The Missing Link Between Financial Constraints and Productivity

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Abstract

This paper provides new evidence on the link between finance and firm-level productivity focusing on the case of Estonia. We contribute to the literature in two important respects: (1) we look explicitly at the role of financial constraints; and (2) we develop a methodology that corrects for the misspecification problems of previous studies. Our results indicate that young and highly indebted firms tend to be more financially constrained. Overall, a large number of firms shows some degree of financial constraints, with firms in the primary sector being the most constrained. More importantly, we find that financial constraints do not lower productivity for most sectors with the exception of R&D, where the dampening effect of financial constraints on productivity is remarkably large. These results are robust to a variety of sensitivity tests.

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1 Introduction

A growing empirical evidence suggests there is a positive relationship between financial development and growth.[2] As in other countries in emerging Europe, Estonia's income convergence to EU levels has actually been accompanied by rapid financial deepening. Although the precise channels through which finance affects growth are not yet well understood, the existing literature underscores that, by mitigating information and transactions costs, a well-developed financial system can influence saving rates, investment decisions, and productivity—which embodies technological innovation. This paper focuses on the link between access to finance, specifically financial constraints, and productivity given the central role of the latter for economic growth and development.[3]

On the theoretical side, several models have articulated the mechanisms by which the financial system may increase productivity. The main idea is that access to finance facilitates firms' investment in long-duration and productivity-enhancing projects. These projects are more easily undertaken when there are liquid financial markets given that investors can sell their stake in the project if they need their savings before the project matures (see, for example, Levine, 1991; and Bencivenga et al., 1995). Also, financial markets can help by evaluating prospective entrepreneurs, mobilizing savings to finance the most promising investment projects, and diversifying the risks associated with these innovative activities (King and Levine, 1993a). In addition, perfect credit markets increase the propensity to engage in long-term productivity-enhancing investment by decreasing the level of liquidity risk involved in those investments (see Aghion et al., 2007a). It follows from these models that financial frictions will result in lower productivity.

The objective of this paper is to examine whether financial constraints have indeed reduced firm-level productivity in Estonia. The case of Estonia is particularly interesting because, despite significant financial deepening and rapid credit growth, more than 60 percent of

[2] See the surveys by Levine (1997, 2005) for a review of the theoretical and empirical literature.

[3] Access to finance can clearly affect capital accumulation. However, the literature has identified innovation and technological progress as the main drivers of growth over extended periods of time (see, for example, Solow, 1957). Moreno Badia (2007) also finds that most of Estonia's income convergence with EU15 since the mid-1990s stems from closing the gap in total factor productivity.

corporate investment in Estonia is financed with internal funds.[4] Moreover, the 2006 progress report on the implementation of the Lisbon Strategy argues that Estonia's adoption of new technologies is hindered by insufficient access to capital.[5] This suggests that some firms may be constrained in their investment and input decisions, with a potentially detrimental impact on productivity relative to unconstrained firms.

To identify the effect of financial constraints on firms' productivity, we use a unique firm-level dataset covering the primary, manufacturing, and service sectors for the years 1997 to 2005 and proceed in two steps. First, we construct a measure of financial constraints by building on the literature of investment sensitivity to internal finance. Since firms may transit from different financial states, we allow this measure to vary with a set of firm characteristics that, a priori, are considered to determine the ability of a firm to attract external finance. The advantage of this approach is that it allows us to capture differences in the degree of financial constraints across firms and time. Second, we estimate the impact of this measure on firm-level productivity. For comparison with previous studies, we first estimate two separate equations: (i) a production function equation following Levinsohn and Petrin (2003) to obtain firm-level productivity estimates; and (ii) a productivity equation whose main regressor is the measure of financial constraints.[6] This *indirect* approach has, however, two shortcomings: (1) while Levinsohn and Petrin assume firm productivity follows a first-order Markov process, the productivity equation in (ii) does not control for lagged productivity and thus suffers from serial correlation; and (2) firms observe their own financial constraints and may respond by adjusting their inputs, which biases the firm-level productivity estimates in (i). To address these problems, we develop an alternative *structural* approach similar to the one used in the trade literature where we estimate a production function equation that directly includes financial constraints as a regressor while allowing productivity to evolve as a first-order autoregressive process.[7] To control for the potential

[4] This could be due to financial frictions but may also be explained by the fact that, since 2000, retained earnings are not taxed in Estonia.

[5] According to the same report, access to loans is hindered by many factors including, insufficient guarantees or own capital, short financial history or insufficient business plan, financial institutions' disproportionally large costs of processing small-scale loans.

[6] A similar approach is used, for example, in Gatti and Love (2008).

[7] See, for example, Van Biesebroeck (2005), Amiti and Konings (2007), De Loecker (2007), and Fernandes (2007).

simultaneity bias between productivity shocks and financial frictions we consider the lag of the financial constraints measure and control for unobserved industry fixed characteristics.[8]

Our main findings are as follows. First, we show that the investment of both young and highly indebted firms is more sensitive to internal funds and, as expected, foreign firms tend to be less financially constrained than the average Estonian firm. Overall, a large number of firms displays some degree of financial constraints with firms in the primary sector being the most constrained. Second, the results from the *indirect* approach suggest that financial constraints may have a negative impact on productivity. However, once we correct for the biases in this approach we find that financial constraints do not have an impact on productivity for most sectors with the exception of R&D, where the dampening effect of financial constraints on productivity is remarkably large. These findings are robust to several sensitivity tests.

The empirical literature on the relationship between finance and productivity is scant, with most studies focusing on the role of financial development. For example, at the macro level King and Levine (1993a, b) find that financial development has a positive effect on productivity. Beck et al. (2000) show that financial intermediaries help economic growth through more efficient resource allocation rather than through investment or saving. Arestis et al. (2003) argue that financial policies affect growth mainly through total factor productivity (TFP). Rioja and Valev (2004) find that finance has a strong positive effect on productivity growth primarily in more developed economies. At the micro level, Ayyari et al. (2007) use a large panel of firms in 47 developing countries to show that external finance increases innovation. Finally, Gatti and Love (2008) find that access to credit has a positive impact on TFP in Bulgaria. Although these papers study various aspects on financial development or access to finance, they put little or no emphasis on the direct effect of financial constraints on productivity. They also tend to rely on country specific data or firm level data that do not allow to estimate TFP accurately. Our results show that the misspecification error can be large. Ours is the first study to provide empirical evidence at the firm level that financial constraints may not lead to lower productivity.

[8] The simultaneity bias arises because investors may ration credit to the less productive firms.

The remainder of this paper is organized as follows. Section 2 describes the data. Section 3 discusses the previous literature testing for the presence of firm-financing constraints and estimates the baseline measure of financial constraints. Section 4 outlines the estimation strategy to analyze the impact of financial constraints on productivity. Section 5 presents the results. Section 6 concludes.

2 Data and stylized facts

We use firm-level data provided by the Estonian Business Registry covering the period 1997 to 2005. The dataset is an unbalanced panel containing detailed information on balance sheets and income statements of all registered firms in Estonia. Entry and exit are observed, and the number of business entities in the registry more than doubles over the sample period, from 21,183 firms in 1997 to 51,385 firms in 2005. However, due to missing information and the exclusion of extreme or unrealistic observations, only the data of 45 percent of the firms in the registry (accounting for about 60 percent of aggregated value added in 2004[9]) can be used.[10]

One of the unique features of the dataset is the absence of any size thresholds. About 99 percent of the firms in the dataset are small and medium-sized enterprises (SMEs), of which micro-enterprises are the dominant form of business organization, accounting for 69 percent of the total number of firms (Figure 1).[11] In addition, more than 90 percent of the firms included in the dataset are privately owned (Table 1).[12] The sectors with the largest share of foreign-owned firms are "mining and quarrying" and "manufacturing", but the percentages remain very low. This makes this dataset particularly well-suited to analyze the implications of financial frictions since privately owned firms, and SMEs in particular, usually receive a very low share of credit in many emerging markets, despite accounting for a large share of

[9] Comparability between the micro and macro data is limited, however, owing to methodological inconsistencies. Value added at the macro level is a broader concept since it covers not only the activities of enterprises but also of other economic units. According to the Statistical Office of Estonia, all enterprises registered in Estonia accounted for about 70 percent of aggregate value added in 2005.

[10] For a detailed description of the data and definitions, see Appendix A. More detailed information on the dataset itself can be found in Masso et al. (2004).

[11] SMEs are defined as enterprises with less than 250 employees. Micro-enterprises are those with 10 or less employees.

[12] A firm is labeled private (foreign) if the sum of the private (foreign)-owned shares surpasses 50 percent.

enterprises, employment, and output. The OECD notes that SMEs are, in fact, in a severe disadvantage relative to their larger and more established counterparts, mainly due to monitoring difficulties and asymmetric information (OECD, 2006). As a result, the majority of these firms is often denied any access to the formal credit markets in emerging and developing countries.

Another salient feature of the dataset is the availability of data from all economic sectors in Estonia. Table 2 reports the number of firms in the sample by year and broad industry group. Most enterprises (61 percent of the total number of firms) are operating in business services sectors (such as wholesale and retail trade, hotel and restaurants, or transport activities). The manufacturing sector is the second most important sector in Estonia, accounting for 17 percent of the total number of enterprises. The number of firms in the dataset increases over time, partly due to an improvement in the coverage.[13] However, most of the new firms are newly registered firms and are thus effective entrants. Although declining, Estonian entry and exit rates are fairly high by international standards (Figure 2). Exit rates among Estonian firms were particularly high in the late 1990s. The high firm turnover may be partly related to the restructuring during the transition period, with a shift from large-scale state-owned production to smaller private units. Although start-ups and very young firms may have innovative products and services and high growth prospects, they typically lack sufficient collateral. According to the OECD, this group in particular faces important obstacles in accessing adequate financing.

For the rest of the analysis we exclude all financial, insurance and real estate firms, plus public services companies since they are not or less subject to financial constraints, or their investment behavior depends more on political decisions or broader economic policy rather than on access to (external) finance.[14] In addition, we exclude state-owned firms since they are more likely to face soft budget constraints, and are not necessarily profit-maximizing agents—a necessary assumption in our productivity estimation in Section 4.[15]

[13] The improvement in data coverage may be related to the introduction in 2000 of fines penalizing those firms that do not submit income or balance sheet statements.

[14] More specifically, we exclude the sectors with EMTAK 65 to 70 (financial intermediation and real estate activities) and EMTAK 75 to 99 (public services). See Table A.1 for a complete list of the sectors.

[15] See Kornai (1979, 1986) for the introduction and discussion of the concept of a soft budget constraint. A

As a preliminary analysis of the impact of financial frictions, we provide some summary statistics on the differences between firms that utilize external finance versus firms without it. In particular, Table 3 shows that more than half of the firms in our sample have no long-term liabilities on their balance sheets during their entire lifespan. These firms are on average much smaller in terms of number of employees, sales or value added, and they are slightly younger. In addition, their capital intensity, labor productivity, and investment rate are considerably lower than those firms that borrow from banks or private investors. Figures 3 through 5 graph trends in key microeconomic variables for firms with long-term liabilities (Debt) compared to firms without them (No debt). Specifically, Figure 3 shows that firms with debt are on average always more productive, but the difference is rather small until the year 2000. However, in more recent years, firms with debt experienced an exponential growth in their labor productivity, whereas no-debt firms' productivity increased only slightly. Figure 4 focuses on the capital intensity, and shows a comparable pattern. Capital intensity more than doubled from 124,000 Estonian Krones in 2000 to almost 310,000 Estonian Krones in 2005 for those firms with long-term liabilities, as opposed to an almost flat trend for the group of firms without debt. Finally, Figure 5 graphs investment as a ratio of total assets, and shows that the ratio is about twice as high for firms utilizing external finance than those without it over the entire sample. Although the trends in the investment ratio are similar for both groups, the investment ratio of indebted firms declined immediately in the aftermath of the Russian crisis, whereas the no-debt firms responded with one-year lag. In addition, the rate of increase in investment was much higher among indebted firms: the investment ratio rose by merely one percentage point for firms without external finance, while that ratio was 22 percent higher than the 1999 level for firms with external debt. Overall, these patterns illustrate fundamental differences in the performance and operation of firms that borrow from banks or private investors versus firms without long-term liabilities. In the rest of the paper we exploit these observed dissimilarities and try to disentangle the correlation between a more formal measure of financing constraints and productivity.

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series of papers have found that financial constraints were absent or limited in some transition countries and have argued this was due to the persistence of soft budget constraints (see, for example, Budina et al., 2000; Lizal and Svejnar (2002); and Konings et al., 2003).

