0.004	0.020
Share of technical personnel	0.029	0.044	0.139	0.015	0.066
Share of subcont. employ.	-0.058	-0.090	-0.282	-0.030	-0.134
Pre-calcination technology	0.061	0.095	0.299	0.031	0.142
Technology age	-0.002	-0.002	-0.008	-0.001	-0.004
Technology type	-0.004	-0.006	-0.020	-0.002	-0.010

Figure 1. Technical efficiency in Turkish cement industry, 1980-1995