

Firm Ownership and Economic Efficiency

George C. Bitros*

Department of Economics

Athens University of Economics and Business

76 Patision Street, Athens 10434, Greece

Tel.: 8223545, Fax: 8203301, E-mail: bitros@aueb.gr

Abstract

The objective in this paper is to improve the existing evidence regarding the role ownership plays in economic efficiency. It is pursued through enhancements in modeling, estimation techniques, and experimental design. With respect to modeling, state ownership is explicitly introduced into the simple model of the financially constrained firm in order to trace its implications. In turn, the interrelated, three-equation input demand model that emerges is estimated with consistent panel data techniques, using information gathered from state and private firms that operated in large-scale Greek manufacturing during the 1979-1988 period. The results show that, per unit of output, the amounts of labor, capital, and credits employed by state firms were 15.7, 12.2, and 49.1 percent larger than those employed by private firms in the same industries. Moreover, taking input prices into consideration, these findings indicated that state firms incurred 46.2 percent higher costs per unit of output and that liable for their relative inefficiency were technical, allocative and ownership reasons by contributing respectively 16.3, 25.5 and 4.4 percentage points. Last, but not least, state ownership was found to alter significantly the conventional patterns in which the employment of inputs responds to equity and input price changes. Thus, in contrast to claims made by some researchers, state ownership may influence economic efficiency as well as exercise several other important effects.

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I. Introduction

Before the advent of privatization, empirically minded researchers in the area of public economics had suspected that public enterprises were failing with regard to productive efficiency. As a result, given that allocative efficiency is automatically violated in the absence of productive efficiency, researchers had turned their attention to discovering whether it was the lack of competition, the ownership of these enterprises, or some other factor responsible. The ensuing evidence, however, showed that none of these explanations was compelling. Thus, the controversy that grew out of this was destined to linger on until richer data sets and more suitable research methods became available.

With the advent of privatization, first adopted 30 years ago in many parts of the world, things began to slowly change. As more companies underwent a change in ownership, the testing grounds improved, giving impetus to a large body of literature.¹ Yet, despite these valuable efforts, there remain certain aspects that deserve further consideration. One such aspect is that all existing studies more or less arbitrarily adopt regression approaches that do not derive explicitly from the theory of rational entrepreneurial behavior.² Another is that while state enterprises may pursue wider social objectives, profitability-based criteria are used to compare their performance to that of private firms.³ Yet, another aspect is that the tests are carried out using single-equation estimating techniques, which do not allow for the multiplicity of dynamic adjustments made by firms in response to changing technology and market conditions.

To improve on these aspects, this study adopts three innovations. First, it explicitly introduces ownership into a simple model of the financially constrained firm. The analytical framework that results from this adaptation makes it possible to trace the effects of ownership by focusing on the output produced and the inputs employed by private and state firms. Second, system-estimating techniques specifically designed for the study of dynamic economic behavior are utilized. Aside from the increased accuracy of the estimates obtained, these techniques enable one to control for such structural changes as shifts in tastes, technology, market conditions, and institutions. Finally, the third innovation lies in the nature of the data used in the estimations.

These consist of two sets of observations. The first set comes from 19 state-controlled firms that operated continuously in large-scale Greek manufacturing from 1979 to 1988. According to the Standard Industrial Classification System (SICS), these companies were grouped into nine, two-digit industries. By aggregating the data in the industries with more than one

¹ For a recent selective survey of the literature in this area see Shleifer (1998).

² This shortcoming extends also to studies like the one conducted by Teeple and Glyer (1987) that employ the dual cost function approach. The reason being that they do not explain how ownership might enter into the profit maximizing or cost-minimizing problem of the firm.

³ For a few examples in this respect see Vining and Boardman (1992), Megginson, Nash and Randenborgh (1994), and most recently Dewenter and Malatesta (2001).

company and dividing them by their number, I obtained observations for nine average, or representative, state firms. The second set of observations was extracted from the *Annual Industrial Surveys* of the National Statistical Service of Greece. More specifically, by dividing in each year the data in the corresponding two-digit industries by the number of firms surveyed, observations were received for nine average, or, representative, private firms. Finally, by stacking the two sets of observations over the nine-year period, a balanced 18-by-10 panel was formed.

The results are quite revealing. From the analysis of the model it emerges that state firms may be equally or more efficient than their private counterparts only in one case. This happens when the beneficial effects of state ownership on the finances of state firms significantly dominate the adverse effects of state ownership on the production side of state firms. However, the results refute this condition because, per unit of output, the amounts of labor, capital and credits employed by state firms were found to be 15.7, 12.2, and 49.1 percent larger than the respective amounts employed by private firms in the same industries. Moreover, allowing for the differences in the input prices they pay, these findings indicated that state firms incurred 46.2 percent higher costs per unit of output and that liable for their relative inefficiency were technical, allocative and ownership reasons by contributing 16.3, 25.5 and 4.4 percentage points, respectively.

The remainder of the paper is organized as follows. Sections II and III present respectively the theory and the estimated model that guide the empirical investigation. Section IV describes the nature of the sample, the definition and measurement of the variables, and the working assumptions that had to be adopted due to various data limitations. Section V addresses the econometric issues raised in the estimation stage. Section VI presents and comments on the results. And, finally, Section VII summarizes the conclusions.

II. The model

By following, for example, Vickers (1968) let the financially constrained firm behave as if it solved the following problem:⁴

$$\text{Max } \Pi = P(Y)Y(L,K) - wL - c[r(D)]K - r(D)D \quad (\text{i})$$

$$\text{s. t. } E + D = \alpha Y(L,K) + \beta_1 L + \beta_2 K, \quad (\text{ii})$$

$$\alpha, \beta_1, \beta_2 > 0, L, K > 0, D \geq 0, \quad (\text{iii}) \quad (1)$$

$$P'_Y, P''_Y < 0, Y'_L, Y'_K > 0, Y''_L, Y''_K < 0, c'_D, c''_D > 0, r'_D, r''_D > 0, \quad (\text{iv})$$

where: Π = net profits

⁴ The original model has been modified slightly. The modification lies in the specification of the cost of capital, c , as a function of the interest rate, r , which in turn depends on debt, D .

- Y = output
 L = labor as variable factor of production
 K = physical capital as fixed factor of production
 E = equity
 D = liabilities
 p = price of output
 w = wage rate
 $c[r(D)]$ = user cost per unit of physical capital
 $r(D)$ = interest rate paid on debt
 α = operating funds required to finance such things as sales, raw materials, and energy. These funds are presumed to constitute a constant proportion of the level of output.
 β_1 = financial capital requirement for the variable factor. Since production takes time, even the variable factors of production must be financed, i.e., they must be paid before proceeds are received. Hence, this coefficient indicates that the financial capital required for labor is a constant proportion of the quantity employed.
 β_2 = financial capital requirement for the fixed factor. This signifies that the financial capital required to secure the services of the physical capital is a constant proportion of the amount employed,

and the primes to the upper left of a variable indicate the order of derivative taken with respect to the subscripted variable.

Then, if $R = P(Y)Y(L,K)$ and λ denotes the Lagrange multiplier associated with (1)(ii), the first order necessary conditions for an interior solution to (1) are:

$$\begin{aligned}
 R'_L - w - \lambda [\alpha Y'_L + \beta_1] &= 0 & \text{(i)} \\
 R'_K - c[r(D)] - \lambda [\alpha Y'_K + \beta_2] &= 0 & \text{(ii)} \\
 c'_D K + r'_D D + r(D) - \lambda &= 0. & \text{(iii)}
 \end{aligned}
 \tag{2}$$

As illustrated by the diagrams in the Appendix C, these equations imply that, relative to the neo-classical firm, the financially constrained one produces less output, employs less labour and uses a lower capital-to-labour ratio.⁵

⁵ In the diagrams of Appendix B the effects of ownership are indicated by the position of the dotted curve. If ownership enhances the efficiency of the state-controlled firm, relative to the financially constrained private firm, from Figure 1 it can be observed that its “marginal cost plus marginal capital and ownership cost” curve will lie at A. If it worsens its efficiency, the dotted curve will lie at B. Finally, if efficiency is invariant with re-

The rationale for invoking this model should be rather obvious. Since it refers to financially constrained firms in general and without regard to their ownership, it can be used as a benchmark to discern the effects of state ownership on the performance of firms.⁶ What this requires is to identify these effects, introduce them explicitly into (1), and trace their implications. The focus below is exactly on these matters.