3 Measuring financial constraints

To construct a measure of financial constraints, we rely on the literature of investment sensitivity to internal finance. Modigliani and Miller (1958) show that under certain assumptions, including perfect capital markets, internal and external funds are perfect substitutes. Therefore, a firm's financial structure and liquidity should be irrelevant for its investment decisions. Since this influential paper, however, an extensive theoretical literature has shown that capital market imperfections can make external finance more expensive than internal finance due to informational asymmetries, costly monitoring, contract enforcement, and incentives problems.[16] As a result, firms with weak balance sheets may have limited access to external finance, and are obliged to rely on internally generated cash to finance their investment projects. The majority of the empirical literature has interpreted the excess sensitivity of a firm's investment spending to its ability to internally generate cash as the existence of financial constraints.

The first empirical papers in this field used a *Q*-model of investment to study financing constraints.[17] Several articles emphasize, however, a number of problems with the *Q*-methodology related to measurement errors, unrealistic assumptions, and identification problems.[18] This paper follows the more recent literature (inter alia Bond et al. 2003; Love, 2003; and Forbes, 2007) and focuses on an Euler-equation model of financial constraints. Although the *Q*-theory and Euler-equation models of investment depart from the same optimization problem, the assumptions required to estimate the Euler equation are less strong. In addition, Kaplan and Zingales (1997) critique, who question the approach of Fazzari et al. (1988) of using investment-cash flow sensitivities as a proxy for financing constraints, has not yet been theoretically proven in a dynamic multi-period setting with investment adjustment costs (Bond et al., 2003). Finally, information on a firm's market value, which is used as a proxy for Tobin's *q*, is only available for publicly listed companies. The Euler equation has the advantage that it avoids the use of share prices.

[16] See Stein (2001) for a review of the theoretical literature.

[17] The *Q*-theory of investment was pioneered by Tobin (1969) and further extended by Hayashi (1982). We refer to Hubbard (1998) for a review of the empirical literature.

[18] See Schiantarelli (1996) and Hubbard (1998) for a detailed description of these issues.

3.1 Euler-equation approach

The Euler equation is a structural model derived from a dynamic optimization problem under the assumption of symmetric, quadratic costs of adjustment. It relates current investment to last period's investment and the marginal product of capital, and has the advantage of controlling for all expectational influences on the investment decision. The main disadvantage is that the structure of adjustment costs is rather restrictive. Besides, the Euler equation approach may fail to detect the presence of financial constraints if the tightness of such constraints is approximately constant over time (Schiantarelli, 2005). While this risk is particularly severe in very short panels, our data covers a period long enough to record changes in individual firms' financial strength and overall macroeconomic conditions. The empirical specification of the Euler equation is as follows (see Appendix B for the derivation):

$$\left(\frac{I_{it}}{K_{it-1}}\right) = \theta_0 + \theta_1\left(\frac{I_{it-1}}{K_{it-2}}\right) + \theta_2\left(\frac{Sales_{it}}{K_{it-1}}\right) + \theta_3\left(\frac{Cash_{it}}{K_{it-1}}\right) + \alpha_i + \delta_t + \varepsilon_{it}, \qquad (1)$$

where I_{it} is the investment expenditure of firm i at time t; $Sales_{it}$ is the net revenue received from the sale of products, goods and services: $Cash_{it}$ represents a firm's internal financial position measured by its stock of liquid assets at the start of period t; α_i represents a firm fixed effect, and δ_t denotes a time dummy. All variables in equation (1) are in real terms and are weighted by one-period lagged capital (K). In this model, the cash stock affects the rate of inter-temporal substitution between investment today and investment tomorrow. If a firm is financially constrained, the impact of cash stock on the inter-temporal allocation decision will be positive. The more financially constrained a firm is, the larger will be the impact of its available cash stock on the cost of capital. In other words, an increase in cash stock will lower the implied cost of capital, making investment today more attractive that investment tomorrow. This implies that a firm is considered to be financially constrained if the cash coefficient, θ_3, is estimated to be positive. The idea behind this equation is that the larger the sensitivity of investment to cash stock (or cash flow), the more constrained the firm is because it has to rely on its internal funds to finance its investment projects.[19]

3.2 Empirical model

Typically, the literature divides a sample of firms based on a characteristic that is a priori expected to affect financial constraints, and then compares the cash-sensitivity of investment for both groups. This approach implies that a firm belongs to the financially constrained or unconstrained group for the entire period of time, without the possibility to transit between different financial states. In addition, partitioning observations into groups on the basis of a single indicator may not always be a sufficient indicator for liquidity constraints. The severity of financial constraints often varies among firms of the same subgroup because of other factors that are not controlled for. One possible way to address both issues is to use endogenous switching regressions methods with unknown sample separation.[20] Yet, this approach comes at the cost that one has to make very restrictive assumptions of the underlying investment model. Instead, we estimate and construct for each firm a score of cash sensitivity based on a range of firm characteristics that may affect its ability to attract external finance, while controlling for the information contained in other factors. To determine this set of variables, we browse the existing literature. First, one of the most widely used proxy for the degree of liquidity constraints is firm *Size*. Smaller firms are likely to be financially constrained for a number of reasons: (1) small firms often lack sufficient collateral; (2) SMEs tend to show a more volatile pattern of growth and earnings, with greater fluctuations than larger companies; (3) large firms can raise debt more easily because they are more diversified and less prone to bankruptcy. All these factors raise the cost of external finance for small firms, hence supporting the hypothesis that small firms have a higher sensitivity of investment to internal funds. Second, similar to size, *Age* may proxy for the wedge between the costs of external versus internal capital. Agency and information problems are more severe for young firms since they have not yet built up a track record that

[19] Although cash stock may be a proxy for future profit opportunities, it has been argued that this would only be the case in the presence of financial constraints (see, for example, Love, 2001). The main idea is that holding liquid assets is costly. Therefore, a firm, anticipating profitable investment opportunities, will accumulate liquid assets only if it expects to be financially constrained.

[20] This methodology does not require a prior knowledge of whether a firm is financially constrained since the probability of a firm facing a high premium on external finance is endogenously determined by multiple firm characteristics. See, for example, Hu and Schiantarelli (1998), Hovakimian and Titman (2004), and Almeida and Campello (2007).

helps investors to distinguish good from bad enterprises. Also the provision of collateral is particularly difficult for start-ups and other relatively young businesses. Third, the ratio of debt to total assets, *Leverage*, signals two opposite effects. On the one hand, higher debt means that the firm had access to external finance in the past, which may be an indication that the firm does not face liquidity constraints. However, it does not necessarily mean that the firm obtained as much finance as it would have liked to or whether the received loan was below the optimal value. On the other hand, leverage may negatively affect investment expenditures through (1) a liquidity effect (see, for example, Lang et al., 1996); and (2) because highly leveraged firms may face bigger hurdles in accessing external sources of capital.[21] Finally, Harrison and McMillan (2003) argue that foreign firms are not or less credit constrained because they are more profitable and/or have access to more collateral, and they find evidence supporting their hypothesis. To assess the statistical significance of a given factor in proxying financial constraints, each of the above discussed variables is interacted with ($Cash_{it}/K_{it-1}$) in equation (1)

$$\left(\frac{I_{it}}{K_{it-1}}\right)=\theta_0+\theta_1\left(\frac{I_{it-1}}{K_{it-2}}\right)+\theta_2\left(\frac{Sales_{it}}{K_{it-1}}\right)+\theta_3\left(\frac{Cash_{it}}{K_{it-1}}\times\mathbf{\Omega}_{it}\right)+\alpha_i+\delta_t+\varepsilon_{it}, \qquad (2)$$

with

$$\mathbf{\Omega}_{it}=\delta_1 I_1+\ldots+\delta_N I_N+\lambda_1 \ln(Size)_{it}+\lambda_2 \ln(Age)_{it}+\lambda_3 Leverage_{it}+\lambda_4 Foreign_{it}.$$

$Size_{it}$ is measured as total assets at the beginning of period t; Age_{it} is the age of the firm at the beginning of period t, based on the entry date in the Registry; $Leverage_{it}$ stands for the ratio of long-term liabilities to total assets at the beginning of period t; $Foreign_{it}$ is a dummy equaling one if more than 50 percent of the shares is foreign owned at time t. Finally, we take into account differences in investment-cash sensitivity across sectors, i.e. we allow for a different intercept for each 2-digit industry ($I_1,\ldots,I_N$). The estimated coefficients for the δ's and the λ's are then used to calculate a firm-specific score of financial constraints $\hat{F}_{it}^n$ based on the firm's characteristics:

[21] The basic idea is that debt-overhang reduces the incentives of shareholders to invest in profitable projects since the benefits partly accrue to the debt holders. For a detailed discussion see Jensen and Meckling (1976), and Myers (1977).

$$\hat{F}_{it}^{n} = \hat{\delta}_n I_n + \hat{\lambda}_1 Size_{it} + \hat{\lambda}_2 Age_{it} + \hat{\lambda}_3 Leverage_{it} + \hat{\lambda}_4 Foreign_{it} \quad (3)$$

The bigger $\hat{F}_{it}^{n}$, the higher the degree of financial constraints. Although the coefficients are constant over the entire sample period, the characteristics of each firm change over time and hence also its degree of financial constraints.

3.3 Estimation issues

Since equation (2) is a dynamic investment model with a lagged dependent variable (I_{it-1}/K_{it-2}) and unobserved time-invariant firm-specific effects (α_i), we estimate the equation using a Generalized Methods of Moments (GMM) estimator. By construction, the fixed effects are correlated with the lagged dependent variable, making standard estimators inconsistent. First-differencing the equation removes the fixed effects, eliminating a potential source of omitted variable bias in the estimation. Yet, the presence of the lagged dependent variable continues to bias the coefficient estimates, and many of the variables in the investment equation are likely to be jointly endogenous—i.e. simultaneously determined with the dependent variable or subject to two-way causality.

To control for these biases, Arellano and Bond (1991) developed a two-step GMM estimator that instruments the differenced variables that are not strictly exogenous with all their available lags in levels. Under the assumptions that (i) the explanatory variables are predetermined by at least one period, and (ii) the error terms are not serially correlated, the estimated coefficients will be consistent and efficient. A problem with the original Arellano-Bond estimator is that lagged levels are poor instruments for first differences if the variables are close to a random walk. Arellano and Bover (1995) and Blundell and Bond (1998) describe how the use of lagged first-differences as instruments for equations in levels, in addition to the usual lagged levels as instruments for equations in first-differences, can increase efficiency of the estimator.[22] This so-called system GMM method is flexible in generating instruments, and one can test the validity of the assumptions First, the Sargan/Hansen *J*-test of over-identifying restrictions tests the null hypothesis of no correlation between the instruments and the residuals, and its statistic has an asymptotic

[22] The additional assumption for the system-GMM estimator is that the first-differences of instrumenting

chi-square distribution with degrees of freedom equal to the difference in the number of instruments and regressors. Second, we test for different-order serial correlation in the residuals. The presence of autocorrelation in the error terms would indicate that lags of the dependent variable (and any other variables used as instruments that are not strictly exogenous), are in fact endogenous and thus bad instruments. Since first-order autocorrelation is expected, one has to test for second-order serial correlation in the differenced equation. If there is evidence of second-order serial correlation, but no third-order (or higher), then the level variables lagged by two periods (or more) are valid instruments.

A weakness of the first-difference transformation is that it magnifies gaps in unbalanced panels. To maximize our sample size we use the "orthogonal deviations transform" of Arellano and Bover (1995). Instead of subtracting the previous observation from the contemporaneous one, it subtracts the average of all future available observations of a variable. No matter how many gaps, it is computable for all observations except the last for each individual, so it minimizes data loss.

3.4 Results on financial constraints

The results for the estimation of the Euler-equation model are reported in Table 4. Equation (2), with I_{it}/K_{it-1} as dependent variable, is estimated for each of the 10 industries separately. We apply a system GMM estimator combining equations in first-differences with equations in levels. The instruments used are the lagged values of all right-hand side variables dated *t-3* and *t-4*. This allows for contemporaneous correlation between these variables and shocks to the investment equation, as well as correlation with unobserved firm-specific effects. In other words, all right-hand variables are treated as potentially endogenous variables in the investment equation.

The autocorrelation test and the robust estimates of the coefficient standard errors assume no correlation across individuals in the idiosyncratic disturbances. Time dummies make this assumption more likely to hold, so they are included in all regressions. In the GMM estimation year dummies are used as instruments for the equations in levels only.

