Determinants of Firm-level Technical Efficiency: Evidence Using Stochastic Frontier Approach

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Abstract

By estimating stochastic frontiers we investigate the determinants and dynamics of firm efficiency. We use a representative sample of Estonian firms for the period 1993-1999 – and are able to address problems that plague much previous work, such as the endogeneity of ownership. Our main findings are that: (i) foreign ownership increases technical efficiency; (ii) firm size and higher labor quality enhance efficiency, while soft budget constraints adversely affect efficiency; (iv) Estonian firms operate under constants returns to scale; (v) the percentage of firms operating at high levels of efficiency increases over time. As such our findings provide support for hypotheses that a firm's ownership structure and its characteristics such as firm size, labor quality, soft budget constraints and time of privatization are important for its technical efficiency.

Keywords: Stochastic Frontier, Technical Efficiency, Soft Budget Constraints, Ownership Structure and Competition.

JEL Classification: C33, D21, D24, G32, J54, L25.

1. Introduction

The privatization process in transition economies has resulted in the emergence of a variety of ownership structures and has also generated an extensive theoretical debate over which form of private ownership would lead to better restructuring outcomes and higher efficiency levels. This theoretical literature concludes that certain ownership forms are preferred, in particular that outsider ownership is expected to be more efficient than insider ownership (Aghion and Blanchard, 1998). There is also an extensive empirical literature, which assesses the effects of different ownership structures on enterprise performance and efficiency. In a comprehensive literature review of that literature, Djankov and Murrell (2002) conclude that, in general, privatization improves firm performance and that concentrated ownership is beneficial for firm performance. They also find that Central and Eastern European countries experienced a larger positive impact of privatization than did CIS countries. Similarly, Brown et al. (2006) find that both privatization and the method of privatization matter. Further, their results also display significant differences in pre and post privatization performance between Hungary and Rumania, and Russia and Ukraine.

However, as Djankov and Murrell (2002) note, the empirical literature on firm performance and privatization has faced formidable estimation challenges and thus most conclusions are necessarily tentative. Of central importance are issues related to the endogeneity of ownership structures, for example the view that often insiders selected the best performing firms. Furthermore, problems related to differences in accounting standards often undermine the credibility of performance variables. Another problem is that many studies may not have used the most reliable empirical strategies and that much empirical work may have neglected key issues such as the dynamics of efficiency. Finally, confidence in the reliability of general findings in this field is undermined by the fact that often data samples have been small and not representative.

The purpose of this paper is to investigate the impact that ownership structure and other firm characteristics, such as, firm size, labor quality, investment in new equipment, trade orientation, soft budget constraints and competition, have on firm level technical efficiency. Accordingly, this paper builds upon several advantages. First, our data are a long and rich panel for a sample of firms that is representative of the Estonian economy and including firms with diverse ownership structures. Second, these data and the technical approach we employ enables us to estimate the impact on the level of firm technical efficiency of several crucial variables, including ownership structures, soft budget constraints and competition. Third, the panel nature of the data enables us to account for the issue of endogeneity. Fourth, our modeling strategy permits us to distinguish between shifts in the production function, namely, technological changes as well as changes in technical inefficiency over time.

The structure of the paper is as follows. In section 2, we discuss the determinants of firm efficiency. In the following two sections the privatization process in Estonia is first outlined and then we discuss our data. This is followed in section 5 by a discussion of the estimation strategy. In the following two sections we present our findings with returns to scale. Finally, in section 8, we conclude.

2. The determinants of firm efficiency

The growing body of theoretical and empirical literature on firm performance and privatization has identified a host of variables, namely, ownership structure, investment in fixed capital, soft budget constraints (SBC), firm trade orientation, the quality of labor, and competition as determinants of firm performance and consequently firm efficiency (Djankov and Murrell, 2002; Aw et al., 2000; Brown and Earle, 2001; Frydman et al., 1999). The aim of this section is to briefly discuss how each of these factors affects firm efficiency and establish the direction of the relationship.

As noted already the bulk of the theoretical literature concludes that certain ownership forms are to be preferred, in particular that outsider ownership is expected to be more efficient than insider ownership. Accordingly, Aghion and Blanchard (1998), stress that privatization to insiders would lead to less restructuring as insiders suffer from lack of capital and expertise. As a result, privatization to outsiders would be desirable for restructuring outcomes. To test these hypotheses, however, has not always been an easy proposition. For one thing, diverse insider and outsider ownership structures have seldom co-existed within one country. In addition, often ownership has been dispersed within firms so that it has not always been able to clearly identify the main owner. In turn this has led to classifications based on dominant as opposed to majority owners[i].

One common feature of firms in emerging economies is that they started the development process with old technology, which could not be used to produce goods of sufficient quality to compete in both domestic and world markets. As such, a common challenge for these firms is to carry out high investment rates to substitute the new advanced technology for the old obsolete capital in order to be able to survive and compete in the market-oriented economy. In return, this will contribute to increases in productivity and thereby efficiency. Under the conditions of under-developed capital markets with a weak banking and non-banking sector there would be fierce competition for funds and not all firms would be able to raise all the much needed capital. Consequently, it is expected that firms with better access to finance and higher investment rates will display higher levels of efficiency. However, state-owned firms were characterized by lack of financing, possible bankruptcy and soft budget constraints. The existence of soft budget constraints is detrimental for firm efficiency, because it distorts managerial incentives and erodes the effect of competitive pressure. The notion of soft budget constraints include not only cheap credit provided in the form of direct government subsidies, but also tax arrears, trade credits and cheap loans from the financial sector (Schaffer, 1998)[ii]. Ascertaining its effect, however, is a difficult task because of the lack of appropriate data. However, in view of its importance, in this paper we follow the literature and attempt to ascertain the effect of soft budget constraints by constructing a measure as in Schaffer (1998).

With respect to trade orientation, it is expected that those firms that produce mainly for export are under the pressure of international competition and, consequently, will utilize resources more efficiently. Indeed, Hossain and Karunaratne (2004) find that export orientation has a significant impact on the reduction of technical inefficiency. Export market participation leads to exporters acquiring knowledge and expertise about new production methods, product design, etc., from international contacts. In turn, learning-by exporting results in higher productivity for exporters compared with non-exporters (Roberts and Tybout, 1997; Bernard and Jensen, 1999). However, the positive correlation between productivity and exporting, could simply suggest that only the most productive firms can survive in a highly competitive international environment.

It is expected that the higher the level of labor quality, the more efficient will be both the use of existing technology and the absorption of new technology, which will consequently result in higher efficiency levels. To proxy labor quality we use average labor cost (and assume that a more qualified labor force commands higher wages and salaries.) However, we recognize that the use of average labor cost is potentially problematical since it can also capture the rent extraction effect, i.e., labor cost is high because workers are able to extract rents through higher salaries.

The existence of competitive markets is considered a prerequisite for productive efficiency and a fundamental requirement for efficient allocation of resources in an economy. Competitive product and factor markets induce firms to use their inputs more efficiently or to push inefficient firms out of the market. Accordingly, firms facing domestic competition may restructure since they do not lag far behind other domestic firms, except for local firms with foreign direct investment. For instance, Brown and Earle (2001) find that domestic competition has a significant disciplinary effect on Russian enterprises. Likewise, Carlin et al. (2001) find a strong significant impact of the perceived intensity of local competition on firm performance. Furthermore, the combined effect of competition and ownership on enterprise performance and efficiency may be mutually reinforcing. Thus early writings on the subject, including Lipton and Sachs (1990), Blanchard and Layard (1992) and Boycko et al. (1996) viewed both rapid privatization and competition as complements in their effect on enterprise efficiency. That is, it is expected that more competitive markets will enhance the impact of privatization on enterprise efficiency.