Ownership should influence the performance of a firm through three channels: the objectives the firm pursues,⁷ its production function, and its financial constraint. If state ownership were established to enhance the government's employment policies, to attain some other "social welfare" objectives, or to satisfy the self-serving interests of politicians⁸, etc., *ceteris paribus*, the state firm—as opposed to its private counterpart—would be expected to be less efficient. This is so because the achievement of its non-market objectives must cost the state firm something in terms of resources. Hence, if both firms have the same production technology, one way to model the effect that the difference in their objectives exercises on their output is to postulate that:

$$\tilde{Y} = \{1 - h_1(O)\} Y(L, K) \begin{cases} h_1(O) = 0, & \text{for } O=0, \text{ private firm} \\ 0 \leq h_1(O) < 1, & \text{for } O=1, \text{ state firm} \end{cases}$$

where \tilde{Y} is the output adjusted for ownership, O indexes the type of ownership, and $h_1(O)$ represents some mechanism which for $O=1$ shifts the production function downward.

However, whereas the preceding effect may cause certain loss in revenues, state ownership may give the firm some financial benefit in the form of an interest rate subsidy to defray the costs for achieving the non-profit objectives assigned to it by the government. In the framework of model (1) this subsidy would imply that the $r(D)$ curve facing the state firm would lie below that of the private firm at all levels of debt.⁹ Therefore, one way to model this financial effect is the following:

spect to ownership, the dotted curve will coincide with the solid one. The significance of this analysis will become much clearer shortly.

⁶ Most of the present day modeling in public vs. private ownership research focuses on firm objectives, market structure, barriers to entry, and strategic competition (see, for example, De Fraja (1991) and Katsoulacos (1994)). So, in retrospect, the adopted model may appear to be quite obsolete. However, as this paper demonstrates, by virtue of its simplicity it is possible to derive an analytically explicit comparison of the production and financial effects of state ownership, something that would have been impossible to do under a model of more recent vintage.

⁷ For an excellent attempt at tracing empirically the impact of alternative operating objectives on the performance of state firms, see Hu and Birch (1999).

⁸ For an excellent analysis of the processes adopted by politicians to serve their own interests through state firms see Shleifer and Vishny (1994).

⁹ Aside from state subsidies, several other factors influence the shape and location of this curve. One such factor is, for example, the perception that state firms rarely, if ever, go bankrupt. If this is widespread, the lenders of state firms may experience less risk and hence charge a lower interest rate by comparison to private firms. Another factor is efficiency. Since the interest rate a bank charges on loans to a firm depends, among other things, on its profitability, the cost of debt to state firms may be higher than that charged to private firms, if state firms are run less efficiently. Still another factor is ownership itself. For, if firms belong to state banks, as is true in our case, economic theory suggests

$$\tilde{r} = \{1 - h_2(O)\}r(D) \begin{cases} h_2(O) = 0, \text{ for } O=0, \text{ private firm} \\ 0 \leq h_2(O) < 1, \text{ for } O=1, \text{ state firm} \end{cases}$$

where \tilde{r} is the interest rate adjusted for ownership, and $h_2(O)$ is a subsidy mechanism that shifts the relationship of the interest rate to debt downward whenever $O=1$.

If we set $g_1 = 1 - h_1(O)$ and $g_2 = 1 - h_2(O)$ and introduce these expressions into (1), the ownership-sensitive firm may be perceived as solving the problem:¹⁰

$$\begin{aligned} \text{Max } \Pi &= g_1(O)R - wL - c[g_2(O)r(D)]K - g_2(O)r(D)D & (i) \\ \text{s. t. } E + D &= \alpha g_1(O)Y(L,K) + \beta_1 L + \beta_2 K, & (ii) \\ &1(iii) - 1(iv) & (iii) \quad (3) \\ g_1(O) &= g_2(O) = 1, \text{ for } O = 0, & (iv) \\ 0 < g_1(O) < 1, \quad 0 < g_2(O) < 1, \text{ for } O = 1. & (v) \end{aligned}$$

By implication it follows that while trying to solve (3) the private firm solves (1) since for $O=0$ the former becomes equivalent to the latter. But, if the firm is controlled by the state and $O=1$, the solution of (3) implies that the firm maximizes (minimizes) the residual profits (losses); that is, after allowing for the costs and benefits that are associated with state ownership.

Specified in this way, the objective function for the state firm has considerable merits. For example, depending on the range of permissible values for O , (3) offers the potential to analyze intermediate degrees of state participation in private firms. Or, by looking into the analytic properties of g_1 and g_2 —while O varies over a continuum of values—one may be able to shed light on the optimal structure of ownership from an economic efficiency point of view. Yet, because the state firm is assumed to maximize a financial objective, albeit in a limited sense, those who view state enterprises as extensions of the state's political apparatus may still question its validity.¹¹ My view is that, at least for state companies in competitive industries, on which this study focuses, (3) is a good behavioral approximation for the following reasons. First and foremost, because, what a firm maximizes belongs to the "fundamental" or "high-level generalizations" which do not need independent empirical verification

that state banks will have better and timelier information than any other potential lender and thus they may provide loans to these firms at a lower cost. However, see Edwards and Fischer (1994), who demonstrate how this may not be universally true.

¹⁰ For an alternative, but less general approach to modeling the effects of state ownership on economic efficiency, see Ehrlich et al. (1994).

¹¹ Apparently they would also have good grounds to do so because the existing empirical evidence (see, for example, Sheshinski and Lopez-Calva (1999), Lopez-de-Silanes (1998), and World Bank (1995)) suggests that state-owned

if they constitute significant steps in arguments reaching propositions that are empirically testable.¹² Second, because contrary to state monopolies, state firms in competitive industries are subject to the risk of bankruptcy, and several of them have gone bankrupt in Greece. Third, because in the last twenty years the thrust of government policies has been to force all state companies to operate as if they were private firms in competitive industries. And fourth, because state subsidies to these enterprises constitute a flagrant violation of fair competition laws and are prohibited by articles 84 and 85 of the Treaty of Rome.

Solving (3) in the usual way, the first order conditions for maximum profits or, in case of losses, for minimum losses, take the form of:

$$g_1(O)R'_L - w - \mu[\alpha g_1(O)Y'_L + \beta_1] = 0 \quad (i)$$

$$g_1(O)R'_K - c[g_2(O)r(D)] - \mu[\alpha g_1(O)Y'_K + \beta_2] = 0 \quad (ii) \quad (4)$$

$$g_2(O)[c'_D K + r'_D D + r(D)] - \mu = 0, \quad (iii)$$

where μ stands for the new Lagrange multiplier and measures the marginal impact on net profits of the financial constraint. Now, let us look at these conditions a little closer.

Assuming that $c[g_2(O)r(D)] = g_2(O)c[r(D)]$, from conditions (2)(iii) and (4)(iii) can be observed that the relationship between the two Lagrange multipliers is $\mu = g_2(O)\lambda$. By substituting for μ into (4), simplifying the shift functions, and rearranging the results, the first order conditions transform into:¹³

$$R'_L - \frac{w}{g_1} - \lambda \frac{g_2}{g_1} [\alpha g_1 Y'_L + \beta_1] = 0 \quad (i)$$

$$R'_K - \frac{c[r(D)]g_2}{g_1} - \lambda \frac{g_2}{g_1} [\alpha g_1 Y'_K + \beta_2] = 0 \quad (ii) \quad (5)$$

$$c'_D K + r'_D D + r(D) - \lambda = 0. \quad (iii)$$

Now looking at (5) it is easy to see that, when the firm is financially constrained but free from state

enterprises care little, if at all, about financial constraints.

¹² To put the same argument in more authentic terms, consider the following passage from the famous logician Royce (1913):

"One often meets with the remark that a scientific hypothesis must be such as to be more or less completely capable of verification or of refutation by experience. The remark is sound. But equally sound it is to say that a hypothesis which, just as it is made, is, without further deductive reasoning, capable of receiving direct refutation or verification, *is not nearly as valuable to any science as is a hypothesis whose verifications, so far as they occur at all, are only possible indirectly, and through the mediation of a considerable deductive theory*, whereby the consequences of the hypothesis are first worked out, and then submitted to test."

control, i.e. $O = 0$ and $g_1 = g_2 = 1$, model (3) reduces to (1). Assuming in this case that $P(Y) = 1$, let the solution be L^* , K^* , and Y^* . The important question that arises is how this solution might change when $O=1$? In this event, the following cases exist.¹⁴

Case 1: $0 < g_1 = g_2 < 1$

Without loss in generality, since the bracketed terms in (5) are positive, let $c[r(D)] = r$ and $\lambda = 0$. Then, (5)(i) and (5)(ii) become:

$$\begin{aligned} g_1 Y'_L &= w \\ Y'_K &= r. \end{aligned} \tag{6}$$

From this it is clear that the solution would be $K^* = K$ and $L^* > L$. This implies that the state firm would employ less labor and produce less output than its private counterpart.