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variables are uncorrelated with the unobserved firm-specific effects.

Additionally, each regression includes interactions of the variable $Cash_{it}/K_{it-1}$ with 2-digit industry dummies ($I_1,\dots,I_N$), to allow for differences in financial constraints across sub-sectors in each industry. Neither the time dummies nor the 2-digit industry intercepts are reported in Table 4 to keep a clear overview, but we report the Wald test of the null hypothesis that both groups of variables are jointly insignificant.

Since we have more instruments than exogenous variables, we have a number of over-identifying restrictions in each regression. Since the Sargan statistic is not robust to heteroskedasticity or autocorrelation, we report the robust Hansen *J*-statistic, which is the minimized value of the GMM criterion function. The Sargan/Hansen tests for over-identifying restrictions are unable to reject the validity of the instruments for each of the industries, and the tests of second-order serial correlation find no evidence of second-order autocorrelation in the differenced residuals.[23]

The coefficients on lagged investment and sales have the correct sign for most specifications, but are much smaller in absolute value than suggested by theoretical predictions. The coefficients are usually positive, with significance fluctuating across specifications. Focusing next on the interactions of the cash variable with the different proxies for liquidity constraints we find that, contrary to expectation, there are no significant differences in financing constraints based on firm size. The coefficient on ($Cash_{it}/K_{it}$ x Age_{it}), on the other hand, illustrates that in half of the industries older firms face significantly less hurdles in accessing external funds. Also highly indebted firms tend to encounter significant liquidity constraints. Finally, foreign firms seem to have easier access to external capital.[24]

Based on these results we construct a firm-specific score of financing constraints using the estimated coefficients and the information we have on its size, age, leverage, ownership structure, and the industry to which the firm belongs. In other words, we calculate for each firm a score based on equation (3). If a firm is not financially constrained, the score $\hat{F}_{it}$ is

[23] Only for sector "renting of machinery and computer" (Ind. 9) we cannot reject the presence of second-order autocorrelation at the 5 percent significance level.
[24] As shown in Section 2 there are few foreign firms in each sector. This lack of variation could be a reason why we fail to find a significant effect of foreign ownership in most sectors.

censored to zero.[25] The bigger $\hat{F}_{it}$ the higher the degree of liquidity constraints a firm faces. Table 5 provides an overview of the magnitude and distribution of the degree of financing constraints across sectors. A large number of firms seems to be subject to some degree of financial constraints. Overall, the degree of financial constraints tends to be highest in the primary sector ("agriculture" and "mining and quarrying", and "energy, gas, and water supply"). This does not imply, however, that firms in other (less constrained) sectors are not financially constrained. As can be seen in the last column of Table 5, variation across firms is relatively larger in the primary sector and "hotels and restaurants".

Figure 6 graphs the industry means of the financing constraints over the period 1998-2005 and shows wide discrepancies across sectors. In particular, financing constraints were relatively high in "agriculture" over the entire sample period but they have even increased further in recent years. The "mining and quarrying" sector displays a similar upward trend, while the financing constraints remained relatively constant across time for the other sectors.[26]

As a first indication of the impact of financing constraints on a firm's performance, we look at the correlation between a firm's degree of financing constraints and a number of firm characteristics, such as its value added, labor productivity, TFP, and sales per worker. Table 6 displays the Spearman's rank correlation coefficients for all pairs of variables. This table shows that firms in industries with a relatively higher degree of financial constraints perform worse at all levels relative to firms in industries with easier access to external funds. The correlation is particularly strong in the case of firm labor productivity and TFP. In the next sections we explore this relationship more formally.

[25] The overall conclusions are similar even if we do not censor the score of financial constraints to zero. A minority of firms has a negative score, but the industry means and medians remain positive. Also, the results for the rest of the analysis are similar.

[26] In principle, we would expect financial constraints to ease overtime as the degree of financial intermediation increased in Estonia during this period. However, demand for credit may have increased more than the available funds because of the emergence of new financing needs as the economy grew and the entry of new firms. Also, this could be an indication of credit misallocation.

4 Relating productivity to financial constraints

To analyze the relationship between firm-level financial constraints and productivity, we follow two alternative estimation procedures: an indirect approach and a structural one.

4.1 Indirect approach

In this approach, we proceed in two steps. First, we estimate firm-level total factor productivity. Assuming a Cobb-Douglas production function, a measure of TFP can be obtained by estimating the equation

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \varepsilon_{it}, \tag{4}$$

where i and t indicate firm and time respectively, and all variables are presented in natural logarithms. Value added (y_{it}) is measured as net sales minus intermediate inputs, labor input (l_{it}) stands for the number of employees, and capital (k_{it}) is net of accumulated depreciation and calculated as the sum of tangible and intangible fixed assets minus goodwill. All variables are in real terms (see Appendix A for details). The error term has two components: a productivity term ω_{it} known to the firm and correlated with the inputs, and a random productivity shock ε_{it}.

Equation (4) cannot be consistently estimated by ordinary least squares (OLS) because of an endogeneity bias and a selection bias. The endogeneity bias stems from the correlation between unobserved productivity and a plant's input decisions. If more productive plants tend to hire more workers and buy more materials due to higher current and anticipated future profitability, OLS will tend to provide upwardly biased estimates on the input coefficients. The selection bias arises because firms with productivity level below some threshold exit from the market. Yet, firms with larger capital stocks can expect larger future returns for any given level of current productivity, and will therefore continue in operation for lower productivity levels. This self-selection induced exit behavior leads to a negative bias in the OLS capital coefficient.

To control for both biases, Olley and Pakes (1996) and Levinsohn and Petrin (2003) suggest a methodology using respectively investment or intermediate inputs as a proxy for productivity. Both papers make two key identifying assumptions. First, the proxy must be monotonically increasing with respect to the true productivity shock. Second, the so-called freely variable input (labor) responds immediately to a shock, while the state variable (capital) responds only after an adjustment lag. Given that state variables do not respond to contemporaneous noise, the idiosyncratic shock can be represented as a function of the proxy variable and state variables. A detailed description of the semi-parametric estimation methodology can be found in Appendix C.

The key difference between the Olley-Pakes and Levinsohn-Petrin estimators is the choice of the proxy variable, where the former uses investment and the latter intermediate inputs. The data coverage of the proxy is an important factor in deciding which approach to use.[27] Namely, the monotonicity condition requires strictly positive investment (in the case of Olley-Pakes) or intermediate inputs (in the case of Levinsohn-Petrin). Plants with infrequent investment would be systematically dropped from the Olley-Pakes estimation, with a significant loss in efficiency as result.[28] On the other hand, most firms report positive use of materials in each year, so it is possible to retain most observations. Given this feature of the Estonian data, we choose to use the Levinsohn-Petrin intermediate proxy estimator rather than the Olley-Pakes investment proxy estimator.

We estimate equation (4) for each 2-digit industry separately to allow for technological differences across industries, and time dummies are included to capture macroeconomic changes. The estimated input coefficients are reported in Appendix C (Table C.1), together with the OLS estimates for comparison. We use bootstrapping methods to obtain correct standard errors for the capital coefficient, where we use 1000 replications.[29] As expected, the labor coefficients are over-estimated with OLS. Using these production coefficient estimates, we define the log of measured *TFP* of firm i at time t in industry j as $tfp_{it}^{j} = y_{it} - \hat{\beta}_{l}^{j} l_{it} - \hat{\beta}_{k}^{j} k_{it}$ (Table C.1, last column).

[27] Other differences are related to the underlying assumptions and estimation techniques. See Ackerberg et al. (2005) for a review and detailed discussion of the Olley-Pakes and Levinsohn-Petrin methodologies.
[28] In our dataset there is a substantial number of zero or missing investment observations (about 45 percent of the total number of observations).
[29] The use of estimated regressors at different stages of the procedure increases the final coefficients' variability. Therefore, bootstrapped standard errors on the capital coefficient tend to be overestimated (Pakes and Olley, 1995). See Horowitz (2001) for an overview of the bootstrap estimation methodology.

In the second step of our indirect approach, we examine the relation between firm productivity and financing frictions, and estimate a productivity equation with financial constraints as main regressor. For ease of notation the industry index is dropped.

$$tfp_{it} = \beta_0 + \beta_f \hat{F}_{it-1} + \beta_x^{'} X_{it} + \delta_j + \delta_t + \varepsilon_{it} \tag{5}$$

where $\hat{F}_{it-1}$ represents the lagged firm-level measure of financial constraints obtained from Section 3. To limit a potential endogeneity of financial constraints with respect to productivity, our measure of financial constraints is included in the regression with one-year lag. X_{it} is a vector of firm *i*'s characteristics, which includes the logarithm of age and size, and ownership dummies. δ_j and δ_t are 2-digit industry and year dummies. Equation (5) is estimated using OLS and we use bootstrapping methods to obtain consistent standard errors for the coefficients. Here again we use 1000 replications.

4.2 Structural approach

The indirect approach described above suffers from two problems. First, Levinsohn and Petrin (2003) assume firm productivity follows a first-order Markov process. However, equation (5) does not control for lagged productivity and thus suffers from serial correlation. As a result, our lagged measure of financial constraints will be correlated with the error term, yielding our estimates inconsistent.[30] Even if we were to control for lagged productivity there will be a second problem. In particular, conditional on lagged productivity, we would still be assuming that current productivity depends on financial constraints and other determinants, which are known to the firm in advance. Yet, the Markov process assumption in the Levinsohn-Petrin methodology implies that, conditional on lagged productivity, current firm productivity should be a surprise. Thus, the estimated productivity measures and the impact of financial constraints on productivity would be biased.[31]

To control for these issues, we incorporate financial constraints directly as a regressor in the

[30] tfp_{it-1} will be part of the error term in equation (5) since productivity is assumed to follow a first-order Markov process. Given the endogeneity of financial constraints with respect to productivity, $\hat{F}_{it-1}$ will be correlated with tfp_{it-1} and, therefore, the error term in (5).

[31] It could be argued that, in this case, the identification conditions for productivity are violated and the materials demand function is not invertible.

production function equation:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_a \ln(Age)_{it} + \beta_f \hat{F}_{it-1} + \delta_j + \delta_t + \omega_{it} + \varepsilon_{it}, \qquad (6)$$

where ε_{it} is a zero-mean shock uncorrelated with inputs, financial constraints, and firm characteristics. To estimate equation (6), we modify Levinsohn-Petrin algorithm and treat financial constraints as an additional state variable.[32] As in Levinsohn and Petrin (2003), the coefficients of labor and plant characteristics are obtained in the first step using semi-parametric techniques utilizing the variable materials to correct the simultaneity bias between labor and productivity. However, the materials' demand function now becomes a function of three state variables, capital, productivity and financial constraints, $m_{it} = m_{it}\left(k_{it}, \omega_{it}, \hat{F}_{it-1}\right)$. Assuming monotonicity holds we can invert the materials' demand function to obtain an expression for productivity depending on observable state variables, $\omega_{it} = \omega_{it}\left(m_{it}, k_{it}, \hat{F}_{it-1}\right)$. Then, equation (6) can be rewritten in the following partially linear form

$$y_{it} = \beta_l l_{it} + \beta_a \ln(Age)_{it} + \lambda_t\left(m_{it}, k_{it}, \hat{F}_{it-1}\right) + \delta_j + \delta_t + \varepsilon_{it}, \qquad (7)$$

where

$$\lambda_t\left(m_{it}, k_{it}, \hat{F}_{it-1}\right) = \beta_0 + \beta_k k_{it} + \beta_f \hat{F}_{it-1} + \omega_{it}\left(m_{it}, k_{it}, \hat{F}_{it-1}\right).$$

We use a third-order polynomial with a full set of interactions to approximate unknown function λ_t, and estimate equation (7) using OLS. This gives us consistent coefficients on labor and other firm characteristics. In the second stage of the estimation algorithm, the probability that a firm exits from the Estonian registry is determined by the probability that the end-of-period productivity falls below an exit threshold. The same third-order polynomial in m_{it}, k_{it}, and $\hat{F}_{it-1}$ of the first stage is used to estimate the surviving probability. In the final step we estimate the coefficients on capital and financial constraints using non-linear least squares. Year and 2-digit industry dummies are included as well and taken along the estimation procedure. Standard errors for the parameter estimates are obtained by bootstrap.