Finally, we also consider the effect of other firm characteristics such as firm size and industrial sector. It is expected that firm size is positively correlated with firm efficiency. If firm size reflects economies of scale, larger firms are able to spread the fixed costs of production over more production units. In other words, size may be associated with lower average costs of production. Also, to account for differences in efficiency levels in different industries and over time, industry and time dummies were included.

3. The Privatization Process in Estonia

Privatization was one of the policies that successive Estonian governments committed themselves to after the beginning of transition. Economic considerations and the power of different groups in policy formulation and implementation led to the emergence of a wide range of post-privatization ownership structures. The beginning of privatization dates back to 1986, when, under the perestroika reforms, quasi-private forms of "small state enterprises" and "new cooperatives" emerged. Early forms of privatization were based on the principle of leasing, according to which the company was leased either collectively, with ownership shares determined by wages received, or individually, with ownership shares determined by individual contributions. Until 1993, around 300 enterprises went through this scheme, whose assets, as reported by Mygind (2000), were later on fully privatized mainly by insiders.

Further support for insiders was established through the law on privatizing small enterprises, which was enacted in December 1990. This law explicitly stipulated that enterprises valued up to 500.000 Roubles would be privatized for cash through auctions, but employees would be the first who would be offered the enterprise. This option was abolished in an amendment of the law in 1992, which also increased the valuation threshold to 600.000 Roubles. However, the adoption of the initial law led to almost 80% of the first round of 450 enterprises ending up in the hands of insiders. The privatization of small enterprises started slowly, but accelerated substantially after June 1992, when Estonia adopted its own currency, kroon, instead of the Russian rouble. The EBRD Transition Report (1999), stressed that, while by the end of 1991 only 16% of small enterprises were privatized, by the end of 1992 this number had increased to 50% and in late 1997 it had increased to 99.6%.

Unlike the privatization process for small enterprises, the privatization of medium and large enterprises reflected the governments' preferences for core investors and, especially, foreign investors. Although it started slowly, the process gained speed and as documented by 1998, 483 large enterprises earmarked for privatization were already sold to strategic investors through open international tenders for a total value of around 400 million USD, investment guarantees of a similar amount and job guarantees of more than 55000 places (Mygind, 2000).

Overall, the privatization process in Estonia has been characterized by some preference for insider ownership at the beginning of transition, extensive use of auctions in the privatization of small enterprises and the use of international tenders in the privatization of medium and large enterprises. Moreover, in the later stages of privatization, governments displayed strong preferences for core and foreign investors. The outcome of this process is a highly diverse ownership configuration.

4. Data

Our data consist of annual firm-level observations for Estonian firms for 1993 through 1999 and it contains detailed information on financial statements and ownership structure for firms from a stratified random sample chosen to represent eighteen economic branches at a 3-digit Nace classification. The data set includes firms with more than 10 employees in a given year. Prior to using the data, a series of consistency checks were performed and inconsistent data is left out[iii]. Furthermore, in the econometric analysis we focus on three main economic sectors, namely, agriculture, manufacturing, and construction and, accordingly, our final sample consists of 2174 observations. Table 2 shows the distribution of the firms over time for the three economic sectors.

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Table 1 & 2 approximately here

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A detailed description of the variables and their definition is provided in Table 1. In order to avoid biases that might arise due to inflation, all data are deflated to 1993 prices, using two digit PPI deflators.

Regarding the measure of soft budget constraint, following Schaffer (1998), it is assumed that a firm has a SBC if it is loss making and is receiving net financing either as subsidies or in the form of lending and increases in debt over interest costs. Then, the SBC for each firm in the sample is constructed as follows:

$$Net\ Financing(t) = \frac{Debt(t) - Debt(t-1) - Interest\ Cost(t)}{Fixed\ \ Assets(t)} \tag{1}$$

$$Dummy\ SBC = \begin{cases} 1 \quad if \quad Net\ Financing(t) \succ 0 \quad \& \quad EBITD \prec 0 \\ 0 \quad otherwise \end{cases} \tag{2}$$

where, EBITD is earnings before interests, profit taxes and depreciation[iv, v].

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Table 3 approximately here

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An important distinction of our paper is that the available data enable us to construct a broader range of ownership categories than is typically used in other studies, which usually distinguish only between state, domestic private and foreign owned firms. In addition, even when they can identify insider owned firms, they are not able to separate employee owned firms from managerial owned firms. By contrast, in this paper we are able to distinguish between five ownership groups, namely foreign, domestic, employee, manager, and state owned.

Table 3, shows the dynamics of enterprise ownership structures over time when we classify firms into these five groups on the basis of dominant ownership. A firm is dominantly owned by the group that owns the largest share. The distribution and evolution of ownership structures over time reveal that the number of managerial, domestic and foreign owned firms increases over time. In contrast, starting from 1995, the number of employee and state owned firms decreases over time. This shows considerable movement away from the initial preference for employee ownership.

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Table 4 approximately here

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Table 4 shows the dynamics of means and standard deviations for our main variables. Some interesting facts that emerge from this table are that capital stock and value added increase over time while the average number of employees decreases over time. Accordingly, the ratio of capital to labor and value added to labor increase over time. In addition, the Herfindahl index is higher during the first years and lower in the last two years when competition increased. Both increased capital intensity and labor productivity as well as increased competition between firms in the industry suggest improvements in firm efficiency. This conjecture is further supported by the fact that the share of exports in total sales and average labor costs increase over time. However, investment levels in new machinery and equipment fluctuate over time, sometimes being quite small.

5. The Estimation Strategy

Technical efficiency is a very useful concept to utilize, especially, in a developing economy context, where firms may be maximizing profits or output subject to profit constraints, as well as other goals such as employment. Technical efficiency is a necessary, though, not a sufficient condition for profit maximization, and a necessary condition for most of the constrained output maximization. Therefore, it can be applied within a country to the analysis of firms that have differing objectives (Brada et al., 1997).

The stochastic frontier applied in the analysis is defined as in Coelli et al. (1998):

$\ln y_{it} = \ln f(x_{it}; t, \beta) + v_{it} - u_{it}$ where *i* – denotes the firm (3)

x_{it} – is a vector of the logarithm of input quantities

t – is a time trend

$f(x_{it}; t, \beta)$ – is a general production function for whose functional form we explicitly test

v_{it} – is white noise, assumed to be normally and identically distributed $N(0, \sigma_v^2)$

u_{it} – is a non-negative random variable, associated with the technical inefficiency of production, assumed to be identically and half normally distributed, $N(\mu_{it}, \sigma_u^2)$. Mean inefficiencies μ_{it} for each firm are explained by the Z_{ik} variables, which are expected to affect/determine firm level technical efficiency.

$$\mu_{it} = a_0 + a_1 Z_{i1,t-1} + a_2 Z_{i2,t-1} + a_3 Z_{i3,t-1} + \dots\dots\dots\dots + a_k Z_{ik,t-1} + a_{k+1} t \qquad (4)$$

where a_k are parameters to be estimated. The time trend parameter is included both in the production function as well as the inefficiency function. The time trend variable in the production function represents the rate of technical change or shifts in the production function over time. This specification makes it possible to consider time varying coefficients and a non-neutral technical change. On the other hand, the time trend variable in the inefficiency function represents changes in technical inefficiency over time.