Case 2: $0 < g_1 < g_2 < 1$

Now conditions (5)(i) and (5)(ii) become:

$$\begin{aligned} g_1 Y'_L &= w \\ g_1 Y'_K &= g_2 r. \end{aligned} \tag{7}$$

Clearly, since g_1 pulls down the marginal product of capital more than g_2 reduces the interest rate, the solution would give $K^* > K$ and $L^* > L$. This implies that the state firm would employ less capital and labor and produce less output than the private firm does.

Case 3: $0 < g_2 < g_1 < 1$

Looking at (7) we see now that g_1 would pull down the marginal product of capital less than g_2 would reduce the interest rate. This implies that the solution would give $K^* < K$ and $L^* > L$, and hence, the impact of state ownership on output would be indeterminate.

With arguments similar to the above, it is possible to investigate the effects of state ownership on the employment of all inputs, as well as the ratios in which they are employed. If pursued, these endeavors would show that in the third case all outcomes are possible. The reason is that, when the adverse production effect of state ownership is insignificant and markedly domi-

¹³ For a discussion regarding the second order conditions see the analysis in Appendix A.

¹⁴ It should be stressed that, even though in the model all markets have been presumed to be imperfectly competitive,

nated by its beneficial financial effect, the state firm may be less, equally or more efficient than the private firm.¹⁵ Due to limited space, these proofs were skipped, and the issues involved in the transition from the theoretical model to its empirical implementation were immediately considered. This amounted to deriving from (5) an input demand model and using it to test the hypothesis that, *ceteris paribus*, state ownership does not matter. Or, alternatively, to test the hypothesis that h_1 and h_2 are such that both state and private firms are equally efficient or inefficient.

III. From the theoretical to the estimated model

The equations in (5), including the financial constraint, cannot be solved explicitly even for simple analytical specifications of the various functions involved. As a result, in order to obtain an approximation to the input demand functions, the only alternative left is to linearise the first-order conditions in the neighborhood of the long-run equilibrium. But there is a problem in doing so because, while linearisation requires taking derivatives, the variable that indexes ownership in the model is discrete. For this reason, even though a (1,0) dummy will denote ownership in the estimations, it is assumed that the partial derivatives of the first-order conditions do exist with respect to ownership. Under this convention, and assuming that “price expectations are static”, the linearisation process yields:

$$\begin{aligned} L^* &= f_1(E, O, w, \bar{c}, \bar{r}) & (i) \\ K^* &= f_2(E, O, w, \bar{c}, \bar{r}) & (ii) \\ D^* &= f_3(E, O, w, \bar{c}, \bar{r}), & (iii) \end{aligned} \quad (8)$$

where \bar{c} and \bar{r} are those parts of the $c[r(D)]$ and $r(D)$ functions that are independent of the firm's level of debt.¹⁶

By adopting the standard partial adjustment model, the approach to the long-run equilibrium of the system of inputs can be approximated through the following set of difference equations:

$$x_{it} - x_{it-1} = \sum_{j=1}^3 \beta_{ij} [f_i(E, O_t, w_t, \bar{c}_t, \bar{r}_t) - x_{jt-1}] + v_{it}, \quad \text{for } i = 1, 2, 3, \quad (9)$$

the analytical results derived below are invariant with respect to the nature of competition that prevails.

¹⁵ In other words, the dotted curve in Figure 1 in Appendix B, representing the “marginal cost plus marginal capital and ownership cost”, may lie on either side of the “marginal cost plus marginal capital cost” curve or even coincide with it.

¹⁶ Since the user cost of capital and the interest rate are functions of debt, D , for consistency with the theoretical model, the variables c and r ought to be considered as endogenous. However, to keep the empirical analysis simple I have assumed that the $c[r(D)]$ and $r(D)$ functions consist of two parts: one exogenous, which is denoted by a bar over the variables r and c , and one endogenous, which dropped out during the linearisation process.

where x_i indicates the inputs, β_{ij} is a non-diagonal matrix of adjustment coefficients and v_1, \dots, v_3 are random errors with zero means and variance-covariance matrix Ω ¹⁷. When estimated, this system can help us find (a) the short-term impact of changes in equity, ownership and prices, (b) the transition or distributed lag patterns of the inputs to changes in these variables, and (c) the long-run equity, ownership and price elasticities of inputs. Hence, the first step towards attaining these objectives is to estimate (9).¹⁸

To this effect, the specific form of the three-equation system to be estimated is:

$$\begin{aligned} L_t &= \alpha_0 + \alpha_1 E_t + \alpha_2 O + \alpha_3 w_t + \alpha_4 \bar{c}_t + \alpha_5 \bar{r}_t + \alpha_6 L_{t-1} + \alpha_7 K_{t-1} + \alpha_8 D_{t-1} \\ K_t &= \beta_0 + \beta_1 E_t + \beta_2 O + \beta_3 w_t + \beta_4 \bar{c}_t + \beta_5 \bar{r}_t + \beta_6 L_{t-1} + \beta_7 K_{t-1} + \beta_8 D_{t-1} \\ D_t &= \gamma_0 + \gamma_1 E_t + \gamma_2 O + \gamma_3 w_t + \gamma_4 \bar{c}_t + \gamma_5 \bar{r}_t + \gamma_6 L_{t-1} + \gamma_7 K_{t-1} + \gamma_8 D_{t-1}. \end{aligned} \quad (10)$$

As Nadiri and Rosen (1969,1973) have shown, in this system the transitory responses are embedded in the coefficients of the matrix:¹⁹

$$B = [\beta_{ij}] = \begin{bmatrix} \alpha_6 & \alpha_7 & \alpha_8 \\ \beta_6 & \beta_7 & \beta_8 \\ \gamma_6 & \gamma_7 & \gamma_8 \end{bmatrix}.$$

Next, let A be a matrix of estimated coefficients for the exogenous variables and X a matrix of ratios of some initial values for the exogenous and the corresponding dependent variables. Then, the transitory responses can be computed from $[\mathbf{I} - (\mathbf{I} - \mathbf{B})\mathbf{Z}]^{-1} \mathbf{A}\mathbf{X}$, where \mathbf{I} denotes the identity matrix and \mathbf{Z} is the lag operator, whereas the long-term elasticities can be obtained from $(\mathbf{I} - \mathbf{B})^{-1} \mathbf{A}\mathbf{X}$.

V. Data, definitions and measurement of variables

The crucial part of the data used in the estimations comes from balance sheets, income statements, and other sources of 19 manufacturing firms that operated continuously in Greece

¹⁷ Lest it may be conjectured that the steps of going from (5) to (14) have no foundations in economic analysis, it is mentioned that (14) could have been formally derived by following Eisner and Strotz (1963) and Lucas (1967), to mention only but a few.

¹⁸ Admittedly, since Nadiri and Rosen (1969,1973), an impressive body of literature has been brought to bear on the specification and estimation of the adjustment process. This is especially true in connection with the development of Vector Autoregressions (VAR) and Vector Error Correction (VEC) models. For example, Holtz-Eakin, Newey and Rosen (1988,1989) apply VAR techniques in conjunction with panels of data to analyze the dynamic relationships between wages and hours worked in the first study, and government revenues and expenditures in the second. However, given that the coefficients in these models are difficult to interpret, I decided to stick with the older approach that offers greater flexibility in obtaining economically meaningful results

¹⁹ Cassing and Kollintzas (1992) derive a system of dynamic interrelated demand functions for factors of production from generalized investment costs and rational expectations much like the one used here. The benefit is that they can distinguish expectations from structural effects in B . This distinction is not possible in the present case.

from 1979 to 1988 under the control of state-owned banks.²⁰ Initially the number of companies and years of observation at my disposal were much larger. But due to various limitations the sample had to be restricted. For example, from 1987 firms were obliged to switch to a new national accounting system. This happened gradually and made it imperative to focus on the period before 1988. As a result, all observations after this year were lost. Moreover, by defining ownership on the basis of who owned at least 50% of the share capital, a large number of firms had to be dropped because the state controlled smaller percentages in their share capital. Some firms were omitted because they did not have continuous records of operations over the sample period. And still some other firms were left out because of data inconsistencies that could not be resolved satisfactorily, or because they did not belong to the manufacturing sector.