Since capital and financial constraints enter the function $\lambda_t(.)$ twice, we need an additional identification assumption. We continue to assume that productivity follows a first-order Markov process $\omega_{it} = E(\omega_{it} \mid \omega_{it-1}) + \xi_{it}$. Using this assumption, the identification condition for capital is that capital responds with a lag to productivity shocks. Therefore, we can identify the capital coefficient by using the condition:

$$E[\varepsilon_{it} + \xi_{it} \mid k_{it}] = 0. \tag{8}$$

Because of the potential endogeneity, we include a lag of our measure of financial constraints. It is assumed that the financial constraints are observed by the firm in period t-1, similar to the assumption that plants choose their material input in period t-1 before productivity ω_{it} is known. This means that investors may ration credit to firms based on their information set in t-1. Given that productivity follows a Markov process, the shock in period t should be a surprise to investors and, thus, $\hat{F}_{it-1}$ should be uncorrelated with ξ_{it}. Therefore, the following moment condition identifies the coefficient of financial constraints:

$$E[\varepsilon_{it} + \xi_{it} \mid \hat{F}_{it-1}] = 0. \tag{9}$$

5 Results

5.1 Baseline results

In this section we discuss the baseline results of the indirect and structural approaches. Table 7 presents the results for the indirect approach. The dependent variable is the log form of either labor productivity (column 1), or total factor productivity obtained from estimating equation (4) using OLS (column 2), or using the Levinsohn-Petrin methodology (column 3). This allows us to check the sensitivity of our results to different productivity measures. For the specification with labor productivity we add the capital intensity of a firm as an additional explanatory variable to control for the fact that firms with higher capital intensity tend to have a higher level of productivity. The results in Table 7 are obtained from estimating equation (5) with OLS (bootstrapped standard errors in brackets). Though not reported in the table, all regressions include 2-digit industry dummies and time dummies.

[32] A similar approach is used in Fernandes (2007).

The negative and statistically significant coefficient on financing constraints indicate that firms with bigger hurdles to obtain external finance have a lower productivity level. Overall, the three different specifications of productivity yield very similar results although the effect on TFP is larger than that for labor productivity. The overall fit, as measured by the R-squared, increases when using the more consistent TFP estimator of Levinsohn and Petrin rather than the OLS estimate of TFP. In line with the findings of the literature on enterprise productivity, foreign firms are significantly more productive than their domestic counterparts. Finally, productivity is negatively correlated with age, but positively correlated with size.[33]

To analyze whether the impact of financial constraints on productivity varies across sectors, we estimate equation (5) for each industry (defined at the 1-digit level) separately. Table 8 shows that financing constraints considerably curtail productivity in most sectors except for "mining and quarrying", "wholesale and retail trade", and "transport and communication". This is consistent with the statistics reported in Table 5 and Figure 6 showing that the degree of financial constraints in the latter two sectors was relatively small. However, investment of Estonian firms operating in the mining sectors displayed a much higher sensitivity to internally generated cash flows than in the average sector but this does not seem to affect productivity significantly.

Since the estimates from the indirect approach may be subject to misspecification biases, as discussed in section 4, we report the results from the structural approach in Table 9. The dependent variable is the log form of real value added, and bootstrapped standard errors are reported in brackets. In contrast to the indirect approach, we find that financial constraints do not have an impact on firm-level productivity for most sectors. In particular, the last column of Table 9 shows that the coefficient on financial constraints is not significantly different from zero in eight out of ten sectors. Only in the sectors "construction" and "R&D and other business activities" the negative impact remains significant.[34] A possible explanation for this result could be that firms in both sectors are heavily dependent on external finance for their operations. In particular, firms in the construction sector need capital to pre-finance their

[33] In an alternative specification we estimated equation (5) including the squared age and size terms, but the results remain the same.

[34] In fact, these were two of the sectors where we found the highest impact of financial constraints on productivity using the indirect approach. The magnitude of the coefficients is roughly the same as in the indirect

projects since, in most cases, they will not have enough liquidity until the construction projects are finished and sold. Therefore, if firms are unable to convince banks or investors that their projects are worthwhile, or if they cannot present sufficient collateral, they cannot undertake productivity-enhancing activities with a detrimental effect on TFP relative to unconstrained firms. Similarly, firms in the R&D sector need a continuous inflow of fresh capital to keep up with the latest technology and invest in frontier-research. In general this involves risky investment, and few banks and investors are willing to take this risk. Even the smallest constraint in obtaining adequate funding entails major consequences for the firm. This result is confirmed by a recent OECD study in which they argue that the lack of appropriate financing has been a hindrance to the expansion of innovative (high-tech) SMEs in most OECD countries (OECD, 2006).[35] Without special arrangements to finance R&D projects, the R&D sector will lack the necessary dynamism for employment creation and competitiveness, and positive spillovers to other sectors will be limited.

Overall these results indicate that, although many Estonian firms may be subject to financial constraints, these have not resulted in significant differences in productivity levels. These results also show that the misspecification errors of previous studies could be large.

5.2 Robustness checks

This section discusses the robustness of the structural approach's results reported above. Table 10 summarizes the various tests we perform. We begin by looking at whether the results are sensitive to the time period considered. In particular, we split the sample in two periods: column (1) only includes 1997 to 2000, while column (2) includes the latter period from 2001 to 2005.The choice of these sub-periods is partly motivated by the fact that the quality of data improves substantially after 2000. Also, during the first period, credit growth slowed down sharply in the aftermath of the Russian crisis, recovering after 2000.

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approach.

[35] The results on the R&D sector are also in line with the findings of Aghion et al. (2007b). In particular, they argue that if firms can choose between short-term capital investment and long-term R&D investment, and innovation requires liquidity that can only be covered through short-run earnings and borrowing, negative shocks will reduce R&D investment and innovation more in firms that are credit constrained. Using data for France they find evidence supporting that theory.

Next we explore the impact of sample selection and removing outliers. First, we include those firms with negative investment (column 3). Second, for each industry, we eliminate from our sample those firms above the 99th percentile of the distribution of financial constraints to control for possible outliers in our measure of liquidity constraints (column 4).

Finally, we examine whether modifying the financial constraint variable has any significant impact on the results. In particular, we estimate financial constraints by using a standard accelerator model of investment (as in Konings et al., 2003). This type of model links the demand for capital goods to the level or change in firm's output or sales, and has been used in the empirical literature very successfully (see, for example, Abel and Blanchard, 1986; and Fazzari et al., 1988).

This series of sensitivity tests suggests that the key results reported in section 5.1 are highly robust. In particular, financial constraints do not seem to have a negative impact on productivity for most sectors. However, the results on the construction sector are weak since the coefficient of financial constraints, although still negative, loses its significance in many specifications (for example, for the period 2000-05). The results for the R&D sector are, however, remarkably robust, suggesting that the negative impact of financial constraints on productivity was very large during the period 2000-05. Nevertheless, that effect is reduced when using an alternative definition of financial constraints (column 4).

6 Conclusion

This paper provides new evidence on the link between finance and firm level productivity focusing on the case of Estonia. We contribute to the literature in two important respects. First, we look explicitly at the role of financial constraints. For that purpose, we construct a measure that allows us to capture differences in the degree of financial constraints across firms and time. Second, we develop a methodology to estimate the impact of financial constraints on productivity that addresses some of the shortcomings of previous studies. In our estimation, we rely on production function estimates that correct for the simultaneity of input choices and exit.

Our results indicate that young and highly indebted firms tend to be more financially constrained. Overall, a large number of firms displays some degree of financial constraints with firms in the primary sector being the most constrained. More importantly, we find that financial constraints do not have an impact on productivity for most sectors with the exception of R&D, where financial constraints have a negative impact on productivity and that effect is large. These results are robust to a variety of sensitivity checks.

What can explain these findings? There are a number of reasons why access to finance may not necessarily improve productivity for most sectors. First, in the face or rapid credit growth it is difficult for credit officers to screen clients and ensure that capital is allocated to the most productive activities (see, for example, Ghani and Suri, 1999). The rapid build-up in credit thus lowers the quality of investment and reduces the expected productivity gain. Second, higher liquidity may reduce the incentive of shareholders to undertake costly monitoring of managers, which impedes efficient resource allocation and slows productivity growth (Shleifer and Vishny, 1986; and Bhide, 1993). Third, overinvestment and low productivity may also result when managers maximize their own utility rather than firm profits (Grabowsky and Mueller, 1972). Finally, access to finance may lead to an increase in firms' production capacity—for example, by expanding plant size—without necessarily increasing productivity (Power, 1998). All of these arguments, indicate that financially unconstrained firms many not necessarily have higher productivity levels than constrained firms. In the absence of a more explicit estimation model we cannot distinguish which of these channels is at play in Estonia. This is an area for future research.

Our conclusions are, however, subject to some important caveats. First, firms are defined as being financially constrained if their investment is affected by their cash, after controlling for future expected profitability. Although this strategy has been widely used, there is an open debate on the accuracy of this definition. Second, the use of estimated regressors at different stages of the direct approach increases the final coefficients' variability. Therefore, bootstrapped standard errors on the financial constraints variable may be overestimated, resulting in its insignificance for most sectors. In any case, the results in this paper provide a cautionary note, underscoring that the efficiency of credit allocation is what matters for productivity and output growth and that is not always a sure thing.

Table 1. Ownership Structure 1/

	Private	State	Foreign
Agriculture	96%	0%	3%
Mining & Quarrying	88%	0%	12%
Manufacturing	90%	0%	10%
Electricity, Gas & Water	59%	40%	1%
Construction	97%	0%	2%
Business services	92%	1%	7%
Public services	94%	3%	3%
Total	93%	1%	6%

Sources: Estonian Business Registry database; and authors' calculations.
1/ Percentage of otal firms in each sector.

Table 2. Number of Firms by Year and Industry, 1997–2005

Industry	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Agriculture	516	542	538	599	677	777	829	878	805	6,161
Mining and quarrying	31	29	31	34	42	47	49	47	51	361
Manufacturing	1,377	1,605	1,881	2,205	2,508	2,728	3,000	3,127	3,063	21,494
Electricity, gas, and water	98	133	138	136	142	153	155	158	153	1,266
Construction	714	892	937	1,110	1,303	1,488	1,694	1,988	2,287	12,413
Business services	4,844	5,976	6,662	8,092	9,206	10,132	10,708	11,421	11,376	78,417
Public services	352	505	603	719	874	1,029	1,184	1,272	1,327	7,865
Total	7,932	9,682	10,790	12,895	14,752	16,354	17,619	18,891	19,062	127,977

Sources: Estonian Business Registry database; and authors' calculations.

Table 3. Summary Statistics

	Debt	No debt
Percentage of firms	46%	54%
Number of employees	23	7
Age	6	5
Sales	17,200	4,664
Value added	5,247	1,339
Capital intensity	198	59
Labor productivity	980	750
Labor productivity growth	0.06	0.04
Investment ratio	0.12	0.05

Sources: Estonian Business Registry database; and authors' calculations.
Notes: firms are divided in 2 groups: firms with long-term liabilities (Debt) and firmswith no long-term liabilities on their balance sheets during their entire lifespan (No debt). All variables are measured in thousand of Estonian Krones and deflated by 2-digit sector deflators; all variable definitions can be found in Appendix A. Capital intensity is defined as (net real tangible + net real intangible assets-goodwill)/labor; labor productivity= real sales per worker; investment ratio=real investment/real total assets lagged 1 year.