To estimate (3) and (4) simultaneously the parameterization of Battese and Corra (1977) is applied by replacing σ_u^2 and σ_v^2 with:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \qquad \text{and} \qquad \gamma = \frac{\sigma_u^2}{\sigma^2} \tag{5}$$

Maximum likelihood estimates of β, σ^2 and γ are obtained by estimating the maximum of the log-likelihood function as defined in terms of this parameterization. The maximum likelihood estimation is performed with the frontier program “Frontier 4.1” (Coelli, 1996). Technical efficiencies are then retrieved calculating the expectation of technical efficiency, $TE_{it} = exp(-u_{it})$, for a given distributional assumption for technical inefficiency effects[vi].

It would be highly desirable to carry out the analysis with the optimal model and the appropriate functional form of the production function. Unfortunately, none of them is known *a priori*. Instead, they will have to be determined from the data at hand. Consequently, before actually reporting and interpreting the empirical results, we first report the results of a number of tests that were performed to allow us to select the appropriate functional form of the production function as well as the appropriate model to be estimated.

The results of the aforementioned tests are reported in Tables 5A and 5B. Likelihood ratio tests were performed to test the various null hypotheses[vii]. These tests are performed for the three economic sectors and for both, cross sections and panel data.

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Tables 5A & 5B approximately here

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The first test we performed is on the specification of the production function that best represents the data. The stochastic frontier accommodates both Cobb-Douglas and translog production functions. Instead of assuming an *ad hoc* functional form, we test for the appropriate specification that bests fits the data. The frontier models that we test are the following:

Cobb-Douglas: $$y_{it} = \beta_0 + \sum_{j=1}^{2} \beta_j x_{jit} + \beta_t t + v_{it} - u_{it} \qquad (6)$$

translog: $$y_{it} = \beta_0 + \sum_{j=1}^{2} \beta_j x_{jit} + \beta_t t + \sum_{j=1}^{2}\sum_{h=1}^{2} \beta_{jh} x_{jit} x_{hit} + \beta_{tt} t^2 + \sum_{j=1}^{2} \beta_{jt} x_{jit} t + v_{it} - u_{it} \qquad (7)$$

where *j*, *h* – inputs (capital, labour)

The null hypothesis is that Cobb-Douglas is the appropriate functional form. As seen from the tables, the likelihood ratio (LR) tests lead to rejection of the null hypothesis, accepting the translog as the appropriate functional form in all cases (for the three economic sectors), except for the manufacturing sector in 1995. Given that the translog function is the generally accepted functional form, in what follows we report the estimation results solely for the translog function.

The second test we perform is to determine whether the inefficiency effects need to be included in the model. Alternatively, if inefficiency effects do not matter we do not need to estimate a stochastic frontier model but rather an augmented average production function, because the firm is already operating on the technically efficient frontier. The null hypothesis then is: $\gamma = \alpha_0 = \alpha_k = 0$, i.e., that the systematic and random technical inefficiency effects are zero and, if accepted, that neither the constant nor the inefficiency effects would be necessary to include in the model. However, the null hypothesis that the vector γ is equal to zero, is decisively rejected over time and across the three economic sectors, suggesting that inefficiencies are present in the model and that running average production functions is not an appropriate representation of the data. The closer γ is to unity, the more likely it is that the frontier model is chosen. From Tables 5A and 5B we see that the value of γ is in between

0.7-0.95 in most cases. Furthermore, this implies that for a country like Estonia inefficiencies have been persistent during the whole period under consideration.

The third hypothesis we test is whether the technical inefficiencies in the model are a function of the explanatory variables we consider. Hence, the null hypothesis is α_k =0, i.e., that all inefficiency variables, except for the constant, are jointly equal to zero. Again, the null hypothesis is rejected, confirming that the joint effect of these variables significantly affects inefficiency.

The fourth test we perform is whether the production process of Estonian firms has been affected by technical change. The null hypothesis is that $\beta_t = \beta_{tt} = \beta_{jt} = 0$, i.e., the coefficients in front of the time trend variable, squared time trend variable, and its interaction with inputs are jointly equal to zero. This null hypothesis is also rejected, suggesting that Estonian firms have experienced technical change during this time period. The marginal effect of the technological change on firm productivity is estimated by taking the derivative of equation (7) with respect to time, evaluated at the geometric mean of the respective variables. We find that in all the three sectors there has been technological progress. This means that Estonian firms produce more output for each level of input. This may be the result of efficiency improvements, technology upgrading or scale economies, or a combination of the three. However, since we find evidence of constant returns to scale (in section 7) a combination of the earlier two factors could explain this finding.

Turning to the estimation issues, the estimation of firm efficiency or firm performance usually faces many difficulties, mainly stemming from the endogeneity of different firm characteristics, such as its ownership structure, trade orientation, investment in fixed capital, and soft budget constraints.

Endogeneity is the potential correlation of right-hand side, variables such as firm ownership structure, trade orientation and SBC, with the error term. When firm ownership structure is used as a right-hand side variable this problem arises because in equilibrium, different owners will determine their optimal ownership share based on various firm characteristics, among which is firm productivity or performance. If left unaccounted for, this results in inconsistent estimates.

Likewise, turning to firms' trade orientation, several papers (including Roberts and Tybout, 1997; Bernard and Jensen, 1999; Aw et al., 2000) show that exporting firms are larger, more productive, pay higher wages and survive longer than firms that do not export. The literature has proposed two main reasons that can explain the positive correlation between firm productivity and exporting. First, international contacts enable exporters to acquire knowledge and expertise in many areas such as new production methods and product design. In turn, learning-by exporting results in higher productivity for exporters compared with non-exporters. Second, the positive correlation between productivity and exporting, could simply suggest that only the most productive firms can survive in a highly competitive international environment. Hence, the most efficient firms self-select into the export market. In light of such information, current values of firm level export intensity variable would be endogenous. Similarly, a firms' decisions to invest in new machinery and equipment depend on past and current levels of output and profit, which in turn are also affected by investment rates.

With respect to soft budget constraints, we do know that soft budget constraints hamper restructuring of firms because of the lack of productivity improvements and the operation of unprofitable production activities (Djankov and Murrell, 2002). Hence, firms with soft budget constraints are expected to be less efficient than other firms. On the other hand, firms in financial distress are, by definition, not performing well, and fall in the group of firms with soft budget constraints. Hence, the causality between firm efficiency and soft budget constraints is not clear.

We control for endogeneity of different firm characteristics by estimating the stochastic frontier with firm fixed effects. To obtain fixed effects estimates the data was meandifferenced prior to estimation[viii]. Finally, we employ lagged values of these firm characteristics to avoid any causality issue.

6. The Estimation Results

As previously discussed, the tests on the appropriate functional form of the production function that best fits the data revealed that the translog specification (equation 7) is preferred. Therefore, in this section we report empirical results obtained from estimating the translog function only. The model is estimated for each cross-section and also for the panel when fixed effects methods are used. Our estimates use both balanced and unbalanced panels and we report findings for each of three sectors, i.e. manufacturing, agriculture and construction.