In principle the efficiency of state firms ought to be compared to a set of similar manufacturing enterprises whose only difference lied in their ownership structure. But any attempt to select such a control sample would be open to the likelihood of selection bias. For this reason I adopted the following strategy. I grouped the 19 firms into 9 two-digit industries following the Standard Industrial Classification System (SICS). In each of them I divided the aggregated variables by the number of firms.²¹ Hence, in the industries having more than one firm, what is observed is an “average” or “representative” state firm. The left half of Table 1 shows the distribution of the 19 state firms in the 9 two-digit industries and the values per firm of certain key variables in 1982. Next, since the efficiency of these firms would have to be contrasted to similar “average” private firms, I did the same for the corresponding 9 two-digit industries using data from the *Annual Survey of Industry*, of the National Statistical Service of Greece. The distribution of private firms by industry and the values per firm for the same key variables in 1982 are shown in the right half of Table 1. From these we observe that generally the “average” state firms were much larger than the corresponding private firms.

Before proceeding to the specifications of the variables, certain important comments are in order. The first of them has to do with the nature of private-firm data. Since these are reported on an establishment basis,²² the question arose as to whether the control sample of two-digit industries could be construed to consist of “representative” private firms. Fortunately, after pains-taking inquiries with the National Statistical Service of Greece, I was able to establish that during the obser-

²⁰ The list with their names, activities, and present condition is given in Appendix C.

²¹ For the reasons that will be explained later on, at the estimation stage all non-price variables were normalized by output. Therefore, this averaging does not affect the estimates because the number of firms cancels out.

²² Actually, the *Annual Survey of Industry* distinguishes between small- and large-scale manufacturing on the basis of the number of workers employed. Establishments employing less than 19 workers are considered small-scale, whereas those employing over 20 people are considered large-scale. For better comparability with the state-controlled firms, which are relatively large business concerns, I decided to use the data for large-scale manufacturing.

vation period : a) only a few firms operated more than 2 establishments, and b) in those that they did, the activities were very closely related, so they would have been classified in the same two-

Table 1 “Average” firm values for certain key variables in 1982¹

SICS Codes	State firms					Private firms				
	N	O	L	K	D	N ²	O	L	K	D ³
20	3	669	207	552	842	416	368	113	98	258
21	2	1956	451	2123	1491	74	444	146	299	450
23	3	2766	1248	2637	3406	356	305	178	127	303
25	1	928	435	1660	2141	57	254	147	107	209
27	1	10107	2356	11423	10426	40	627	214	234	399
28	1	268	166	365	270	90	104	105	39	64
31	3	4975	926	5340	2161	213	402	104	139	261
33	1	932	531	1892	1047	92	335	129	213	271
35	4	1695	1308	2412	3737	201	252	122	132	257

- Notes: 1. N = Number of firms in the sample, O = Real output in million drachmae, L = Number of workers, K = Real net capital stock in million drachmae, D = Real debt in million drachmae
2. The number of firms reported in this column was calculated by dividing the number of private establishments by the number of establishments per firm in each industry.
3. This variable was computed with the help of data from the *Annual Report* of the Federation of Greek Industries.

digit industry. On the basis of this assurance, I then proceeded to subtract from the totals reported in the *Annual Survey of Industry* the sums of variables corresponding to state firms. Hence, the values of variables used in the estimations are net with respect to ownership.

The second comment concerns the adopted level of aggregation. Fitting relationships to two-digit SICS data implies that the firms grouped in each industry are reasonably homogeneous. In other words, it is presumed that they use the same technology, they employ the same inputs, and they produce the same outputs. So in view of the diversity of products they may actually produce and the variety of technologies and inputs they may actually employ, one might presume that the “average” state and private firms in the sample are not comparable. However, this presumption would be unfounded because, as Klein (1946, 1962) has long established, and many renown researchers have accepted, the adopted aggregation can be well justified from a methodological point of view and, moreover, it is the “average” firm that is usually the most interesting unit of analysis.

The third comment relates to the nature of state companies. Even to a casual observer of industrial policies, it would be obvious that these companies might have been under-performers and that they may have come under state control through some state banks. This would be consistent with the full employment policies that were pursued by the government throughout the post-war period. However, this realization, which in all probability is correct, would not vitiate the validity of the tests. The fundamental reason being that, even if these firms were under-performers, when they

were taken over by state banks, the latter had the time and resources to restructure them before the beginning of the sample period. In particular, since most of these companies operated under their control for many years prior to 1979, if the firms had been laggard, they ought either to have been restructured or gone bankrupt under the pressure of competition. Actually this is exactly what happened to most of these companies after 1988. Some were liquidated after several attempts to privatize them. Some were privatized, survived for several years and then went bankrupt under their new ownership. And a few continue to operate to the present day.

Finally, if one wishes to argue that there was insufficient time for restructuring these companies in the years preceding the observation period, i.e. before 1979, then one must be willing to concede several points. First, that irrespective of competition, these companies were operated during the observation period by state banks using non-economic criteria. Second, that the taxpayer paid a heavy price for their maintenance. Third, that their presence in the markets did serious damage to the advancement of productive efficiency and competition. And fourth, and most important, that any argument to the effect that ownership is invariant to economic efficiency evaporates.

Turning now to the variables, the following list explains how they were defined and measured. The subscripts t and I index respectively the two-digit industry and the year of the observation in the sample.

Y_{it} = real output, defined as: $(S_{it}/p_{it}^Y) + [(IN_{it}/p_{it}^Y) - (IN_{it-1}/p_{it-1}^Y)]$, where S_{it} is net sales, p_{it}^Y is the Wholesale Price Index for manufacturing output and IN_{it} refers to inventories of goods and raw materials.

L_{it} = number of employees.

K_{it} = real stock of net capital generated through the perpetual inventory method. More specifically, the formula $K_{it} = I_{it} + (1 - \delta_{0t})K_{it-1}$ was used. In this, I_{it} denotes gross investment, deflated by the implicit price deflator for fixed investment in manufacturing p_{it}^I , δ_{0t} is the depreciation rate, calculated as the ratio of depreciation charges over the value of net capital in the benchmark year, and K_{it-1} is the real stock of net capital in the previous period. As K_{i0} , the real value of net capital in 1979 was used.

O_i = ownership dummy, taking the value 1 for state and 0 for private.

D_{it} = short-term and long-term obligations deflated by the Wholesale Price Index for manufacturing output.

E_{it} = equity, defined as share capital plus accumulated reserves and retained earnings minus accumulated losses and deflated by the Wholesale Price Index for manufacturing output.

w_{it} = annual employee remuneration, including bonuses, social security contributions and other fringe benefits, deflated by the Consumer Price Index p_{it}^C .

\bar{r}_{it} = real rate of interest. This was calculated as $\bar{r}_{it} = r_{it} - (\dot{p}_{it}^I/p_{it}^I)$, where r_{it} is the nominal interest rate and $(\dot{p}_{it}^I/p_{it}^I)$ is the expected rate of inflation. The former variable was constructed as a weighted average of short- and long-term interest rates using as weights the short-term and long-term loans from banks at the two-digit industry level. The latter variable was approximated by the rate of change in the implicit price deflator of fixed investment in manufacturing.

\bar{c}_{it} = nominal user cost of capital divided by the Wholesale Price Index for manufacturing output p_{it}^Y . The nominal user cost of capital, c_{it} , was generated with the help of the formula:

$$c_{it} = p_{it}^I (\bar{r}_{it} + \delta_{it}),$$

where \bar{r}_{it} is the real interest rate as defined above, and δ_{it} is the ratio of annual depreciation charges over the value of net capital stock at the end of the previous year.

For private firms the data to construct the variables Y_{it} , L_{it} , K_{i0} , I_{it} and w_{it} were extracted from the *Annual Survey of Industry* of the National Statistical Service of Greece, whereas those for the variables D_{it} , E_{it} , and δ_{i0} were obtained from the *Annual Report* of The federation of Greek Industries. Finally, the data for all remaining variables came from the 1989 issue of *Macroeconomic Times Series of the Greek Economy*, which is published intermittently by the Bank of Greece.