Table 4. Euler-equation specification, estimated using system GMM

	Ind. 1 (1)	Ind. 2	Ind. 3	Ind. 4	Ind. 5	Ind. 6	Ind. 7	Ind. 8	Ind. 9	Ind. 10
IK_{t-1}	-0.147**	0.007	0.159*	-0.089	0.070	0.060	0.203***	-0.109	-0.012	0.052
	[0.064]	[0.079]	[0.085]	[0.076]	[0.094]	[0.068]	[0.075]	[0.066]	[0.068]	[0.069]
YK	-0.002	0.0366***	0.00283**	0.008	0.000	0.000	0.00800**	0.000	0.0198***	0.003
	[0.003]	[0.009]	[0.001]	[0.011]	[0.000]	[0.000]	[0.004]	[0.001]	[0.006]	[0.003]
CK x size	0.034	-0.009	-0.007	-0.004	-0.012	0.007	0.016	0.007	0.001	-0.003
	[0.028]	[0.007]	[0.016]	[0.025]	[0.010]	[0.009]	[0.012]	[0.007]	[0.010]	[0.008]
CK x age	-0.086	0.197*	-0.0748**	0.102	-0.0680**	-0.008	0.062	-0.0897***	-0.0788*	-0.0794***
	[0.053]	[0.110]	[0.036]	[0.064]	[0.029]	[0.034]	[0.074]	[0.026]	[0.043]	[0.027]
CK x leverage	5.374***	5.401***	0.169***	3.745***	0.705	0.026	1.601***	0.056	0.792	0.394***
	[0.940]	[1.140]	[0.061]	[0.970]	[1.070]	[0.097]	[0.400]	[0.120]	[0.540]	[0.140]
CK x foreign	-0.622***	0.278	-0.008	-1.247**	0.046	-0.015	0.009	-0.111***	0.002	-0.052
	[0.210]	[0.470]	[0.079]	[0.500]	[0.037]	[0.022]	[0.077]	[0.039]	[0.032]	[0.039]
Number of observations	1,749	183	7,463	187	3,551	12,211	1,677	3,074	680	3,073
Number of firms	653	44	2,677	73	1,386	4,814	724	1,213	310	1,230
Sargan	0.001	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030
Sargan/Hansen (2)	0.493	1.000	0.815	1.000	0.372	0.103	0.358	0.692	0.658	0.259
AR(2) (2)	0.106	0.368	0.170	0.401	0.965	0.123	0.861	0.317	0.085	0.707
Industry dummies (3)	0.070	0.238	0.000	0.731	0.042	0.978	0.006	0.001	0.594	0.020
Year dummies (3)	0.000	0.772	0.011	0.166	0.011	0.358	0.771	0.077	0.838	0.004

Sources: Estonian Business Registry database; and authors' calculations.

Notes: Equation (2), with I_{it}/K_{it-1} as dependent variable, is estimated using system GMM. Though not reported, all regressions include time dummies, as well as the interaction of Cashit/Kit-1 with 2-digit industry dummies. Variable definitions are in Appendix A. Heteroskedasticity consistent standard errors are reported in brackets, with significance level: *** p<0.01, ** p<0.05, * p<0.1.

(1) The 10 industries are: 1. Agriculture; 2. Mining & Quarrying; 3. Manufacturing; 4. Energy, Gas & Water supply; 5. Construction; 6. Wholesale and Retail trade; 7. Hotels & Restaurants; 8. Transport & Communication; 9. Renting of machinery & Computer; 10. R&D and other business activities.

(2) The Sargan/Hansen and autocorrelation specification tests are reported as p-values.

(3) To keep a clear overview, we report neither the interactions of $Cash_{it}/K_{it-1}$ with the 2-digit industry dummies nor the time dummies. Instead we report the p-values for the Wald test of joint significance for both groups of included variables.

Table 5. Magnitude and Distribution of Financing Constraints by Sector

Industry	Number of observations		Financing constraints		
	Total	Zero constraints	Mean	Median	Standard deviation
1 Agriculture	5,369	286	1.035	0.482	1.441
2 Mining and quarrying	342	110	0.415	0.037	0.839
3 Manufacturing	19,346	3,046	0.093	0.066	0.106
4 Electricity, gas and water supply	550	67	0.456	0.083	0.714
5 Construction	11,001	1,034	0.099	0.055	0.142
6 Wholesale and retail trade	36,836	76	0.031	0.031	0.013
7 Hotels and restaurants	5,296	831	0.304	0.046	1.117
8 Transport and communication	9,547	649	0.090	0.070	0.081
9 Renting of machinery and computer activities	2,413	290	0.121	0.054	0.266
10 Research and development and other business activities	9,819	733	0.094	0.064	0.112

Sources: Estonian Business Registry database; and authors' calculations.
Note: Financial constraints are calculated based on equation (3).

Table 6. Correlation Between Financial Constraints and Other Firm Characteristics

	Financial constraints	Value added	Value added/worker	Labor productivity	TFP
Financial constraints	1.000	...	...	...	...
Value added	-0.411	1.000	...	...	...
Value added/worker	-0.477	0.387	1.000	...	...
Labor productivity	-0.879	0.327	0.428	1.000	...
TFP	-0.840	0.074	0.396	0.659	1.000

Sources: Estonian Business Registry database; and authors' calculations.
Notes: The Spearman rank correlations are based on the industry means to abstract from industry specific effects. Financial constraints are calculated based on equation (3). Labor productivity is measured as real sales per worker. Other variable definitions are in Appendix A.

Table 7. Results for the Two-step Approach

	Labor productivity	OLS	Levinsohn/Petrin
Age	-0.149***	-0.141***	-0.113***
	[0.007]	[0.007]	[0.007]
Size	0.234***	0.114***	0.353***
	[0.003]	[0.003]	[0.003]
Capital intensity	0.115***	...	...
	[0.004]		
Financing constraints	-0.040***	-0.098***	-0.159***
	[0.012]	[0.012]	[0.014]
Foreign dummy	0.271***	0.312***	0.253***
	[0.014]	[0.016]	[0.014]
Number of observations	35,429	35,429	35,429
R-squared	0.458	0.504	0.757

Sources: Estonian Business Registry database; and authors' calculations.

Notes: The dependent variable is the log form of either labor productivity (Column 1), TFP estimated using OLS (Column 2), or TFP estimated using the Levinsohn-Petrin methodology (Column 3). Equation (5) is estimated using OLS, and we use bootstrapping methods to obtain correct standard errors (1000 replications). Though not reported, all regressions include 2-digit industry dummies and time dummies. Significance level: *** p<0.01, ** p<0.05, * p<0.1. Capital intensity is the ratio of capital over the number of employees. Other variable definitions are in Appendix A.

Table 8. Results for the Two-step Approach, by Industry

	Number of observations	Labor productivity	OLS	Levinsohn/ Petrin
Agriculture	1,825	-0.02	-0.051***	-0.072***
		[0.016]	[0.015]	[0.015]
Mining and quarrying	189	-0.049	-0.014	0
		[0.060]	[0.061]	[0.059]
Manufacturing	7,798	-0.102	-0.199	-0.247*
		[0.142]	[0.156]	[0.143]
Electricity, gas, and water supply	196	-0.168**	-0.171**	-0.190***
		[0.080]	[0.087]	[0.072]
Construction	3,756	-0.189**	-0.337***	-0.385***
		[0.087]	[0.116]	[0.126]
Wholesale and retail trade	12,714	-0.095	-0.192	-0.157
		[0.132]	[0.153]	[0.119]
Hotels and restaurants	1,782	-0.067**	-0.076***	-0.149***
		[0.026]	[0.028]	[0.030]
Transport and communication	3,201	-0.114	-0.248	-0.196
		[0.409]	[0.554]	[0.425]
Renting of machinery and computer activities	758	-0.347***	-0.471***	-0.400***
		[0.118]	[0.133]	[0.106]
R&D and other business activities	3,210	-1.191***	-1.564***	-1.281***
		[0.267]	[0.290]	[0.261]

Sources: Estonian Business Registry database; and authors' calculations.
Notes: The dependent variable is the log form of either labor productivity (Column 1), TFP estimated using OLS (Column 2), or TFP estimated using the Levinsohn-Petrin methodology (Column 3). Equation (5) is estimated for each 1-digit industry separately using OLS. To keep a clear overview we report only the coefficients on the financing constraints measure. We use bootstrapping methods (1000 replications) to obtain correct standard errors (reported in brackets), with significance level: *** p<0.01, ** p<0.05, * p<0.1.

Table 9. Results for the Structural Approach, by Industry

	Number of observations	Labor	Capital	Age	Score
Agriculture	1,825	0.505***	0.335***	-0.019***	0.008
		[0.042]	0.070]	[0.010]	[0.018]
Mining and quarrying	189	0.340***	0.322***	0.031	0.059
		[0.135]	0.127]	[0.050]	[0.068]
Manufacturing	7,798	0.586***	0.051***	-0.014***	0.018
		[0.017]	0.026]	[0.005]	[0.124]
Electricity, gas, and water supply	196	0.481***	0.203	-0.003	-0.001
		[0.110]	0.188]	[0.027]	[0.135]
Construction	3,756	0.643***	0.190***	-0.024***	-0.299*
		[0.030]	0.035]	[0.006]	[0.156]
Wholesale and retail trade	12,714	0.520***	-0.022***	-0.012***	0.05
		[0.017]	0.011]	[0.003]	[0.120]
Hotels and restaurants	1,782	0.720***	0.039	-0.035***	-0.009
		[0.043]	0.090]	V0.007]	[0.023]
Transport and communication	3,201	0.567***	0.214***	-0.061***	0.336
		[0.035]	0.053]	[0.013]	[0.410]
Renting of machinery and computer activities	758	0.746***	0.138	-0.040***	-0.208
		[0.054]	0.129]	[0.015]	[0.472]
R&D and other business activities	3,210	0.726***	0.106***	-0.036***	-0.965***
		[0.027]	0.035]	[0.012]	[0.308]

Sources: Estonian Business Registry database; and authors' calculations.
Notes: Financing constraints are directly included in the TFP estimation as an additional state variable. The dependent variable of Equation (6) is the log form of real value added, and we use bootstrapping methods (1000 replications) to obtain correct standard errors (reported in brackets). The structural approach is estimated for each 1-digit industry separately. R-squared statistics are not available for the modified Levinsohn-Petrin estimation. Though not reported, all regressions include 2-digit industry dummies and time dummies. Significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are in Appendix A.

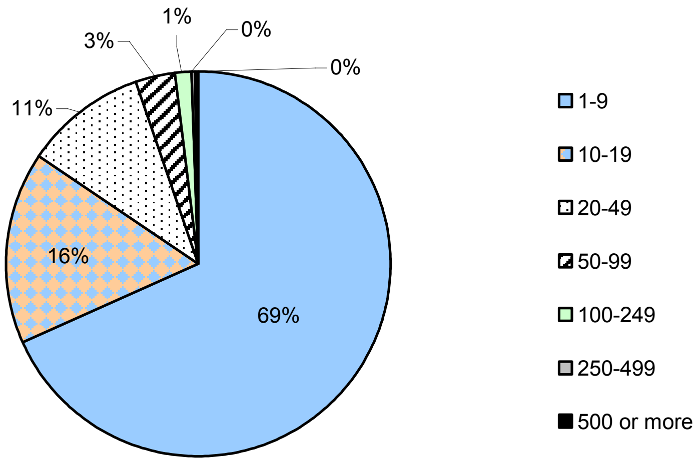
Table 10. Robustness Checks

	Sample splitting		Including negative investment	Outliers excluded	Accelerator model
	1997–2000	2001–05			
	(1)	(2)	(3)	(4)	(5)
Agriculture	-0.023 [0.051]	0.006 [0.022]	-0.059 [0.618]	0.009 [0.021]	0.012 [0.026]
Mining and quarrying	-0.037 [0.570]	-0.122 [0.104]	-0.067 [0.066]	0.046 [0.093]	...
Manufacturing	0.233 [0.633]	-0.103 [0.226]	-0.458*** [0.228]	0.053 [0.111]	0.041 [0.105]
Electricity, gas and water supply	...	0.157 [0.178]	-0.035 [0.068]	0.131 [0.182]	0.041 [0.234]
Construction	-1.222*** [0.579]	-0.281 [0.188]	-0.304 [0.196]	-0.355 [0.227]	-0.282*** [0.104]
Wholesale and retail trade	0.940 [0.728]	-0.084 [0.110]	0.118 [0.585]	0.046 [0.129]	0.199 [0.121]
Hotels and restaurants	0.039 [0.203]	0.004 [0.052]	-0.034 [0.030]	-0.017 [0.065]	-0.442 [0.500]
Transport and communication	2.188 [2.599]	0.132 [0.500]	-1.263 [0.908]	0.272 [0.308]	-0.188 [0.130]
Renting of machinery and computer	-3.281 [6.734]	1.339 [40.992]	-0.351 [0.338]	-0.865 [0.587]	-1.029 [0.664]
R&D and other business activities	-0.319 [1.298]	-1.010*** [0.491]	-1.523*** [0.652]	-1.373*** [0.355]	-0.471*** [0.169]

Sources: Estonian Business Registry database; and authors' calculations.