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Tables 6 & 7 approximately here

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The estimates of the inefficiency function are reported in the second part of Table 6 for the manufacturing sector and in Table 7 for agriculture and construction. In interpreting the results of the inefficiency function one should keep in mind that a negative coefficient reflects reduced firm inefficiency and, hence, increased efficiency. The results reported in Table 6 reveal that ownership structure is generally a significant determinant of firm level inefficiency. For instance, the results show that foreign and managerial ownership increase firm efficiency compared to employee owned firms for the years 1996 and 1998. However, panel estimates show that only foreign ownership increases firm efficiency compared to employee ownership. Furthermore, other ownership forms significantly increase firm inefficiency compared to employee ownership. The finding that foreign ownership increases firm efficiency more than other forms of private ownership is consistent with the findings of Smith et al. (1997), De Mello (1997) and Brown et al. (2006). For reasons related to access to advanced technology, capital and better organization, foreign ownership is expected to have contributed to higher firm efficiency. More surprising, however, is the result that domestic outsider ownership does not produce efficiency gains when compared with employee ownership.

Among other variables, those that are found to have statistically significant effects on firm efficiency are firm size, average labor cost (labor quality), the share of exports in net sales, the share of investment in fixed capital to net sales, and soft budget constraints (SBC). The results reveal that the number of significant parameters increases when panel, rather than cross sectional data, are used. Among these variables, only the effect of the SBC and average labor cost is robust across all specifications, cross-sections and panel estimations. More specifically, the effect of soft budget constraints is positive and significant, except in 1996. This result suggests that, as expected, the availability of easy financing is detrimental to firm efficiency. Several other studies have illustrated that SBC erodes firms' incentives for restructuring. For instance, Coricelli and Djankov (2001), and Claessens and Peters (1997), using a similar measure of SBC find that loss-making enterprises received significantly more bank credit than did the other firms. Also Djankov and Murrell (2002) argue that the evidence for several Central and East European economies shows that hardened budget constraints have a beneficial effect on restructuring. In addition, the effect of average labor cost is negative and significant across all specifications, implying that the availability of qualified workers, at firm level, results in higher firm level efficiency. In contrast, the effect of investment in fixed capital is not consistent across cross sections with this producing increases in firm inefficiency for 1997 and 1998. One explanation for this finding is that investment in fixed capital takes away productive resources and it may take time to become fully operational.

Turning to the remaining variables we observe that they are statistically significant only in the panel estimates. For example, firm size significantly affects firm efficiency, in that larger firms are more efficient, and this result remains robust across both balanced and unbalanced panel estimates. This finding is in line with the argument that large firms exploit economies of scale and produce at lower average cost per unit. Furthermore, the share of investment in sales is also found to significantly increase firm efficiency in specifications estimated using both balanced and unbalanced panels, while the share of exports to sale significantly increases efficiency only in the unbalanced panel, suggesting that export oriented firms which face international competition tend to be more efficient.

The results for the agriculture and the construction sectors are reported in Table 7. These reveal a picture that contrasts slightly with that obtained for manufacturing concerning the impact of ownership structures and firm characteristics. Focusing on the ownership variables we see that, for the agriculture sector, compared to employee ownership, foreign and managerial ownership significantly increase firm efficiency. But for the construction sector, and again compared to employee owned firms, it is domestic and state ownership that leads to increases in efficiency. With respect to the firm characteristics, for the agriculture sector, investment increases firm efficiency and soft budget constraints are found to harm firm efficiency. In addition, the age of privatization improves efficiency in that firms that have been privatized earlier are more efficient. For the construction sector, firm size, investment and age of privatization increase firm efficiency, while export orientation and average labor cost decrease firm efficiency.

In addition to investigating the different firm and industry characteristics as sources of firm technical efficiency, we also explore the dynamics of firm efficiency utilizing the efficiency scores calculated from the balanced panel. We opt for the use of the balanced panel to avoid biases generated by the entry and exit of firms over time. For comparative purposes we create five groups of firm level efficiency: 0-19%, 20-39%, 40-59%, 60-79% and 80-100%, respectively. Figure 1 represents the distribution of firms according to these efficiency groupings over time.

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Figure 1 approximately here

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Figure 1 shows that in 1995 around 70% of firms were operating at the 0-19% level of efficiency and less then 10% were operating at 80-100% level of efficiency. This result is expected since the early 1990s were characterized by highly inefficient firms, who inherited from the centralized market economy outdated capital, lack of advanced technology, expertise and resources necessary to survive in an open market oriented economy. However, the percentage of firms belonging to the lowest levels of efficiency decreased over time, while the percentage of firms belonging to the remaining three efficiency groups (40-59%, 60-79% and 80-100%) has increased. Reasons related to privatization, such as restructuring and the introduction to market competition might have played an important role in increasing firm efficiency. Accordingly, we conclude that, over time Estonian firms have become more efficient.

Overall, our findings confirm several conjectures concerning the effects of key firm characteristics on firm level efficiency. These results are more in line with those of Brada et al. (1997) who find an interval of 40-80% technical efficiency for Czechoslovakia, and Jones et al. (1998) who find an interval of 60-70% for Bulgaria. In contrast, Danilin et al. (1985), in a study of a large sample of Russian cotton refining enterprises, find that more than half of the enterprises in their sample have estimated rates of 94% technical efficiency, and that the overall mean was 92.9%. Similarly to Danilin et al. (1985), Piesse and Thirtle (2000) found a 93.4% mean efficiency for the agriculture sector and of 91.8% for the manufacturing sector. This variance in results obtained could be due to the fact, explained by Smith (1997), that the level of efficiency will depend significantly from the functional form and the level of aggregation chosen. More specifically, they stress that the efficiency level will be lower when capital and labor are the only inputs.

7. Input Elasticities and Returns to Scale

One of the economic distortions of developing economies is the excessive use of inputs in the production process. This phenomenon manifested itself in lower productivity and technical inefficiency. The elimination of such inefficiencies was one of the goals of firm restructuring. Therefore, it would be interesting to know whether, over time, Estonian firms have been operating under decreasing, constant or increasing returns to scale. Input elasticities for the translog production function are calculated as follows:

$$e_j = \frac{\partial \ln(y_i)}{\partial \ln(x_{ji})} = \beta_j + \sum_{j=1}^{2} \beta_{jh} \ln x_j + \beta_{jt} \quad (8)$$

The variance of elasticities is:

$$Var = \lambda_j \hat{\Omega}(\hat{\theta}) \lambda_j' \quad (9)$$

where θ is the vector of maximum likelihood estimators of parameters (β_j), and λ_j is a row vector of the same dimension with zero entries except when corresponding to β_j and β_{jh}, elements of θ. $\hat{\Omega}(\hat{\theta})$ is the estimated covariance matrix for θ. Its components are part of the variance covariance matrix of the maximum likelihood estimation of the frontier program, Frontier 4.1.

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Table 8 approximately here

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Input elasticities and returns to scale, calculated over time and across all sectors, are reported in Table 8. A clear pattern emerging from the results is that labor has a higher elasticity than capital. Given such a pattern we focus on interpreting the results for the balanced panel estimations only. The results show that labor accounts for 39% of the value added (the dependent variable) in the manufacturing sector. It accounts for almost 92% for the agriculture sector and 100% for the construction sector. While this pattern of input elasiticities would not be feasible under a market system, it is not surprising in the context of a developing economy, characterized by outdated and labor-intensive technology.