Compared to the quality of the data a researcher would like to have in order to carry out the test under consideration, the ones described above leave little to be desired. This is true even with regard to the definition and measurement of such traditionally difficult constructs as the real net capital, K_{it} , and the user cost of capital, c_{it} . Moreover, the design of the test provides some additional safeguards against impurities in the data. With this in mind, certain aspects of the estimation procedure will now be examined.

V. Econometric issues

Several problems faced in the estimation stage of the research had to be confronted. The first problem grew out of the concern that, in the presence of scale economies, the estimates would be biased toward showing greater efficiency for state firms due to their being much larger than the private firms in the sample. To deal with this possibility, one ought to be able to distinguish between scale and ownership effects. But this was not technically feasible in the present model. Hence, in order to prevent the results from being unduly influenced by large firms simply because of their size, (10) was transformed to:

$$\begin{aligned}
l_{it} &= \alpha_0 + \alpha_1 e_{it} + \alpha_2 O_i + \alpha_3 w_{it} + \alpha_4 \bar{c}_{it} + \alpha_5 \bar{r}_{it} + \alpha_6 l_{it-1} + \alpha_7 k_{it-1} + \alpha_8 d_{it-1} \\
k_{it} &= \beta_0 + \beta_1 e_{it} + \beta_2 O_i + \beta_3 w_{it} + \beta_4 \bar{c}_{it} + \beta_5 \bar{r}_{it} + \beta_6 l_{it-1} + \beta_7 k_{it-1} + \beta_8 d_{it-1} \\
d_{it} &= \gamma_0 + \gamma_1 e_{it} + \gamma_2 O_i + \gamma_3 w_{it} + \gamma_4 \bar{c}_{it} + \gamma_5 \bar{r}_{it} + \gamma_6 l_{it-1} + \gamma_7 k_{it-1} + \gamma_8 d_{it-1},
\end{aligned} \tag{11}$$

where $l_{it} = L_{it} / Y_{it}$, $k_{it} = K_{it} / Y_{it}$, $d_{it} = D_{it} / Y_{it}$, and $e_{it} = E_{it} / Y_{it}$. Aside from the aforementioned rationale, this normalization was also recommended by two subsidiary considerations. The first was that it tends to reduce the heteroscedasticity that is usually associated with large- and small-scale units of observation, and thus make the stochastic characteristics of the sample correspond more closely to the standard specification of simultaneous-equation models. The second consideration stemmed from the expectation that this normalization would allow much better for the differences in the speeds of adjustment to the preferred levels of input employment that may characterize the operations of large- and medium-size firms.

The second problem had to do with the equity variable. Corporations determine it through two decisions: 1) by issuing new, or buying back outstanding, shares (share capital policy), and 2) by retaining some percentage of profits (dividend policy). So, e_{it} ought to be treated as endogenous. However, in view of the circumstances that prevailed in Greek manufacturing during the sample period, adopting this approach would have entailed considerable risks of misspecification for two reasons. First, because in the case of state firms, the aforementioned decisions were controlled by their parent banks, and, second, because at the time private firms had not discovered the route for raising capital via the Athens Stock Exchange. Hence, to resolve this issue Granger causality tests were run for each equation by regressing e_{it} on several lagged terms of itself and the corresponding dependent variable. These tests showed that e_{it} was Granger-caused, albeit marginally, only in the equation for capital. In this it was treated as endogenous.

Next, the serious problem posed by the autoregressive nature of (11) was addressed. Due to the presence of lagged dependent variables on the right hand side of the equations, obtaining unbiased and consistent estimates required the application of an instrumental variable estimator. But as Baltagi (1995) has shown, the answer is quite uncertain as to which of the estimators proposed by Anderson and Hsiao (1981), Arellano (1988), Arellano and Bond (1991), et al., provides the best results. Therefore, for the purposes of this study, the estimator suggested by Balestra and Nerlove (1966) was adopted. In essence, this necessitated that each equation in (11) be estimated by Ordinary-Least-Squares (OLS) after the lagged dependent variables had been purged from their correlation with the error terms using suitable instruments.

Then, the specification of ownership was considered. Since this takes the form of a dummy variable, if the model were to be estimated as it stands, the interpretation of the coefficient for O_i would not be clear for two reasons. First, because it would be difficult to explain,

why state ownership affects only the intercepts of the three equations, and second, because, although operating in the same competitive industries, state-owned firms could very well produce different goods than those produced by their private counterparts. To allow for these two possibilities, in the estimations all the cross products of variable O_i with the other variables in the model were introduced into (11).

Finally, the question of whether or not to impose the restrictions that are implied by the constraints was confronted. As elsewhere (see Nadiri and Bitros (1980)), I decided not to for three reasons. First, because if the model is “correct”, the unrestricted estimates should satisfy the *a priori* restrictions, and, second, because the exercise of imposing the restrictions might turn out to be too demanding of the data. Instead each equation was estimated using the Instrumental Variables (IV) estimator suggested above, and then the characteristic roots of matrix \mathbf{B} were calculated to see whether the restrictions implied by the constraint were reasonably met.

VI. Results and interpretations

The results reported in Table 2 below were obtained in the following way. First, Ordinary-Least-Squares (OLS) were run on the lagged dependent variables using as instruments the current and lagged values of the exogenous variables plus their cross products with the dummy variable for state ownership.²³ Then, the fitted values for the lagged dependent variables were substituted, and, finally, the three equations were estimated by means of RATS (Regression Analysis for Time Series). Applying its PANEL procedure with unitary weights for the individual and time components gave the estimates of the model with fixed effects, whereas using it with weights derived from analysis of variance produced the estimates of the model with random effects.

In deriving (11) from (5) certain approximations were adopted. Since it was not clear how they might affect the specification of the estimating equations, they were viewed with reservation. Therefore, to check if they introduced misspecification errors, a RESET test was performed and its values are given in the corresponding row of Table 2. The results show that only the equation for capital in the fixed effects model may be misspecified.

With this finding in hand, the estimates were tested for lack of efficiency and asymptotic consistency due to heteroscedasticity in the residuals. To do so, a Breusch-Pagan test was run and the values displayed in the B-P row of the table were obtained. Again, what these values indicate with ample degree of confidence is that the residuals in all equations are free from heteroscedasticity. Thus, on the basis of these two tests, and the understanding that whenever it was necessary the estimates were corrected for serial correlation, I was encouraged to conclude that

²³ With respect to the specification of the instrumental variables in the fixed and random effect estimations of the model see Note 2 at the bottom of Table 2.

the results in Table 2 are as robust as one could have expected.

Turning next to the more conventional statistical features of the results, it can be seen that they are quite satisfactory. The equations explain a large percentage of the variance in the dependent variables. With only a few exceptions, the coefficients are statistically significant at the 5% two-tailed test. Their signs are predominantly in accord with those anticipated from economic theory.

Table 2: Two-Stage-Least-Squares estimates of model (11)

Independent Variables ³	2nd stage estimation using fixed effects ^{1,2}			2nd stage estimation using random effects		
	l_{it}	k_{it}	d_{it}	l_{it}	k_{it}	d_{it}
e_{it}	...	...	-0.190 (-4.75)	...	...	-0.152 (-3.67)
$O * e_{it}$	-0.044 (-2.79)	...	...	-0.076 (-5.00)	...	...
$O * e_{it-1}$	...	0.224 (3.21)	0.509 (5.59)	...	0.261 (4.31)	0.150 (2.01)
$O * e_{it-2}$	0.102 (4.30)	0.119 (1.20)	...	0.097 (3.47)	0.203 (2.29)	...
w_{it-1}	0.213 (2.46)	...	...	0.383 (4.88)	...	...
$O * w_{it-1}$	...	-1.458 (-3.46)	...	...	0.701 (2.59)	...
\bar{r}_{it-1}	5.599 (1.73)	...	-13.92 (-1.13)	0.210 (2.42)	...	1.272 (1.83)
$O * \bar{r}_{it-2}$	...	...	3.243 (2.77)	...	...	2.217 (1.96)
\bar{c}_{it}	0.848 (2.33)	...	...	0.245 (2.96)	...	...
l_{it-1}	0.477 (3.26)	2.452 (4.95)	1.232 (2.37)	0.195 (1.95)	0.790 (2.59)	1.148 (4.64)
k_{it-1}	...	0.354 (1.52)	...	...	0.408 (2.12)	...
d_{it-1}	-0.104 (-3.79)	...	0.704 (5.51)	-0.090 (-3.06)	...	0.357 (2.42)
\bar{R}^2	0.310	0.335	0.539	0.937	0.871	0.747
B-P ⁴	1.022	1.285	1.267	1.188	1.216	1.763
RESET ⁵	0.728	4.923	2.021	1.552	1.242	2.008
H				57.5	157.5	159.4
D.F.	118	120	119	118	120	119