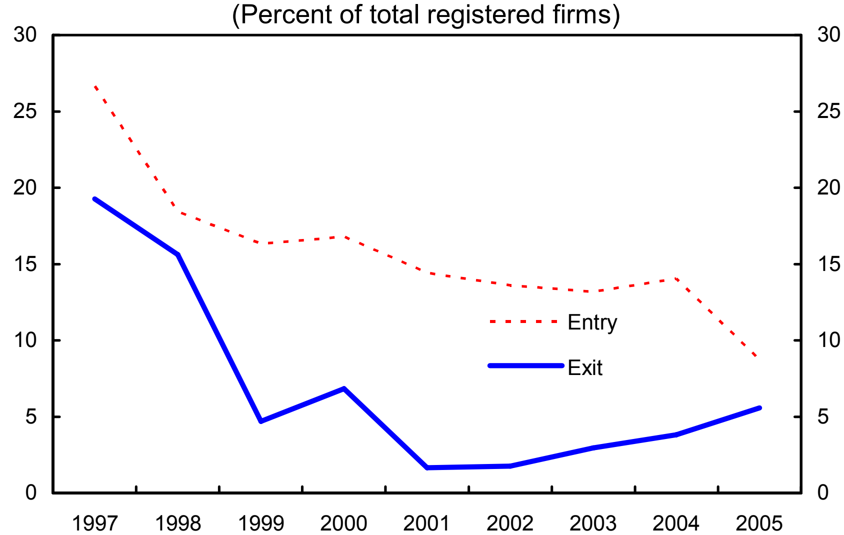
Notes: Financing constraints are directly included in the TFP estimation as an additional state variable. The dependent variable of Equation (6) is the log form of real value added, and we use bootstrapping methods (1000 replications) to obtain correct standard errors (reported in brackets). The estimations are run for each 1-digit industry separately. To keep a clear overview we report only the coefficients on the financing constraints measure. For the regressions in the first four columns the financial constraints are calculated using the Euler-equation methodology, while for the last column the financial constraints are estimated using a standard accelerator model of investment. R-squared statistics are not available for the modified Levinsohn-Petrin estimation. Though not reported, all regressions include 2-digit industry dummies and time dummies. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

Figure 1. Size Distribution
(In terms of average number of employees in a firm)



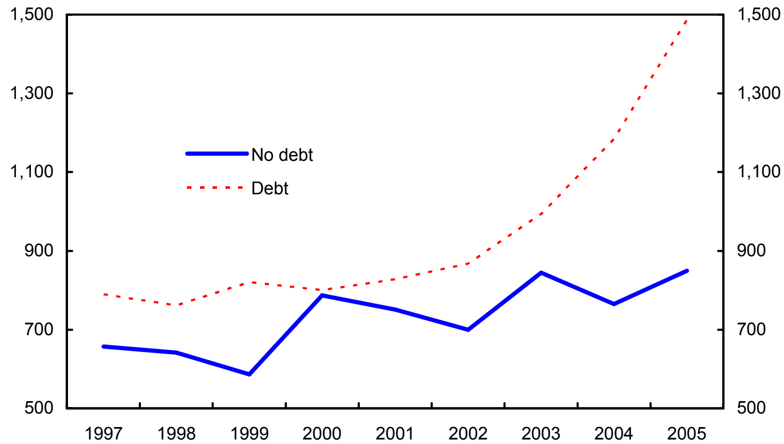
Sources: Estonian Business Registry; and authors' calculations.

Figure 2. Entry and Exit Rates
(Percent of total registered firms)



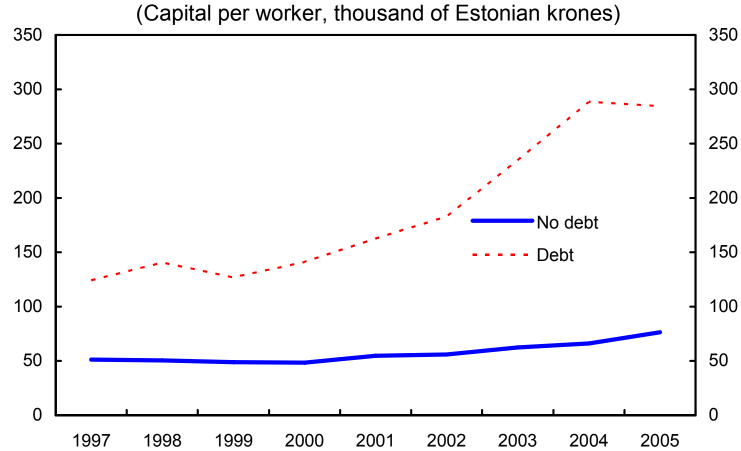
Sources: Estonian Business Registry database; and authors' calculations.

Figure 3. Labor Productivity
(Sales per worker, thousands of Estonian krones)



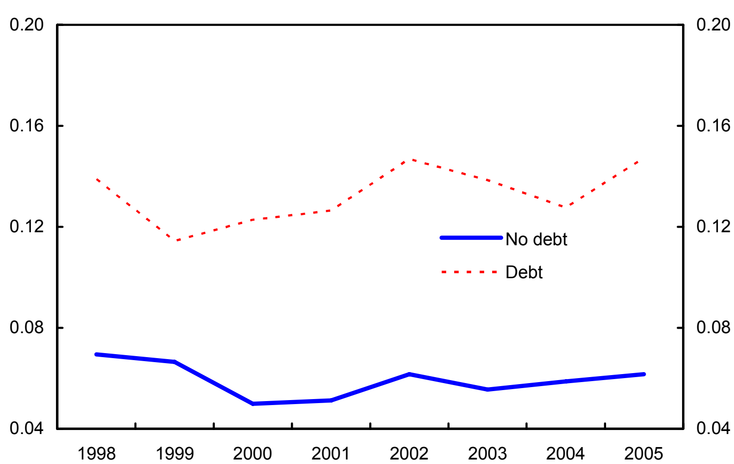
Sources: Estonian Business Registry database; and authors' calculations.

Figure 4. Capital Intensity
(Capital per worker, thousand of Estonian krones)



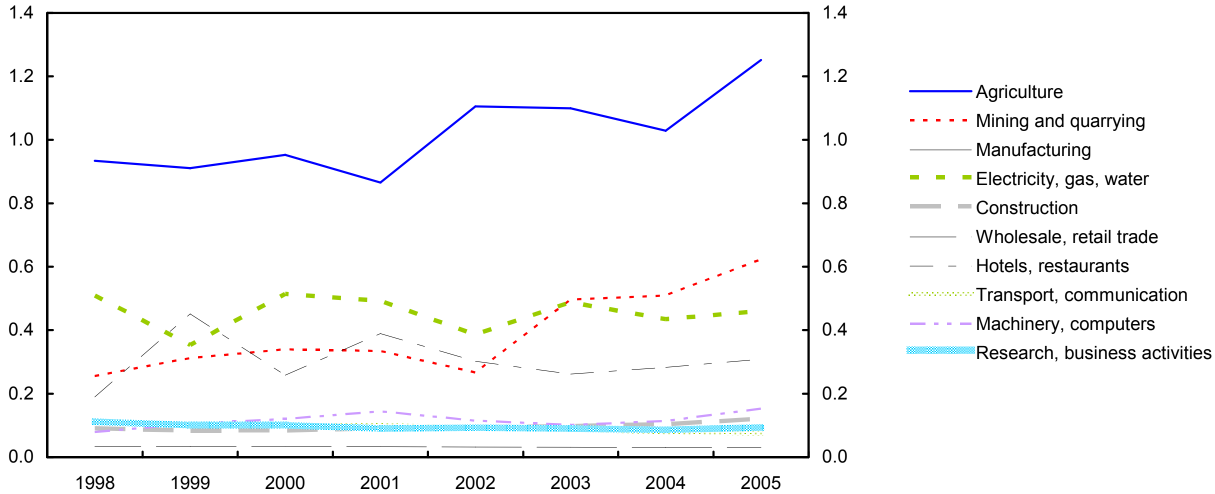
Sources: Estonian Business Registry database; and authors' calculations.

Figure 5. Investment Ratio
(Investment at t divided by total assets at t-1)



Sources: Estonian Business Registry database; and authors' calculations.

Figure 6. Evolution of the Mean Financial Constraints by Industry, 1998-2005 1/



Sources: Estonian Business Registry database; and authors' calculations.
1/ Financial constraints are calculated based on equation (3).

Appendix A. Data sources and definitions

The data used in this paper come from the Estonian Business Registry and cover the period 1995-2005. Due to missing information on employment for the years 1995-1996, we use data only from 1997. In order to create our sample we follow three steps:

1. We construct a longitudinal panel using registration codes. Several corrections are made to take into account the change in registration codes: (1) firms that change registration codes because of the transfer from the Enterprise Registry to the Business Registry are considered the same firm; (2) in case of acquisitions, the acquiring and acquired firms are considered a unique firm for the whole sample period; the employment of the acquired firm is added to the employment of the acquiring firm; and (3) for all other transactions (mergers, breakup, and divesture), we treat firms involved before and after the transaction as different.

2. For 46 percent of the registered firms we have no data on the variables used in the analysis, or there is no clear information about the industry they belong to. These firms are excluded.

3. In addition, we exclude unrealistic observations for the variables used in the estimation. In particular, exclude individual observations where employment, capital, and intermediate inputs are zero or negative (23 firms).

4. During the analysis we noticed that some outliers were influencing to an important extent our results. After checking the data we realized that these outliers were probably the result of input mistakes, poor data quality, mergers and acquisitions, divestments, or revaluations of capital. Therefore we imposed 2 outlier rules to exclude observations with extreme values: (1) we deleted the top-five percentile observations of capital growth, (2) we deleted the top-one percentile observations of the cash stock-to-capital ratio.

5. We exclude the sectors with EMTAK 65 to 70 (Financial intermediation and Real estate activities) and EMTAK 75 to 99 (Public services). Firms in these sectors are not or less subject to financial constraints, or their investment behavior depends more on political decisions or economic policy rather than on access to external finance.

6. Additionally, state-owned firms are more likely to face soft budget constraints, and are not necessarily profit-maximizing agents. Since these characteristics may distort the analysis we decided to exclude the state-owned firms from our analysis (210 firms).

7. Finally, we do not observe a firm's investment expenditure directly, but derive it from the law of motion of capital. As a consequence we cannot discern investment expenditure from the sales of capital goods; we only have a figure for the net investment of a firm. To minimize this problem we exclude observations with negative investment (5 percent of the observations).

All variables used in this paper are in real terms. Sales, value added, and cash are deflated by output deflator; intermediate inputs are deflated by the intermediate inputs deflator; assets, debt and investment are deflated with the gross capital formation price index. All deflators come from the system of national accounts provided by the Statistical Office of Estonia, and are available for 16 sectors (corresponding to the 1-digit ISIC Rev. 3.1).

- Sales ($Sales_{it}$): net revenue received from the sale of products, goods and services;

- Labor (L_{it}): number of employees;

- Intermediate inputs (M_{it}): cost of goods, raw materials, and services purchased for core activities;

- Value added (Y_{it}): net sales minus intermediate inputs;

- Capital (K_{it}): tangible and intangible fixed assets minus the goodwill, net of accumulated depreciation;

- Investment (I_{it}): calculated based on data on capital and depreciation, $I_{it} = K_{it} - K_{it-1} + D_{it}$, where D_{it} stands for reported annual depreciation. Due to this calculation, we have no data on investment for the first year of a firm's observation series;

- Cash stock ($Cash_{it}$): sum of the cash stock and short term financial securities such as shares at the beginning of period t;

- Leverage ($Leverage_{it}$): ratio long-term liabilities to total assets (net of accumulated depreciation) at the beginning of period t;

- Age (Age_{it}): age of the firm at the beginning of period t, based on the entry date in the Registry.

- Size ($Size_{it}$): continuous measure of firm size, measured by total assets (net of accumulated depreciation) at the beginning of period t;

- Owner ($Owner_{it}$): either private, state, foreign or other. Shareholders with more than 10% of share capital of the firm shall be disclosed, and upon this information the Statistical Office of Estonia classified the ownership type. For example, a firm is labeled foreign if the sum of the foreign-owned shares surpasses 50 percent.

- Industry classification: Estonian EMTAK code (Classification of Economic Activities of Estonia).

Table A.1 provides an overview of the industry classification used in Estonia. The total number of observations and the number of firms are listed in column 2 and 3.