Returns to scale are calculated as the sum of individual elasticities from equation (8) as follows:

$$\upsilon = \sum_{j=1}^{2} e_j = \sum_{j=1}^{2} \beta_j + \sum_{j=1}^{2}\sum_{h=1}^{2} \beta_{jh} \ln x_j + \sum_{j=1}^{2} \beta_{jt} \qquad (10)$$

In testing the deviation of actual returns to scale from constant returns to scale the test statistic is the following and it has a t-distribution :

$$S = \frac{\upsilon - 1}{\sqrt{\Omega(\upsilon)}} \qquad \text{where } \Omega(\upsilon) = \gamma_j \hat{\Omega}(\hat{\theta})\gamma_j^{'} \text{ and } \gamma = \sum_{j=1}^{2} \lambda_j \qquad (11)$$

If the value of returns to scale is significantly larger than unity then the firm operates in the increasing returns to scale region, while if it is significantly less than unity then the firm operates in the decreasing returns to scale region.

The results of Table 8 show that the sum of elasticities is usually less than unity except for 1995 and the unbalanced panel for the manufacturing sector, nevertheless, mainly larger than unity for the agriculture and construction sectors. The null hypothesis of constant returns to scale is accepted in all cases. Hence, on average, firms in Estonia operate with the right input mix and are at the right point of their production function.

How then does this evidence reconcile with the efficiency improvements reported in Tables 6 and 7? One explanation is that efficiency gains have been achieved primarily through the decrease in the size of firms. As observed from Table 4, over time firms have reduced in size as evidenced by the decline in average employment, and have also become more capital intensive as evidenced by the increase in capital and the pattern of capital intensity ratio. These data show that, during early 1990s, Estonian firms were characterized as quite labor intensive. Over time they have substituted capital for labor, which may have contributed to higher efficiency levels. However, Tables 6 and 7 reveal that firm size positively affects firm efficiency. These findings are not necessarily contradictory as over time firms increase efficiency by becoming more capital intensive with larger firms still being more efficient.

8. CONCLUSIONS

In this paper we investigate the impact of ownership structure and other firm characteristics, such as, firm size, labor quality, investment in new equipment, trade orientation, soft budget constraints and competition, on firm level technical efficiency. Accordingly, we use a representative panel of Estonian firms over the period 1993-1999 and apply the stochastic frontier as the appropriate representation of the data. The major benefit of using this method is that the parameters of both firm level efficiency and production function are estimated simultaneously, resulting in efficient estimates. We find important evidence of persistent inefficiencies during the period under study, which are explained by a variety of firm characteristics.

Our findings provide support for the hypothesis that a firm's ownership structure and other firm characteristics are important for a firm's technical efficiency. For instance, firms that are foreign and managerially owned, larger in size, with higher labour quality, that invest in new machinery and equipment and are trade oriented as well as privatized in the early stages of transition, display higher levels of efficiency. Finally, as expected, soft budget constraints are detrimental to firm efficiency.

In addition, the results provide evidence of technology improvements and high mean technical efficiency scores, accompanied with higher labor elasticity and constant returns to scale across all economic sectors. While a production function with high labor elasticity is not surprising in a developing economy context, improvements in technical efficiency when constant returns to scale apply, is surprising. We conjecture that the efficiency improvements have been achieved through reductions in firm size and increases in capital intensity. Furthermore, the finding that firm efficiency is high is consistent with other studies across the privatization literature, as for instance Brown et al (2006) for four East European and CIS countries.

With respect to policy implication our findings suggest that, since foreign ownership produces the highest levels of efficiency, governments should promote foreign direct investment as a source of economic growth. Furthermore, this policy should be accompanied with a hardening of soft budget constraints and promotion of training of employees as important determinants of firm level efficiency.

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APPENDIX

Table 1: Variable Definition

Variables	Definition
Value Added	The dependant variable is constructed as the sum of Net Profit, Depreciation and Labor Cost (Wage Salary +Social Security +interest costs). Expressed in thousands of kroons.
Employment	Firm's average number of employees per year.
Capital	Capital is calculated as the average of fixed assets at the beginning and end of year. Expressed in thousands of kroons.
Herfindahl (3 digit)	Used to capture monopoly power Herfindahl$_j$ = $\sum_i \left(\frac{Sale_i}{Sale_j} \right)^2$ j-industry, i -firm Constructed at the three digit industry classification.
Dominant Ownership Dummy	This is a dummy equal to 1 if the share in equity owned by a group for that year is greater than that owned by any other group.
Firm' Debt (used to construct SBC dummy)	Is constructed as the sum of Current Debt and Current Payables. Expressed in thousands of kroons.
Net Financing (used to construct SBC dummy)	Constructed as [Debt(t)- Debt(t-1)-Interest Cost(t)]/Fixed Assets
EBITD (used to construct SBC dummy)	Earnings before Interests, Profit Taxes and Depreciation are equal to the sum of Gross Profit and Depreciation. Expressed in thousands of kroons.
Dummy Soft Budget Constraint	Equals 1 if Net financing>0 & EBITD<0, zero otherwise.
Average Labor Cost	Used to proxy labor quality. Expressed in thousands of kroons.
Age of Privatization	Shows the number of years a firm has been operating as private.
Sales	Net sales are expressed in thousands of kroons. Available at firm level.
Investment/Sales	The share of expenditure on new machinery and equipment to net sales of the firm. Used to account for investment in new technology.
Export/Sales	The share of firm's export to net sales.
Firm Size	The logarithm of firm level employment.
d_t	Time Trend: 1) Included at the production function to account for technical changes in productivity. 2) Also included at the inefficiency function to account for temporal changes in technical inefficiency.
d_j	Industry dummy, constructed on a two-digit level industry classification

Note: All data, except average number of employees and ownership shares, has been deflated to 1993 prices before variable construction.

Table 2: Distribution of Firms by Year and Economic Sectors

Year	Agriculture	Manufacture	Construction	Total
93	55	218	44	317
94	47	216	48	311
95	45	264	61	370
96	35	256	60	351
97	37	229	53	319
98	34	197	44	275
99	28	170	33	231
Total	281	1,550	343	2174

Table 3: The Dynamics of the Dominant Ownership Structure.

Year	Domestic Outsider	Employees	Foreign	Managers	State	Total
93	64	40	28	27	158	317
94	74	45	33	35	124	311
95	80	40	34	39	177	370
96	98	37	45	49	122	351
97	85	23	45	55	111	319
98	76	21	42	47	89	275
99	93	30	54	53	1	231
Total	570	236	281	305	782	2174

Table 4: Mean and Standard Deviations of Main Variables over Time.