Notes:

- Whenever it was necessary the estimates were corrected for serial correlation using the AR1 method with the coefficient of autocorrelation fixed for all cross-sections and all time periods.
- Following Sevestre and Trognon (1992 p. 101) in the fixed effects model the instruments were computed as differences of the exogenous variables from their means, whereas in the random effects model, the instruments were derived by subtracting from the exogenous variables their error component weighted means.
- The figures underneath the coefficient estimates give the values of the t-statistic. \bar{R}^2 is the adjusted R^2 . The notation B-P denotes the Breusch-Pagan test for heteroscedasticity and was computed by regressing the squared residuals on the logarithm of the number of employees per firm. RESET(4) is the fourth order statistic of Ramsey for testing the functional and other misspecification aspects of the equations. H gives the results of the Hausman (1978) test for equality of the coefficient vectors from the two models. Its critical value for $X^2(0,05,3)$ is 0.997. D.F. stands for the Degrees of Freedom.
- Since the B-P statistic is distributed like a X^2 with 1 Degree of Freedom, the critical value for rejecting the null hypothesis regarding the existence of heteroscedasticity at the 5% confidence level is 3.841. Consequently, all estimates pass this test comfortably.
- This test was computed by regressing the residuals on the independent variables and the second, third and fourth powers of the fitted values of the dependent variables. RESET in this form follows the F distribution and its critical value for $F_{(0,05, 3, 118)}$ is 2.7. Hence, all equations pass the test for good functional specification at the 5% level with the exception of the one for capital in the fixed effects model.

And, perhaps more importantly, the ownership dummy enters in both models in conjunction with several independent variables, thus allowing the possibility for sharp predictions regarding the issue under investigation. So the question that arises is which of the two models should be adopted as the better representation of the relationships sought.

As Balestra (1992, p. 27) succinctly states, each model has its own merits. For example, if we believe that the individual effects are related to a large number of non-observable random causes, then the random specification is more appealing. Otherwise, the investigator would be advised to opt for the fixed effects model. For this study, the random effects model appeared to be the better choice for three reasons. First, because the individual characteristics of the industries in the sample are indeed related to a multitude of non-observable random influences. Second, because this model explains a larger percentage of the variance in the dependent variables. And third, because all three equations pass the RESET test. However, as these reasons could be considered relatively weak for choosing the random-effects over the fixed-effects estimates, I ran also a Hausman specification test on the presumption that the fixed-effects model represented the less efficient estimator. The values for this test are shown in the H row of Table 2. Clearly, they ascertain that in all three equations the proper model is the one with random effects.

Having made this choice, the following questions were addressed. If the retained model represented a good description of the mechanisms governing the employment of inputs, did state ownership make a difference in economic efficiency during the period of the sample, and if so, in what direction and by how much? The long-term effects are relevant to answering these questions. Therefore, in order to obtain the stationary state of the model, I set $l_{it} = l_{it-1}$, $k_{it} = k_{it-1}$, and $d_{it} = d_{it-1}$, and solved for the equilibrium values of the inputs at the sample means of the exogenous variables.

Table 3 below presents two sets of results from this experiment. As can be seen on the right-hand side, per unit of output, the amount of labor, capital and credits employed by state firms were 15.7, 12.2, and 49.1 percent larger than the respective amounts employed by private firms in the same industries. To see what might have happened had their owners cared to restructure them, the same calculations were performed at the overall sample means. As the results on the left-hand side of the table indicate, labor and credit inefficiencies would have disappeared, whereas those relating to capital would have remained unaffected.

Drawing on this evidence one could conclude justifiably that state firms operated inefficiently relative to private firms. However, one could not say to what extent, if at all, their inefficiency was due *per se* to their ownership. For this reason, I used the vector of input prices in conjunction with the ratio of inputs employed from Table 3 to calculate three efficiency indices:

Table 3: Input effects of state ownership

Firm ownership	Means employed in the calculations:					
	Overall sample			State and private firm sub-samples		
	l_{it}	k_{it}	d_{it}	l_{it}	k_{it}	d_{it}
State (1)	0.421	0.905	0.705	0.452	0.905	0.848
Private (2)	0.421	0.806	0.712	0.391	0.806	0.569
Ratio (1):(2)	1.000	1.122	0.990	1.157	1.122	1.491

one for *technical efficiency*, one for *allocative efficiency*, and one for *ownership efficiency*.²⁴ Assuming that state and private firms paid the same input prices, but used them in different combinations, the index for technical efficiency took the form:

$$\frac{1.157\bar{w}_p + 1.122\bar{c}_p + 1.491\bar{r}_p}{\bar{w}_p + \bar{c}_p + \bar{r}_p} - 1,$$

where a bar over a variable stands for its mean and the subscript indicates the sub-sample from where the mean originates. The index for allocative efficiency was computed from

$$\frac{\bar{w}_s + \bar{c}_s + \bar{r}_s}{\bar{w}_p + \bar{c}_p + \bar{r}_p} - 1,$$

on the presumption that state and private firms employed the same combinations of inputs but paid them different prices.²⁵ And, finally, the index for ownership efficiency was obtained by subtracting from

$$\frac{1.157\bar{w}_s + 1.122\bar{c}_s + 1.491\bar{r}_s}{\bar{w}_p + \bar{c}_p + \bar{r}_p} - 1,$$

the values of the two previous indices. The calculations showed that per unit of output the cost of inputs employed by state firms was 46.2% larger than that by private firms. In addition, from the allocation of this inefficiency to its sources, it turned out that 16.3 percentage points emanated from

²⁴ For two more sophisticated approaches to allocating relative inefficiency to its sources see Lau and Yotopoulos (1971) and Atkinson and Halvorsen (1986).

²⁵ Ohlsson (1996) recently suggested that further insights as to the effects of ownership could be gained from studying the differences in prices that firms pay for their inputs. Applying this idea to the prices that refuse collection enterprises in Sweden paid for garbage trucks in 1989, he finds that private firms pay 10-15% less than state firms. Similar tests focusing on the input prices paid by the firms in my sample showed that, relative to private firms, state firms paid higher wages and incurred considerably smaller costs for the capital services they used.

technical reasons, 25.5 percentage points came from input prices, and the remaining 4.4 percentage points were due to ownership. Hence, the evidence suggested that state ownership reduces significantly the efficiency of state firms relative to that of private firms, thus contradicting claims made by such researchers as Bardan and Roemer (1992) that ownership does not matter.

Aside from the above main findings, the estimates in Table 2 shed light on several additional issues. One of them concerns the speed with which the three inputs adjust to their equilibrium values. Relevant in this regard are the coefficients of the own-lag terms. From the estimates, it is observed that none of the lagged dependent variables entered into the model jointly with the ownership dummy. Hence, ownership did not appear to affect the speed of adjustment of inputs.

Another issue has to do with the cross-adjustment effects. These are calculated as $-\beta_{ij}$, $i \neq j$, and measure the effect of excess demand of one input on the demand for the others. For example, $-\beta_{12}$, which measures the effect of excess demand for labour on the demand for capital, is depicted by the coefficient 0.709 in row l_{it-1} . By implication, the estimates reveal that in addition to the traditional and well-documented asymmetrical disequilibrium effects, the demand for the three inputs may be subject to strong cross-effects, but not from ownership.

Still another issue concerns the responses of inputs to a once-and-for-all change in the exogenous variables. Table 4 gives the short- and long-term elasticities that were computed at the

Table 4: Short-run and long-run elasticities implied by the random effects model in Table 1.

Ownership	Responses ¹		e_{it}	w_{it-1}	\bar{c}_{it}	\bar{x}_{it}
State	Immediate	l_{it}	0.007	0.635	0.052	0.009
		k_{it}	0	0	0	0
		d_{it}	0.006	0	0	0.022
	Long-run	l_{it}	0.005	0.659	0.053	0.001
		k_{it}	0.003	0.308	0.025	0.001
		d_{it}	0.013	0.469	0.038	0.036
Private	Immediate	l_{it}	0	0.421	0.091	0.009
		k_{it}	0	0	0	0
		d_{it}	-0.121	0	0	0.270
	Long-run	l_{it}	0.036	0.436	0.094	0.001
		k_{it}	0.048	0.578	0.124	0.002
		d_{it}	-0.157	0.381	0.082	0.043

Notes: 1. All calculations have been performed at the sub-sample means of the variables.

mean values of the variables for state and private firms. From these, it can be ascertained that state and private firms react differently. For example, over the long run, a 10% increase in the

wage rate to private firms, *ceteris paribus*, would increase their demand for capital and credits by 5.8% and 3.8%, respectively. But with the same increase, state firms would increase their demand for capital by 3.1% and for credits by 4.9%.