Table A.1. Industry Classification

Code	Sector name	Number of observations	Number of firms
1	Agriculture, hunting, and related service activities	3,138	880
2	Forestry, logging, and related service activities	1,722	595
5	Fishing, fish farming, and related service activities	509	140
10-14	Mining and quarrying	342	59
15-16	Manufacture of food products and beverages, and tobacco products	1,965	494
17	Manufacture of textiles	812	187
18-19	Manufacture of wearing apparel, tanning, dressing, and dyeing	1,969	469
20	Manufacture of wood and straw products, except furniture	3,687	1,014
21-22	Manufacture of pulp, paper, and publishing and printing	1,896	472
23-24	Manufacture of coke, refined petroleum products, nuclear fuel, and chemicals	379	105
25	Manufacture of rubber and plastic products	662	165
26	Manufacture of other non-metallic mineral products	613	165
27-28	Manufacture of basic metals and fabricated metal products	2,707	732
29	Manufacture of machinery and equipment not elsewhere classified	909	231
30-32	Manufacture of office and electrical machinery, computers, televisions, and radio transmitters	732	175
33	Manufacture of medical, precision and optical instruments, watches, and clocks	526	114
35	Manufacture of transport equipment	442	131
36-37	Manufacture not elsewhere classified	2,047	556
40-41	Electricity, gas, steam and hot water supply, and collection, purification, and distribution of water	550	147
45	Construction	11,001	3,428
50	Sale, maintenance and repair of motor vehicles and motorcycles, and retail sale of automotive fuel	5,856	1,631
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	14,720	4,561
52	Retail trade, except of motor vehicles and motorcycles, and repair of personal and household goods	16,260	4,449
55	Hotels and restaurants	5,296	1,560
60-62	Land, water, and air transport	6,680	1,917
63	Supporting and auxiliary transport activities, and activities of travel agencies	2,499	820
64	Post and telecommunications	368	125
65-67	Financial intermediation	416	197
70	Real estate activities	3,902	1,428
71	Renting of machinery and equipment without operator and of personal and household goods	821	307
72	Computer and related activities	1,592	530
73-74	Research and development, and other business activities	9,819	3,192
80	Public administration and defence, compulsory social security, and education	926	281
85	Health and social work	2,728	714
90	Sewage and refuse disposal, sanitation, and similar activities	395	115
92	Recreational, cultural, and sporting activities	1,264	425
91-93	Other service activities	1,630	516
	Total	111,780	33,027

Source: Estonian Business Registry database.

Appendix B. Euler-equation specification

The derivation of the Euler model of investment follows closely Forbes (2007), Laeven (2003), Love (2003), and Harrison et al. (2004), all of which build on Bond and Meghir (1994). We refer to Love (2003) in specific for a more in-depth discussion of the Euler equation specification, and for proofs of the underlying derivations.

To start, assume that each firm maximizes its present discounted value of current and future net cash flows, subject to the capital accumulation and external financing constraints. The firm's market value is given by

$$V_t(K_t, \xi_t) = \max_{\{I_{t+s}\}_{s=0}^{\infty}} D_t + E_t\left[\sum_{s=1}^{\infty} \beta_{t+s-1} D_{t+s}\right], \tag{B.1}$$

subject to

$$D_t = \Pi(K_t, \xi_t) - C(I_t, K_t) - I_t, \tag{B.2}$$

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{B.3}$$

$$D_t \geq 0. \tag{B.4}$$

The first constraint (B.2) is the dividend paid to shareholders at the start of period t, the second constraint (B.3) is the capital stock accounting identity, and the third constraint (B.4) states that dividends (D_t) must be non-negative. $\Pi(K_t,\xi_t)$ is the restricted profit function (i.e. already maximized with respect to variable costs), with K_t the capital stock at time t and ξ_t being a productivity shock. $C(I_t,K_t)$ is the adjustment cost function, I_t is investment expenditure, δ is the depreciation rate of capital, and β_{t+s-1} represents a discount factor.

Financial frictions are introduced via a non-negativity constraint on dividends (B.4), and the multiplier for this constraint is denoted λ_t. This multiplier can be interpreted as the shadow cost associated with raising new equity, and implies that external financing is costly due to information or contracting costs. Rearranging the first-order conditions to the above maximization problem yields the Euler equation:

$$1 + \left(\frac{\partial C}{\partial I}\right)_t = \beta_t E_t\left[\Theta_t\left\{\left(\frac{\partial \Pi}{\partial K}\right)_{t+1} + (1-\delta)\left(1 + \left(\frac{\partial C}{\partial I}\right)_{t+1}\right)\right\}\right], \tag{B.5}$$

where $\partial C/\partial I$ is the marginal adjustment cost of investment, and $\partial \Pi/\partial K$ is the marginal profit of capital (i.e. the contribution of an extra unit of capital to the firm's profits, referred to below as MPK_t). In the Euler equation, the factor $\Theta_t = (1+\lambda_{t+1}/1+\lambda_t)$ is the relative shadow cost of external finance in period $t+1$ versus period t. In perfect capital markets applies ($\lambda_{t+1}=\lambda_t=0$). Thus, a firm is "financially constrained" if the shadow cost of external funds today is higher than tomorrow $(1+\lambda_{t+1}/1+\lambda_t)<1$.

In order to obtain an empirical model of investment allowing us to estimate equation (B.5), we need to parameterize the model. First, we proxy the (degree) of financing constraints Θ_t by the stock of liquid assets at the start of period *t*. Cash stock (or cash flow) has an intuitive interpretation as money that is available for investment when the opportunity presents itself.

$$\Theta_{it} = a_{0i} + a\left(\frac{Cash}{K}\right)_{it}. \tag{B.6}$$

Next, if production follows a Cobb-Douglas production function, then MPK_t can be measured as a sales-to-capital ratio:

$$MPK_{it} = \theta_i + \theta_{1,t}\left(\frac{Sales}{K}\right)_{it}. \tag{B.7}$$

This representation allows for firm-fixed effects θ_i, and a ratio of capital's share in production to the markups $\theta_{1,t}$.

Also, assuming a quadratic adjustment cost function that is linearly homogenous in investment and capital, the marginal adjustment cost of investment can be written as:

$$\left(\frac{\partial C}{\partial I}\right)_t = \frac{1}{\alpha_1}\left[\left(\frac{I}{K}\right)_t - \alpha_2\left(\frac{I}{K}\right)_{t-1} - \alpha_i + \alpha_t\right], \tag{B.8}$$

where α_1 and α_2 are constants, α_i is a firm-specific level of investment at which adjustment costs are minimized, and α_t are time-specific effects.

Finally, to simplify the estimation and interpretation of the coefficients, we linearize the Euler equation using a first-order Taylor approximation around the means. By assuming rational expectations and substituting equations (B.6), (B.7), and (B.8) into equation (B.5), the presence of financing constraints can be tested through the following empirical specification of the Euler equation:

$$\left(\frac{I}{K}\right)_{it} = \theta_0 + \theta_1\left(\frac{I}{K}\right)_{it-1} + \theta_2\left(\frac{Sales}{K}\right)_{it} + \theta_3\left(\frac{Cash}{K}\right)_{it} + \alpha_i + \delta_t + \varepsilon_{it}, \tag{B.9}$$

where α_i captures firm-specific parameters in the adjustment cost function and the *MPK*, plus the average firm-specific level of financing constraints and the price of investment goods. δ_t denotes time dummies. A firm is considered to be more financially constrained if the cash coefficient, θ_3, is estimated to be more positive.

Appendix C. Estimating Total Factor Productivity

Although a full description of TFP estimation based on Olley and Pakes (1996) and Levinsohn and Petrin (2003) is beyond the scope of this paper, the steps implemented are briefly outlined below.

We assume that firms maximize the expected value of both current and future profits from a Cobb-Douglas production function under uncertainty:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \varepsilon_{it}, \tag{C.1}$$

where i and t indicate firm and time respectively. y_{it} represents the natural logarithm of value added, l_{it} and k_{it} stand for the logs of labor and capital respectively. The firm specific error term consists of two parts: the firm productivity ω_{it} which is observed by the firm but not by the econometrician, and ε_{it} are unpredictable zero-mean shocks to productivity after inputs are chosen. This asymmetric information about ω_{it} causes two biases in the OLS estimates: a simultaneity bias and a selection bias. To address these biases Olley and Pakes (1996) developed a semi-parametric approach in which they use capital and investment as a proxy for unobserved productivity. Levinsohn and Petrin (2003) suggest a modification of the Olley-Pakes approach by using intermediate inputs (raw materials, electricity or fuels) instead of investment. The Levinsohn-Petrin algorithm largely follows the Olley-Pakes approach, so we simply substitute intermediate inputs for investment in the first stage.

The timing of decisions of firm i in industry j in year t is as follows. A firm initially observes its productivity ω_{it}, which is assumed to evolve according to an exogenous Markov process. Then the firm decides whether to exit or not, it chooses the input variables labor and materials, and how much to invest in capital. A firm's input demand function depends on capital and on privately known productivity $m_{it} = m_{it}(k_{it}, \omega_{it})$. Assuming that m_{it} is strictly increasing in ω_{it} (monotonicity condition), we can invert the materials' demand function to obtain an expression for productivity depending on observable variables:

$$\omega_{it} = m_t^{-1}(m_{it}, k_{it}) = \phi_t(m_{it}, k_{it}). \tag{C.2}$$

Substituting (C.2) into (C.1) yields the first stage of the estimation procedure

$$y_{it} = \beta_l l_{it} + \lambda_t(m_{it}, k_{it}) + \varepsilon_{it}, \tag{C.3}$$

where

$$\lambda_t(m_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \phi_t(m_{it}, k_{it}).$$

The functional form of λ_t is not known, but can be approximated by a third-order polynomial series in m_{it} and k_{it}.[36] The estimation of the partially linear model in (C.3) yields consistent

[36] The partially linear model in (10) can be estimated using OLS with a polynomial expansion in m_{it} and k_{it} to approximate for the unknown function $\varphi_t(.)$, or using kernel estimators. The former approach not only has the advantage of being easier and faster to implement, Pakes and Olley (1995) and Levinsohn and Petrin (2003)

estimates for the labor coefficient. Since k_{it} is collinear with the non-parametric function, we can not identify β_k. In order to consistently estimate the capital coefficient, the effect of capital on output still needs to be separated from its effect on a plant's materials demand.

Since Levinsohn and Petrin (2003) do not incorporate the survival probability, we follow Olley-Pakes' approach for the second stage. The probability that a firm exits from the sample is determined by the probability that the end-of-period productivity falls below an exit threshold. We generate an estimate of the survival probability by running a probit regression on the same third-order polynomial defined as before; the estimated survival probability is denoted by Π_{it}.

The final step is to estimate β_k from the resulting equation:

$$y_{it} - \hat{\beta}_l l_{it} = \beta_k k_{it} + g\left(\Pi_{it-1}, \hat{\lambda}_{t-1} - \beta_k k_{it-1}\right) + \eta_{it},$$

where $\hat{\beta}_l$ is the estimate for β_l out of the first stage, and $g(.)$ is approximated by a third-order polynomial expansion of Π_{it-1} and $\left(\hat{\lambda}_{t-1} - \beta_k k_{it-1}\right)$, where $\hat{\lambda}_{t-1}$ are the fitted values from the first stage. Since capital enters both in contemporaneous and lagged values, the third stage has to be estimated using non-linear least squares. Ignoring this structure, i.e. not restricting the coefficients on capital to be the same wherever it appears in the estimation of the second stage, would not yield efficient estimates.

report that the results of both approaches are very similar.