Year	Value Added	Capital	Labor	Capital/ Labor	VaAdded/ Labor	Herfindahl	Avg. Labour Cost	[1]Export/Y	Invest./Y
93	4758.63 (11128)	5513.48 (13669.16)	182.11 (380.09)	33.79 (86.63)	24.78 (33.84)	0.27 (0.16)	3019.46 (5698.6)	.	0.400 (2.79)
94	4306.66 (10151.71)	5747.13 (14757.23)	152.33 (275.62)	50.58 (217.31)	29.12 (45.9)	0.28 (0.18)	3333.58 (6422.13)	0.24 (0.30)	0.26 (1.87)
95	3722.41 (8965.83)	5480.89 (13123.93)	152.30 (260.88)	45.81 (193.4)	23.41 (32.0)	0.24 (0.17)	2770.80 (5214.29)	0.25 (0.31)	0.17 (0.91)
96	5087.05 (10481.34)	6077.55 (15186.6)	152.72 (284.24)	46.74 (195.36)	32.28 (30.28)	0.25 (0.17)	4014.55 (7755.55)	0.26 (0.32)	0.099 (0.28)
97	6216.15 (11537.03)	6534.45 (14987.78)	145.73 (255.19)	51.47 (159.25)	55.16 (298.65)	0.26 (0.19)	4344.16 (7708.72)	0.28 (0.32)	0.094 (0.19)
98	6559.6 (10847.16)	8235.95 (16677.36)	151.53 (255.83)	54.58 (97.17)	43.58 (38.05)	0.22 (0.18)	4895.68 (8033.01)	0.27 (0.32)	0.19 (1.42)
99	6991.69 (11925.39)	9887.60 (21169)	130.96 (174.37)	65.01 (100.59)	38.69 (163.31)	0.24 (0.19)	4779.39 (6832.42)	0.29 (0.33)	0.07 (0.12)
Total	5249.60	6591.39	153.39	48.87	34.69	0.25	3801.45	0.26	0.18

Note: [1] Export data for year 1993 is missing.

Table 5A: Hypotheses Tests: Results for Manufacturing

Manufacturing							
Test 1: H_0: Cobb-Douglas is the appropriate functional form versus Translog. Test Statistic ($\chi^2_{3,0.95}$) = 7.81 (Panel $\chi^2_{6,0.95}$ =12.59)							
	1995	**1996**	**1997**	**1998**	**1999**	**Unbalanced Panel**	**Balanced Panel**
Test Statistic (Likelihood Ratio)	4.42	9.96	60.16	12.56	16.42	76.14	37.48
Result	Accept	Reject	Reject	Reject	Reject	Reject	Reject
[1]**Test 2:** H_0: $\gamma = \alpha_0 = \alpha_k$ =0 Cross-Section: ($\chi^2_{24,0.95}$) = 35.827 Panel: ($\chi^2_{25,0.95}$) =37.066							
γ **value**	0.89	0.84	0.92	0.84	0.85	0.89	0.82
Test statistic (Likelihood Ratio)	113.32	151.47	172.97	162.66	95.31	557.1	429.07
Result	Reject	Reject	Reject	Reject	Reject	Reject	Reject
Decision	Front	Front	Front	Front	Front	Front	Front
Test 3: H_0: $\alpha_k = 0$ Cross Section $\chi^2_{22,0.95}$ =33.92 Panel: $\chi^2_{23,0.95}$ = 35.17							
Test Statistic (LR)	76.44	101.46	101.92	109.2	71.02	315.74	255.12
Result	Reject	Reject	Reject	Reject	Reject	Reject	Reject
Test 4: H_0: $\beta_t = \beta_{tt} = \beta_{jt} = 0$ $\chi^2_{4,0.95}$ =9.49							
Test Statistic (LR)	-	-	-	-	-	9.82	9.54
Result	-	-	-	-	-	Reject	Reject

[1]The test statistics has a mixed Chi2 distribution, critical values taken from Kodde and Palm (1986).

Table 5B: Hypotheses Tests Results for Agriculture and Construction

Agriculture			Construction	
Test 1: H_0: Cobb-Douglas is the appropriate functional form vs. Translog. $\chi^2_{6,0.95}$ =12.59				
	Unbalanced Panel	**Balanced Panel**	**Unbalanced Panel**	**Balanced Panel**
Test Statistic (Likelihood Ratio)	16.42	36.22	12.94	14.14
Result	Reject	Reject	Reject	Reject
[1]**Test 2:** H_0: H_0: $\gamma = \alpha_0 = \alpha_k$ =0 $\chi^2_{14,0.95}$ =23.069				
γ **value**	0.79	0.56	0.87	0.75
Test stat (Likelihood Ratio)	88.05	85.16	83.37	39.99
Result	Reject	Reject	Reject	Reject
Decision	Frontier	Frontier	Frontier	Frontier
Test 3: H_0: $\alpha_k = 0$ $\chi^2_{12,0.95}$ = 21.03				
Test stat (Likelihood Ratio)	61.24	83.86	40.8	20.86
Decision	Reject	Reject	Reject	Reject
Test 4: H_0: $\beta_t = \beta_{tt} = \beta_{jt} = 0$ $\chi^2_{4,0.95}$ =9.49				
Test stat (Likelihood Ratio)	17.84	30.84	10.48	11.92
Decision	Reject	Reject	Reject	Reject

[1]The test statistics has a mixed Chi2 distribution, critical values taken from Kodde and Palm (1986).

Table 6: Cross-Section Frontier Estimation of Translog Production Function. Manufacturing Sector.

Production	**1995**	**1996**	**1997**	**1998**	**1999**	**Fixed Effects UnBalanced**	**Fixed Effects Balanced**
Constant	5.34*** (3.48)	4.48*** (5.48)	3.92*** (6.00)	3.88*** (5.75)	3.41*** (3.96)	0.26*** (23.84)	0.21*** (13.35)
LnK	0.010 (0.06)	-0.173 (-0.99)	0.155 (0.80)	-0.040 (-0.26)	0.111 (0.59)	0.146 (1.02)	0.45*** (2.81)
LnL	0.94** (2.20)	1.07*** (4.00)	0.69** (2.33)	1.09*** (4.20)	1.135*** (3.73)	0.927 (0.10)	0.39* (1.41)
LnK2	-0.026* (-1.82)	0.039*** (2.90)	0.082*** (5.1)	0.031*** (2.98)	0.029*** (2.34)	0.002 (0.25)	0.015** (1.97)
LnL2	-0.044 (-0.80)	0.015 (0.41)	0.219*** (5.69)	-0.011 (-0.26)	0.020 (0.42)	0.149*** (3.77)	0.165*** (4.11)
LnK*LnL	0.076* (1.61)	-0.059* (-1.59)	-0.257*** (-7.31)	-0.046* (-1.61)	-0.078** (-2.18)	-0.063** (-1.84)	-0.142*** (-4.22)
Time Trend (T)	-	-	-	-	-	0.129** (1.71)	0.11* (1.37)
T* LnK	-	-	-	-	-	0.054*** (6.24)	0.039*** (4.63)
T* LnL	-	-	-	-	-	-0.052*** (-3.58)	-0.022* (-1.45)
Time Trend Squared	-	-	-	-	-	-0.035*** (-4.02)	-0.038*** (-4.31)
Inefficiency Function							
Constant	3.49*** (2.68)	2.63*** (2.92)	1.36* (1.35)	1.41* (1.43)	1.83** (2.05)	-5.44*** (-5.14)	-3.79*** (-3.96)
Dummy Foreign$_{t-1}$	0.137 (0.48)	-0.87* (-1.34)	0.33 (0.61)	-0.046** (-2.08)	0.066 (0.12)	-1.63** (-2.24)	-2.72*** (-2.80)
Dummy Manager$_{t-1}$	-0.006 (-0.02)	-0.194* (-1.39)	-0.403 (-0.84)	-0.054 (-0.11)	0.057 (0.10)	2.74*** (3.48)	1.57*** (1.75)
DummyDomestic$_{t-1}$	0.24 (1.11)	-0.199 (-0.48)	0.084 (0.19)	0.560 (1.17)	0.428 (0.80)	2.85*** (4.29)	3.41*** (3.58)
Dummy State$_{t-1}$	0.31 (1.08)	0.407 (0.66)	-0.26 (-0.45)	0.259 (0.46)	0.112 (0.19)	2.67*** (3.51)	2.84*** (3.31)
Firm Size$_{t-1}$	0.039 (0.19)	-0.170 (-1.21)	-0.089 (-0.66)	-0.182 (-1.22)	-0.170 (-1.21)	-0.796* (-1.58)	-2.174*** (-2.72)
Avg. Labor Cost$_{t-1}$	-0.059*** (-8.92)	-0.13*** (-8.33)	-0.079*** (-4.41)	-0.064*** (-3.55)	-0.039*** (-3.52)	-0.015** (-1.83)	-0.093*** (-4.36)
Invest/Sales $_{t-1}$	-0.082*** (-3.33)	0.069 (0.91)	0.881*** (3.33)	1.459** (2.08)	0.091 (0.55)	-0.136** (-2.06)	-0.104* (-1.39)
Export/Sales $_{t-1}$	-0.008 (-0.04)	0.017 (0.04)	0.048 (0.14)	0.014 (0.04)	0.069 (0.25)	-2.902*** (-3.09)	1.69 (1.21)
Dummy SBC $_{t-1}$	0.84*** (4.45)	0.732 (0.80)	0.904*** (3.26)	1.128*** (3.33)	0.425* (1.53)	3.86*** (5.77)	1.789*** (2.88)
Herfindahl (3digit)	-0.137 (-0.19)	1.102 (1.22)	-0.306 (-0.43)	0.412 (0.50)	0.221 (0.30)	-0.980 (-1.00)	-1.58* (-1.47)
Age of Privatization	0.013 (0.22)	0.171* (1.33)	-0.011 (-0.14)	0.017 (0.29)	-0.021 (-0.40)	0.162 (0.88)	-0.044 (-0.21)
Time Trend	-	-	-		-	-0.018 (-0.12)	0.102 (0.55)
Industry Dummy	yes	yes	yes	yes	yes	-	-
Mean Efficiency	0.14	0.525	0.503	0.60	0.523	0.58	0.63
ME of Technical change[1)]	-	-	-	-	-	0.12	0.098
No. Obs.	169	243	223	192	163	990	740