Also of considerable interest are the long-run elasticities of input demands with respect to equity. In this regard, an increase in the e_t variable would have induced private firms to increase their demand for labor and capital and reduce their demand for credits, but would have left the demand by state firms relatively unaffected. More specifically, given a 10% increase in equity, *ceteris paribus*, private firms would have increased their demand for labour and capital by about 0.4% and reduced their demand for credits by 1.6%. In contrast, the same change would have led state firms to increase their demand for capital and labor by about 0.04% and their demand for credits by 0.13%. These findings suggest a fundamental difference in the role that equity played in state and private firms during the sample period. In state firms, equity appeared to be largely ignored as a policy variable, whereas in the private firms it was used as an instrument of adjustment to the changing conditions in the financial and input markets.

The results in Table 5 are relevant for gauging the magnitudes and statistical significance of the unaccounted cross-industry and time-series differences. These derive from a two-way analysis of variance on the residuals from the random effect estimates, and trace the impact of

Table 5: Values of F-statistic from a two-way analysis of variance on the residuals from the random effects model in Table 1.

Dependent Variables	Effects	Sum of Squared Residuals	Estimated Value of F-statistic	Marginal Significance Level
l_{it}	Cross-section	0.119	1.151	0.315
	Time-series	0.052	1.231	0.291
	Joint	0.172	1.175	0.279
	Total	0.896		
k_{it}	Cross-section	2.267	1.409	0.144
	Time-series	0.378	0.480	0.847
	Joint	2.585	1.138	0.315
	Total	11.263		
d_{it}	Cross-section	2.416	1.242	0.243
	Time-series	2.228	2.782	0.010
	Joint	4.644	1.691	0.034
	Total	13.615		

changes in such factors as competition, technological progress, tastes, and institutions. On reflection, it transpires that the effects of these factors in all equations are relatively small consid-

ering the total error and mostly insignificant at the conventional levels of confidence. Hence, even if one attempted to account for them explicitly, they would not explain much of the remaining residual variance in the dependent variables. However, should the case prove to be different in similar research endeavors in the future, such evidence would go a long way towards settling the controversy that surrounds the role of competition in economic efficiency.

Finally, there remains the issue of whether or not the estimates meet the restrictions that are implied for the adjustment coefficients by the constraint. Following Nadiri and Rosen (1973), the restriction sought is for

$$\alpha(\mathbf{I} - \mathbf{B}) = 0$$

where α is the matrix of the parameters involved in the constraint, \mathbf{I} is the identity matrix, and \mathbf{B} denotes the matrix of adjustment coefficients. Since each α_{ij} is nonzero, it follows that $|\mathbf{I} - \mathbf{B}| = 0$. In principle, this provides the restriction test since the constraint would be overidentified otherwise. One way to carry out this test is to look into the characteristic roots of $|\mathbf{I} - \mathbf{B}|$. If the roots have modules no greater than unity, this would insure that $|\mathbf{I} - \mathbf{B}|$ approaches zero, no matter how fast or slow.

The three characteristic roots of $|\mathbf{I} - \mathbf{B}|$ are 0.7232, 0.7232, and 0.5918. They suggest that the response patterns of inputs to changes in the exogenous variables display damped oscillations. In turn, this finding implies that the restriction $|\mathbf{I} - \mathbf{B}|$ is approximately met.

VII. Summary and conclusions

The research reported in this paper aimed at improving the existing evidence on the effects of ownership on economic efficiency. The improvement sought was expected to result from enhancements in modeling, estimation techniques, and experimental design. With regard to modeling, I introduced state ownership into the simple model of the financially constrained firm and traced its effects on the quantity of output produced and the inputs employed by state and private firms. From the analytical results it turned out that, for state ownership to be invariant with respect to economic efficiency, its adverse effect on the firm's production must be insignificant and markedly dominated by its beneficial financial effect.

In order to investigate this condition empirically, I extracted a three-equation interrelated input demand system from the model and estimated it for the 1979-1988 period. The data came from 19 state-controlled companies, grouped into 9 two-digit Standard Industrial Classification (SICS) industries, as well as from comparable information originating in the corresponding industries of large-scale Greek manufacturing. The equations were estimated by consistent panel data

techniques. Considerably more attention was paid to the adjustment dynamics than in previous research, and the estimates passed a barrage of tests with adequate degrees of confidence.

State firms in competitive industries were found to distort the utilization of resources in several ways. First, relative to private firms, they were found to employ per unit of output more quantities from all inputs. In particular, the amounts of labour, capital and credits they use were 15.7, 12.2, and 49.1 percent larger than those employed by private firms in the same industries. These figures indicated that state firms operated relatively inefficiently, but did not reveal the underlying causes. For this reason, with the help of the model the analysis went on to calculate the cost of inputs per unit of output by state and private firms and to allocate the difference between them to its sources. From these calculations it emerged that: a) the cost of inputs per unit of output by state firms was 46.2% larger than that by private firms, and b) that technical, allocative and purely ownership reasons contributed to this inefficiency 16.3, 25.5 and 4.4 percentage points, respectively. So, secondly, state ownership was found to contribute significantly to the relative inefficiency of state firms. And, thirdly, state ownership modified the patterns in which the employment of the three inputs responded to equity and input price changes. Hence, in contrast to the claims made by previous researchers, state ownership has been found to matter, and indeed not solely in terms of economic efficiency.

Finally, the aforementioned effects of state ownership are net in the sense that the impact on input employment of changes in such factors as competition, technological progress, and institutions were accounted for through separate cross-section and time-series dummy variables. The importance of this finding being that it indirectly sheds some light on the controversy surrounding the role of competition in economic efficiency.

Appendix A

Second-order conditions

To simplify the analysis, assume that the production function of the firm is given by

$$Y = AL^{\alpha_1} K^{\alpha_2}, \quad (\text{A.1})$$

where $A > 0$, $0 < \alpha_1 < 1$, $0 < \alpha_2 < 1$. Since the sum of the elasticities is not constrained to be less than 1, constant, decreasing, and increasing returns to scale are allowed for the moment.

Also, in view of the remark in footnote 12 that the analytical results go through irrespective of the nature of competition in product and input markets, let

$$\begin{aligned} P(Y) &= p \\ r(D) &= \bar{r} \\ c[r(D)] &= q(\bar{r} + \delta) \end{aligned} \quad (\text{A.2})$$

where p is the price of output, q is the purchase price of capital goods, \bar{r} is the interest rate paid by the best customers, and δ is the rate of depreciation.

Given (A.1) and (A.2), the second-order conditions for the existence of an interior maximum in problem (3) will be satisfied if the principal minors of the following matrix

$$H = \begin{bmatrix} \alpha_1(\alpha_1 - 1)AL^{\alpha_1 - 2}K^{\alpha_2}(p - \lambda\alpha g_2) & \alpha_2\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2 - 1}(p - \lambda\alpha g_2) & 0 & -(\alpha\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2}g_1 + \beta_1) \\ \alpha_2\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2 - 1}(p - \lambda\alpha g_2) & \alpha_2(\alpha_2 - 1)AL^{\alpha_1}K^{\alpha_2 - 2}(p - \lambda\alpha g_2) & 0 & -(\alpha\alpha_2AL^{\alpha_1}K^{\alpha_2 - 1}g_1 + \beta_2) \\ 0 & 0 & 0 & 1 \\ -(\alpha\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2}g_1 + \beta_1) & -(\alpha\alpha_2AL^{\alpha_1}K^{\alpha_2 - 1}g_1 + \beta_2) & 1 & 0 \end{bmatrix}$$

alternate in sign starting with plus.