Table C.1. TFP Estimation

Code	Emtak industry classification	OLS			Levinsohn/Petrin		
		Labor	Capital	Log(TFP)	Labor	Capital	Log(TFP)
1	Agriculture, hunting and related service activities	0.592	0.308	7.632	0.441	0.224	9.111
2	Forestry, logging and related service activities	0.643	0.399	7.205	0.399	0.480	6.517
5	Fishing, fish farming and related service activities	0.940	0.332	6.969	0.698	0.444	5.978
10	Mining and quarrying	0.591	0.442	6.835	0.365	0.296	9.639
15	Manufacture of food products and beverages, and tobacco products	0.810	0.295	7.938	0.468	0.246	9.496
17	Manufacture of textiles	0.774	0.263	8.639	0.567	0.168	10.345
19	Manufacture of wearing apparel, and tanning, dressing and dyeing	0.842	0.206	9.108	0.735	0.067	11.067
20	Manufacture of wood and straw products, except furniture	0.783	0.283	8.208	0.441	0.295	8.790
22	Manufacture of pulp, paper; publishing and printing	0.788	0.251	9.311	0.512	0.115	11.570
24	Manufacture of coke, refined petroleum products, nuclear fuel, and chemicals	0.779	0.329	8.203	0.385	-0.072	14.583
25	Manufacture of rubber and plastic products	0.910	0.195	9.680	0.677	0.157	10.745
26	Manufacture of other non-metallic mineral products	0.856	0.307	7.968	0.542	0.310	8.647
28	Manufacture of basic metals and fabricated metal products	0.791	0.265	8.855	0.537	0.136	11.044
29	Manufacture of machinery and equipment, not elsewhere classified	0.669	0.299	8.720	0.448	0.177	10.753
32	Manufacture of office and electrical machinery, computers, televisions and radio transmitters	0.797	0.260	9.039	0.654	0.081	11.660
33	Manufacture of medical, precision and optical instruments, watches and clocks	0.814	0.216	9.715	0.542	0.282	9.425
35	Manufacture of transport equipment	0.811	0.192	9.857	0.648	0.168	10.589
36	Manufacture, not elsewhere classified	0.808	0.268	8.500	0.440	0.296	8.977
40	Electricity, gas, steam and hot water supply, and collection, purification and distribution of water	0.821	0.259	8.582	0.538	0.259	9.228
45	Construction	0.836	0.260	8.651	0.637	0.242	9.256
50	Sale, maintenance and repair of motor vehicles and motorcycles, and retail sale of automotive fuel	0.987	0.229	8.839	0.528	0.163	10.394
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	0.818	0.256	9.410	0.416	0.149	11.308
52	Retail trade, except of motor vehicles and motorcycles, and repair of personal and household goods	0.896	0.206	9.154	0.468	0.110	11.004
55	Hotels and restaurants	1.003	0.169	9.070	0.616	0.187	9.615
62	Land, water and air transport	0.630	0.419	7.122	0.476	0.269	9.381
63	Supporting and auxiliary transport activities, and activities of travel agencies	0.861	0.258	9.333	0.715	0.225	10.003
64	Post and telecommunications	0.817	0.315	8.443	0.546	0.207	10.284
71	Renting of machinery and equipment without operator and of personal and household goods	0.726	0.431	6.838	0.481	0.324	8.560
72	Computer and related activities	0.969	0.287	8.735	0.851	0.152	10.456
74	Research and development, and other business activities	0.836	0.255	9.115	0.714	0.145	10.567

Sources: Estonian Business Registry database; and authors' calculations.

References

Abel, A., and O., Blanchard (1986), "The Present Value of Profits and Cyclical Movement in Investment," *Econometrica*, Vol. 54(2), pp. 249-73.

Aghion, P., Angeletos, G., Banerjee, A., and K. Manova (2007a), "Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment," unpublished manuscript.

———, Askenazy, P, Berman, N., Cette, G., and L. Eymard (2007b), "Credit Constraints and the Cyclicality of R&D Investment: Evidence from France," Weatherhead Center for International Affairs Working Paper No. 2007-4 (Boston: Harvard University).

Almeida, H. and M. Campello (2007), Financial Constraints, "Asset Tangibility, and Corporate Investment," *Review of Financial Studies*, Vol. 20(5), pp.1429-1460.

Amiti, M. and J. Konings (2007), "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia," *American Economic Review*, Vol. 97(5), pp.1611-1638.

Arellano, M. and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, Vol. 58(2), pp.277-297.

Arellano, M. and O. Bover (1995), "Another Look at the Instrumental-Variable Estimation of Error Components Models," *Journal of Econometrics*, Vol. 68(1), pp.29-51.

Arestis, P., Demetriades, P., and B. Fattouh (2003), "Financial Policies and the Aggregate Productivity of the Capital Stock: Evidence from Developed and Developing Economies," *Eastern Economic Journal*, Vol. 29, No. 2, Spring.

Ayyagari, M., Demirgüç-Kunt, A., and V. Maksimovic (2007), "Firm Innovation in Emerging Markets," World Bank Policy Research Paper No. 4157 (Washington: World Bank).

Beck, T., Levine, R., and N. Loayza (2000), "Financial Intermediation and Growth: Causality and Causes," *Journal of Monetary Economics*, Vol. 46, pp. 31-77.

Bencivenga, V. R., Smith, B. D., and R. M., Starr, "Transaction Costs, Technology Choice, and Endogenous Growth," *Journal of Economic Theory*, Vol. 67, pp. 153-77.

Bhide, A. (1993), "The Hidden Costs of Stock Market Liquidity," *Journal of Financial Economics*, Vol. 34(2), pp. 31-51.

Blundell, R. and S. Bond (1998), "Initial Condition and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics*, Vol. 87, pp.115-143.

Bond, S., J. Elston, J. Mairess, and B. Mulkay (2003), "Financial Factors and Investment in Belgium, France, Germany, and the United Kingdom: A Comparison using Company Panel Data," *Review of Economics and Statistics*, Vol. 85(1), pp.153-165.

Budina, N., Garretsen, H., and E. de Jong (2000), "Liquidity Constraints and Investment in Transition Economies. The Case of Bulgaria," *Economics of Transition*, Vol. 8(2), pp. 453-475.

De Loecker, J. (2007), “Do Exports Generate Higher Productivity? Evidence from Slovenia,” *Journal of International Economics*, Vol. 73, pp.69-98.

Demirgüç-Kunt, A., Beck, T., and P. Honohan (2008), “Finance for All? Policies and Pitfalls in Expanding Access,” World Bank Policy Research Report (Washington: World Bank).

Fazzari, S., G. Hubbard and B. Peterson (1988), “Financing Constraints and Corporate Investment,” *Brookings Paper on Economic Activity*, Vol. 1, pp.141-195.

Fernandes, A. (2007), “Trade Policy, Trade Volumes and Plant-level Productivity in Colombian Manufacturing Industries,” *Journal of International Economics*, Vol. 71, pp.52-71.

Forbes, K. (2007), “One Cost of the Chilean Capital Controls: Increased Financial Constraints for Smaller Traded Firms,” *Journal of International Economics*, Vol. 71, pp.294-323.

R. Gatti, R., and I. Love (2008), “Does Access to Credit Improve Productivity? Evidence from Bulgarian Firms?,” CEPR Working Paper No. 6676 (London: Centre for Economic Policy Research).

Grabowsky, H., and D. Mueller (1972), “Managerial and Stockholder Welfare Models of Firm Expenditures,” *Review of Economics and Statistics*, Vol. 54, pp. 9-24.

Hanushek, E. (1974), “Efficient Estimators for Regressing Regression Coefficients,” *The American Statistician*, Vol. 28(2), pp.66-67.

Harrison, A., I. Love, and M. McMillan (2004), “Global Capital Flows and Financing Constraints,” *Journal of Development Economics*, Vol. 75, pp.269-301.

Harrison, A. and M. McMillan (2003), “Does Direct Foreign Investment Affect Domestic Firms Credit Constraints?” *Journal of International Economics*, Vol. 61(1), pp.73-100.

Hayashi, F. (1982), “Tobin’s Marginal q and Average q: A Neoclassical Interpretation,” *Econometrica*, Vol. 50, pp.213-224.

Horowitz, J. (2001), The Bootstrap, in J. Heckman and E. Leamer (eds.) Handbook of Econometrics, Vol. 5, Oxford: Elsevier Science, pp.3159-3228.

Hovakimian, G. and S. Titman (2006), “Corporate Investment with Financial Constraints: Sensitivity of Investment to Funds from Voluntary Asset Sales,” *Journal of Money, Credit, and Banking*, Vol. 38(2), pp.357-374.

Hu, X. and F. Schiantarelli (1998), “Investment and Capital Market Imperfections: a Switching Regression Approach using U.S. Firm Panel Data,” *Review of Economic and Statistics*, Vol. 79, pp.466-479.

Hubbard, G. (1998), “Capital-Market Imperfections and Investment,” *Journal of Economic Literature*, Vol. 36(1), pp. 193-225.

Jensen, M. and W. Meckling (1976), “Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure,” *Journal of Financial Economics*, Vol. 3, pp.305-360.

Kaplan, S. and L. Zingales (1997), "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?, *Quarterly Journal of Economics*, Vol.112, pp.169-115.

King, R., and R. Levine (1993a), "Finance, Entrepreneurship, and Growth," *Journal of Monetary Economics*, Vol. 32, pp. 513-542.

King, R., and R. Levine (1993b), "Finance and Growth: Schumpeter Might Be Right," *Quarterly Journal of Economics*, Vol. 108, No. 4, pp. 717-38.

Koivu, T. (2002), "Do Efficient Banking Sectors Accelerate Economic Growth in Transition Economies," BOFIT Discussion Paper, No. 14.

Konings, J., Rizov, N., and H. Vandenbussche (2003), "Investment and Financial Constraints in Transition Economies: Micro Evidence from Poland, the Czech Republic, Bulgaria, and Romania," *Economic Letters*, Vol. 78, pp. 253-258.

Kornai, J. (1979), "Resource-Constrained Versus Demand-Constrained Systems," *Econometrica*, Vol. 47(4), pp.801-819.

Kornai, K. (1986), "The Soft Budget Constraint," *Kyklos*, Vol. 39(1), pp. 3-30.

Laeven, L. (2003), "Does Financial Liberalization Reduce Financing Constraints?" *Financial Management* (spring), pp.5-34.

Lang, L., Ofek, E., and R., Stulz (1996), "Leverage, Investment, and Firm Growth," *Journal of Financial Economics*, Vol. 40, pp. 3-29.

Levine, R. (1991), "Stock Markets, Growth, and Tax Policy," *Journal of Finance*, Vol.46, No. 4, pp. 1445-65.

Levine, R. (1997), "Financial Development and Growth: Views and Agenda," *Journal of Economic Literature*, Vol. 35 (June), pp. 688-726.

Levine, R. (2005), Finance and Growth: Theory and Evidence, in P. Aghion and S. Durlauf eds. *Handbook of Economic Growth*, Elsevier.

Levinsohn, J. and A. Petrin (2003), "Estimating Production Functions Using Inputs to Control Unobservables," *Review of Economic Studies*, Vol. 70, pp.317-341.

Lizal, L. and J. Svejnar (2002), "Investment, Credit Rationing, and the Soft Budget Constraint: Evidence from Czech Panel Data," *Review of Economic and Statistics*, Vol. 84(2), pp. 353-370.

Love, I. (2001), "Financial Development and Financing Constraints: International Evidence from the Structural Investment Model," World Bank Policy Research Working Paper, No. 2694 (Washington: World Bank).

Love, I. (2003), "Financial Development and Financing Constraints: International Evidence from the Structural Investment Model," *Review of Financial Studies*, Vol. 16(3), pp.765-791.

Masso, J., R. Eamest, and K. Philips (2004), "Firm Demographics and Productivity Dynamics in Estonia," University of Tartu Faculty of Economics and Business Administration Working Paper No. 25.

Modigliani, F. and M. Miller. (1958), "The Cost of Capital, Corporation Finance, and the Theory of Investment," *American Economic Review*, Vol. 48(3), pp.261-97.

Moreno Badia, M. (2007), "Medium-term Growth and Productivity in Estonia: A Micro Perspective," *Estonia—Selected Issues*, IMF Country Report No. 07/257 (Washington: International Monetary Fund).

Myers, S. (1977), "Determinants of Corporate Borrowing," *Journal of Financial Economics*, Vol. 5, pp.147-175.

OECD (2006), The SME Financing Gap (Vol. I): Theory and Evidence. OECD, Paris.

Olley, S. and A. Pakes (1996), "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, Vol. 64(6), pp.1263-1297.

Pakes, A. and S. Olley (1995), "A Limit Theorem for a Smooth Class of Semiparametric Estimators," *Journal of Econometrics*, Vol. 65(1), pp.1-8.

Power, L. (1998), "The Missing Link: Technology, Investment, and Productivity," *The Review of Economics and Statistics,* Vol. 80, No. 2, pp. 300-313.

Rioja, F., and N. Valev (2004), "Finance and the Sources of Growth at Various Stages of Economic Development," *Economic Inquiry*, Vol. 42, No.1, pp. 127-140.

Schiantarelli, F. (1996), "Financial Constraints and Investment: Methodological Issues and International Evidence," *Oxford Review of Economic Policy*, Vol. 12(2), pp.70-89.

Shleifer, A. and R., Vishny (1986), "Large Shareholders and Corporate Control," *Journal of Political Economy*, Vol. 96(3), pp. 461-88.

Stein, J. (2001), Agency, Information and Corporate Investment. In George Constantinides, Milt Harris and René Stulz, eds., *Handbook of the Economics of Finance*.

Solow, R. (1957), "Technical Change and the Aggregate Production," *Review of Economics and Statistics*, Vol. 29 (August), pp. 312-320.

Tobin, J. (1969), "A General Equilibrium Approach to Monetary Theory," *Journal of Money Credit and Banking*, Vol. 1, pp.265-293.

Van Biesebroeck, J. (2005), "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms," *Journal of International Economics,* 67(2), pp.373-391.