Note: ***, ** and * significant at 1%, 5% and 10% respectively. The marginal effect of technical change can be estimated by taking the derivative of equation (9) with respect to time and evaluate it at the geometric mean of respective variables.

Table 7: Fixed Effects Panel Data Frontier Estimation of the Translog Production Function. Agriculture and Construction Sector.

Production	Fixed Effects Agriculture Sector		Fixed Effects Construction Sector	
	Unbalanced Panel	Balanced Panel	Unbalanced Panel	Balanced Panel
Constant	0.146*** (5.78)	0.318*** (4.90)	0.218*** (5.21)	0.21*** (2.58)
LnK	-0.115 (-0.49)	-0.097** (-2.32)	0.109 (0.46)	0.372 (0.55)
LnL	1.129* (1.39)	0.922 (0.87)	1.09*** (4.07)	0.927* (1.45)
LnK2	0.027 (0.98)	0.003 (0.06)	0.022 (1.15)	0.06* (1.52)
LnL2	-0.076 (-0.62)	0.087 (0.50)	-0.048 (-0.57)	0.080 (0.49)
LnK*LnL	-0.003 (-0.02)	0.168 (1.04)	-0.069 (-0.93)	-0.21* (-1.46)
Time Trend (T)	0.492*** (3.48)	0.342** (2.19)	0.367*** (2.37)	-0.093 (-0.34)
T*LnK	-0.018 (-0.60)	0.065** (1.90)	0.018 (0.82)	-0.039 (-1.01)
T*LnL	0.001 (0.03)	-0.079* (-1.51)	-0.055* (-1.41)	0.087 (0.99)
Time Trend squared (T2)	-0.052*** (-3.21)	-0.06*** (-3.04)	-0.034** (-2.22)	0.002 (0.09)
Constant	-2.456*** (-4.20)	-0.069 (-0.20)	-1.55* (-1.62)	-1.45* (-1.57)
Dummy $Foreign_{t-1}$	-2.373** (-2.25)	-0.270 (-0.34)	1.078 (1.11)	0.309 (0.33)
Dummy $Manager_{t-1}$	-2.070** (-2.18)	-0.503 (-1.06)	-0.720 (-1.21)	-0.540 (-0.79)
$DummyDomestic_{t-1}$	1.116** (2.30)	0.348* (1.32)	-2.657** (-2.12)	-2.035* (-1.33)
Dummy $State_{t-1}$	0.003 (0.009)	-0.510 (-0.92)	-2.84*** (-2.46)	-2.67** (-2.02)
Firm $Size_{t-1}$	-0.134 (-0.15)	0.284 (0.41)	-1.14*** (-2.37)	-0.97*** (-2.36)
Avg. Labor $Cost_{t-1}$	-0.006 (-0.27)	0.014 (0.75)	0.024** (1.86)	0.010 (0.61)
Invest/$Sales_{t-1}$	-4.723*** (-3.15)	0.169 (0.17)	-1.93** (-2.00)	-2.068** (-2.28)
Export/$Sales_{t-1}$	0.959 (0.69)	0.846 (0.80)	5.73 (1.18)	5.002 (1.22)
Dummy SBC_{t-1}	1.33** (2.10)	-0.532 (-0.97)	0.244 (0.51)	-0.231 (-0.36)
Herfindahl (3digit)	-0.580 (-0.55)	1.348 (0.83)	0.336 (0.34)	-1.128 (-0.94)
Age of Privatization	-0.713*** (-2.47)	0.092 (0.13)	0.017 (0.09)	-0.504* (-1.44)
Time Trend	1.472*** (4.23)	0.092 (0.13)	0.4* (1.46)	0.88** (1.91)
Mean Efficiency	0.75	0.62	0.70	0.74
ME of Technical change[1)]	0.477	0.337	0.349	-0.0914
No. Obs.	156	100	219	120

Note: ***, ** and * significant at 1%, 5% and 10% respectively. [1)] The marginal effect of technical change can be estimated by taking the derivative of equation (9) with respect to time and evaluate it at the geometric mean of respective variables.

Table 8: Input Elasticities and Returns to Scale.