The first principal minor of this matrix is

$$H_2 = \begin{bmatrix} \alpha_1(\alpha_1 - 1)AL^{\alpha_1 - 2}K^{\alpha_2}(p - \lambda\alpha g_2) & \alpha_2\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2 - 1}(p - \lambda\alpha g_2) & -(\alpha\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2}g_1 + \beta_1) \\ \alpha_2\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2 - 1}(p - \lambda\alpha g_2) & \alpha_2(\alpha_2 - 1)AL^{\alpha_1}K^{\alpha_2 - 2}(p - \lambda\alpha g_2) & -(\alpha\alpha_2AL^{\alpha_1}K^{\alpha_2 - 1}g_1 + \beta_2) \\ -(\alpha\alpha_1AL^{\alpha_1 - 1}K^{\alpha_2}g_1 + \beta_1) & -(\alpha\alpha_2AL^{\alpha_1}K^{\alpha_2 - 1}g_1 + \beta_2) & 0 \end{bmatrix}$$

The value of the determinant of this matrix depends on the value of the expression $p - \lambda\alpha g_2$. More specifically, in order for the determinant to be positive as required, it must hold that $p > \lambda\alpha g_2$. This implies that for an interior maximum in (3) the cost of money capital for financing the material costs of producing the last unit of output must exceed the market price of output. But under rational entrepreneurial behavior the revenue from selling the last unit of out-

put must cover at least the variable costs of production including wages. Hence, for a firm in operation this condition can be assumed to apply naturally.

Next, the value of the determinant of H must be negative. For this to be the case it must hold that $\alpha_1 + \alpha_2 < 1$, or, that the returns to scale are diminishing. This is as could be expected because, if the returns to scale were constant or increasing, the assumption embedded in the simplified model that competition is perfect in all markets would be contradicted. Moreover, since under (A.1)-(A.2) and diminishing returns to scale the objective function in (3) could be shown to be everywhere strictly concave, the interior maximum is globally unique.

By way of summary then it can be stated that if the production function is neo-classical with decreasing returns to scale and competition is perfect in all markets, the solution of the first order conditions yields a unique global maximum. Assuming that these conditions do apply, this is all that is required for the econometrics in the empirical part of the paper to be legitimate from a methodological point of view.

Appendix B

Output (Figure 1), Labor (Figure 2), and Capital-Labor combinations (Figure 3), of financially constrained (C) and unconstrained (U) firms

Figure 1

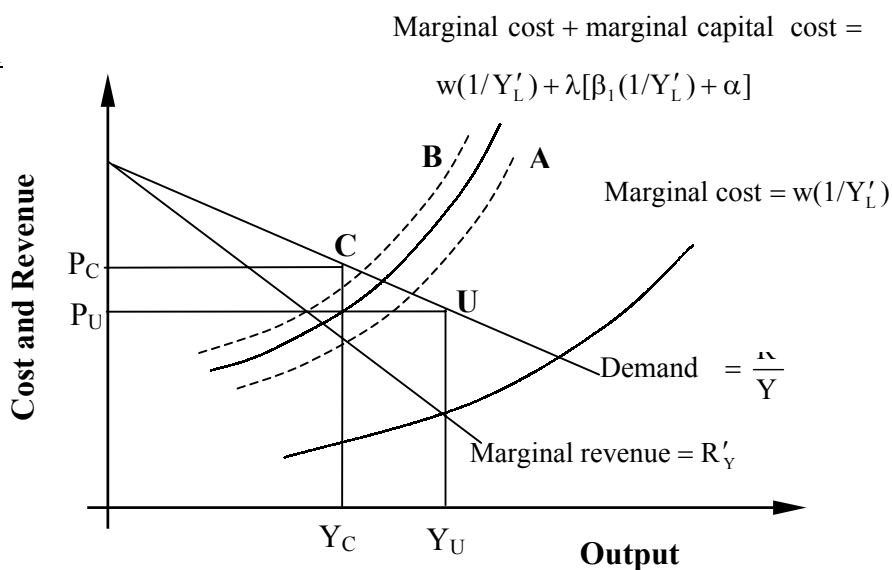


Figure 2

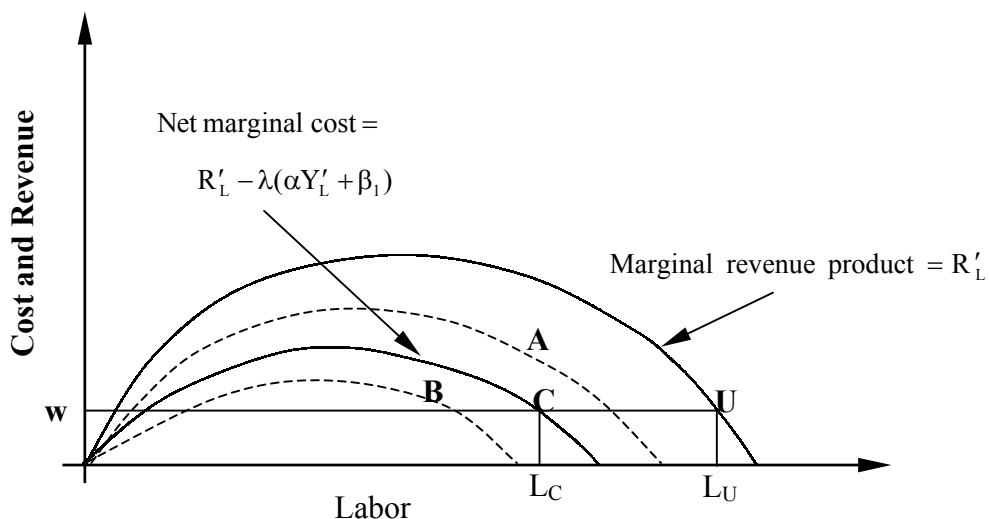
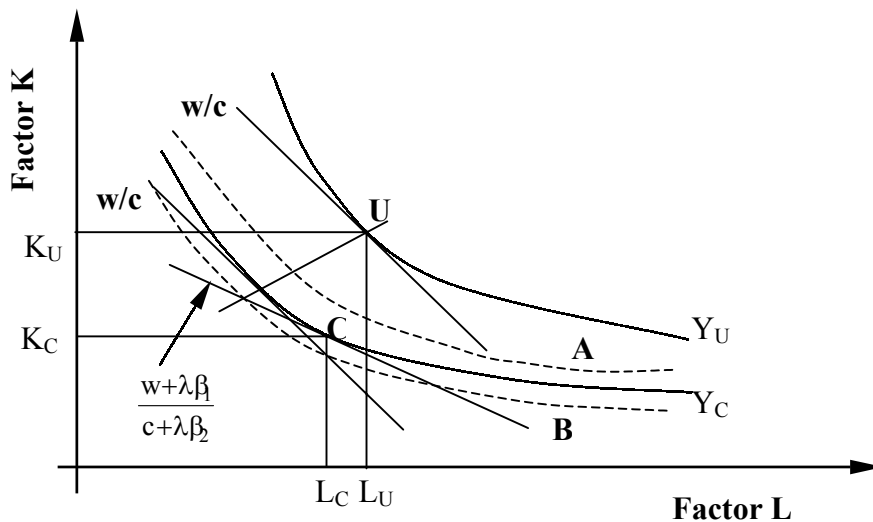


Figure 3



Appendix C
State-bank controlled companies included in the sample

SICS Codes	Names of companies	Main activity	Present condition
20	THRAKI	Meat processing	Privatized and thriving
	DODONI	Diary and cheese farming	Under state control and thriving
	ELEOURGIA ELLADOS	Olive oil	Liquidated
21	HENNIGER	Brewery	Privatized and merged into the Breweries of Northern Greece
	CAMPAS	Wines and spirits	Privatized and later on split up and resold.
23	AIGEAN	Textile products	Liquidated
	MICHAILIDIS	Knitting	Liquidated
	ILIOS-TEN CATE	Cotton spinning mills	Liquidated
25	EPAS-SOTIROPOULOI	Wood products	Liquidated
27	ATHENIAN PAPER MILLS (SOFTEX)	Paper and paper products	Privatized and struggling
28	ASPIOTI-ELKA	Printing and publishing	Under state control
31	EKO CHEMICALS	Chemicals	Under state control
	AEVAL (NITRATE FERTILIZERS)	Chemicals	Liquidated
	INDUSTRY OF PHOSPHATE FERTILIZERS	Chemicals	Under state control
33	BAUXITE METALS OF ELEFSIS	Non-ferrous metals	Liquidated
35	ATHENIAN MANUFACTURING OF PIPES	Steel pipes	Liquidated
	PYRKAL.	Ordinances and munitions	Under state control
	DEXION	Metal shelves	Liquidated
	VIEX	Metal constructions	Liquidated

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