Manufacturing	95	96	97	98	99	Unbalanced	Balanced
Capital Elasticity	-0.0325*** (0.0066)	0.143*** (0.0302)	0.058** (0.02955)	0.24*** (0.006)	0.231*** (0.022)	0.146 (0.0087)	0.45*** (0.02)
Labor Elasticity	1.104*** (0.401)	0.765*** (0.2853)	0.695*** (0.2052)	0.63** (0.2848)	0.684** (0.344)	0.927 (0.21)	0.39* (0.11)
Returns to Scale	1.0715 (0.399)	0.908 (0.2942)	0.753 (0.1954)	0.87 (0.287)	0.915 (0.3384)	1.073 (0.20)	0.84 (0.13)
Test Statistic H_0: RTS=1	0.18	-0.313	-1.26	-0.47	-0.25	-1.1	-0.82
Decision	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS

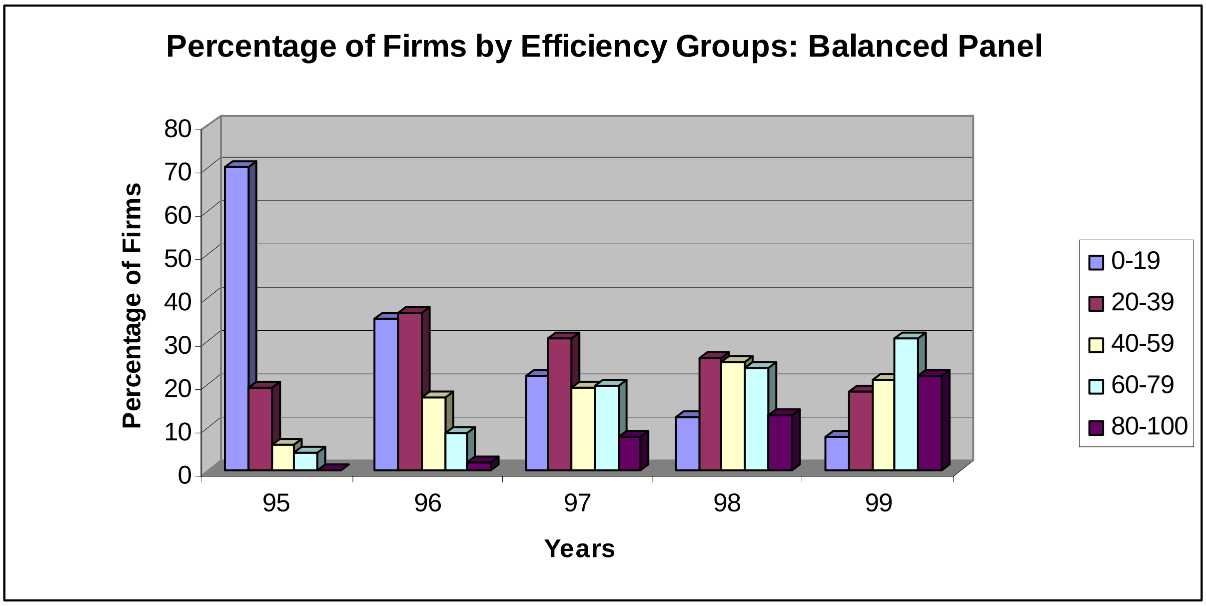
Note: ***, ** , * significant at 1%, 5% and 10% respectively.
Standard errors in parenthesis

Table 8 continued

	Agriculture		Construction	
	Unbalanced	**Balanced**	**Unbalanced**	**Balanced**
Capital Elasticity	-0.115 (0.066)	-0.097*** (0.074)	0.109 (0.0074)	0.372 (0.119)
Labor Elasticity	1.129* (0.43)	0.922 (0.44)	1.09*** (0.63)	1.027* (0.29)
Returns to Scale	1.014 (0.41)	0.825 (0.78)	1.199 (0.40)	1.399 (0.30)
Test Statistic H0: RTS=1	0.18	0.2	0.44	0.27
Decision	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS	Accept H_0 CRS

Note: ***, ** , * significant at 1%, 5% and 10% respectively.
Standard errors in parenthesis

Figure 1



[i] Fortunately, as we shall see, in our case most of these issues do not present large problems and we are able to construct measures for five types of ownership in Estonia, including our being able to separate the two main types of insider ownership (employee and manager), which are often lumped together in other studies.

[ii] In fact, direct budgetary subsidies constitute an insignificant part of financing to firms (Schaffer, 1998). Under these circumstances the other components of soft budget constraints might constitute an important source through which the state and/or other institutions extend support to distressed firms. For instance, the state might postpone the collection of corporate and social security taxes. Alternatively, cheap capital can be obtained as overdue trade credit to suppliers. However, in this respect, Schaffer (1998) argues that, at least in more advanced transition economies, firms have learnt to apply hard budget constraints to each other. A final source of soft budget constraints is easy access on the part of distressed or loss-making firms to bank lending through special relations with banks and/or other financial institutions. In order to properly establish the pervasiveness of this channel of soft budget constraints one needs to combine data from both firms and banks. It is tempting to interpret positive net financing to a loss-making firm as evidence of soft budget constraints. However, this would be the case only if the stated loan has a low economic value to the bank itself.

[iii] We check for inconsistencies using different criteria. For instance, a firm's capital at the beginning and end of each year should be positive; sales should be positive; labour cost in a given year should be positive; average employment per year should be positive and equal or greater than 10; investment in new machines and equipment should be non-negative; and the ownership shares should add up to 100. Furthermore, one of the main weaknesses of the stochastic frontier approach is the presence of outliers, which push the frontier up for all the firms in the sample, causing pronounced firm inefficiency. Therefore, before carrying out the analysis, we perform a series of checks for outliers in the following variables: capital stock, employment, wages and salaries, sales and value added. These consistency checks reveal that eighteen observations belonging to 6 firms are outliers. For these observations employment, capital or sales are more than four times that of the sample average. Consequently, they are dropped from the analysis.

[iv] This measure of soft budget constraint suffers from two pitfalls. First, it might fail to capture firms with genuine soft budget constraints. More specifically, a firm with negative earnings and zero net financing in a given period is still experiencing soft budget constraint if it expects to receive financing in the future. However, this involves unobservables and it will always fail to capture the true degree of soft budget constraint. Second, it might mistakenly classify some firms with soft budget constraints. For example, it could well be the case that young or newly established firms might be loss-making during the first years of their existence until they gain market share and establish relations with financial institutions. In the meantime, they might be receiving outside financing in response to their long-term growth potential. Again, this involves unobservables and as such it is not possible to account for using accounting data. Both these problems generate biases in the real number of firms that experience soft budget constraints, and as such, should be kept in mind in the interpretation of results.

[v] Soft budget constraints result from cheap credit provided in the form of direct government subsidies, tax arrears, trade credits and cheap loans from the financial sector. Yet, the measure constructed in (1) and (2) is based solely on information on funds received from the financial sector. This results from the lack of appropriate data to measure other potential sources of soft budget constraints. Nevertheless, we do not expect all the other channels of soft budget constraints to play a significant role in Estonia. For example, the policies of Estonian governments to run balanced budgets and promote competition have resulted in minimal levels of direct government subsidies, which, according to EBRD (2000), have been under 1% of GDP for the period 1996 through 2000. Another possible source of the SBC is the availability of overdue trade credit to suppliers and tax arrears. However, the limited evidence shows that Estonian firms enjoy some relief in terms of delayed tax collection. For example, EBRD (2000) stresses that the efficiency of the collection of social security tax at the enterprise level in Estonia was 85.6% in 1998 and 76.2% in 1999.

[vi] A problem is that u_{it} is unobservable, hence its prediction is needed. The best predictor for u_{it} is the conditional expectation of u_{it} given the value of $e_{it}=v_{it}-u_{it}$ (Jondrow, Lovell, Materov and Schmidt, 1982).

[vii] The likelihood ratio test statistic is $\lambda = -2\{\log(likelihood(H_0)) - \log(likelihood(H_1))\}$. It has a χ_k^2 distribution where k is the number of parameters assumed to be zero in the null hypothesis. Log likelihoods needed to construct the test statistics are estimated from the Frontier 4.1 program as part of the frontier output (see Coelli, Battese and Rao, 1998).

[viii] A similar approach is followed by Piesse and Thirtle (2000).