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Business investment, the user cost of capital and firm heterogeneity

Alari Paulus*

Abstract

The sensitivity of business fixed investment to one of its key determinants, the user cost of capital, has been little investigated with firm-level data that captures firm heterogeneity to the full extent. I study the determinants of business fixed investment in Estonia, using the universe of business statements for non-financial firms in 1994-2020 from administrative records. The results with various panel data models provide strong support for a theoretical long-term relationship between the gross investment rate, and changes in production output and the user cost of capital. I find that the capital stock is modestly responsive to changes in output and the user cost of capital, with elasticities less than 0.5 in absolute size, and that different estimation strategies yield broadly similar results. Elasticities differ by firm size, but sectoral variation is relatively limited. User cost elasticities also exhibit notable variation over time, while output elasticities are much more stable. I also find that investments in machinery and equipment are more elastic than investments in buildings and structures.

JEL codes: D22, E22, H32.

Keywords: business investment, user cost of capital, corporate taxation, firm panel data

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Non-technical summary

A substantive part of economic growth comes in the form of business fixed investment, mostly in tangible assets such as buildings and structures, or machinery and equipment. To have a better understanding of economic growth, it is therefore important to study the dynamics and driving factors of business investments as well. One of its key determinants is the implicit rental price of capital, the user cost of capital, which not only reflects the financial cost of capital but also takes asset depreciation and capital taxation into account.

There is relatively little research into the sensitivity of investments to user cost using firm-level data, which allow differences to be captured across firms to their full extent. A further limitation is that the existing literature has mainly focused on major western countries, large firms, and periods before the global financial crisis. By addressing these issues, this paper extends the empirical literature by estimating a range of prevalent investment models using an extensive firm-level dataset. The dataset contains the universe of business statements for Estonian firms in 1994-2020 from administrative records.

The results show that gross investment rate is positively related to changes in production output, and negatively related to the user cost of capital, providing strong empirical support for the standard neoclassical theory of factor demand. The capital stock is found to be modestly responsive to changes in output and the user cost of capital. The responsiveness to user cost is similar to recent estimates using aggregate or sectoral cross-country data, but lower than other estimates that use firm-level data. This could be explained by differences in the sample composition, as the results also show that responsiveness varies with firm size, as medium and large firms are found to be almost twice as responsive as micro and small firms.

The responsiveness varies somewhat by economic sector as well, but there are no clear patterns. The responsiveness is higher for agriculture, and transport and storage, and lower for real estate, and hotels and restaurants. The responsiveness of the capital stock to output has been remarkably stable since the late 1990s and appears to be only slightly pro-cyclical, while the responsiveness to user cost is much more volatile and has a stronger relationship with price developments over time. Investments in machinery and equipment are found to be substantially more responsive to output and user cost than investments in buildings and structures are.

While the user cost of capital proves to be an essential factor for business investments, the combination of low interest rates and low capital tax rates in Estonia limits for the time being the scope for encouraging investments much further through policies aimed at lowering the user cost.

Contents

1 Introduction

Business fixed investment makes an important contribution to economic growth and also reflects expectations about potential future growth given its forward-looking nature. To improve our understanding of investment dynamics and economic growth, various factors that shape corporate investment decisions have been extensively studied in the empirical literature, ranging from economic fundamentals to financial constraints, adjustment costs, uncertainty and so forth. As the literature developed, its initial focus on the time-series data of aggregate investments shifted towards firm-level panel data in a search for an additional source of variation to improve identification and tackle potential endogeneity between various determinants (Mairesse et al., 1999; Hassett and Hubbard, 2002).

Microeconometric studies have however paid little attention to how sensitive investment is to one of its key determinants, the user cost of capital and its components (Bond and Van Reenen, 2007). Despite subsequent contributions by Gilchrist and Zakrajsek (2007), Dwenger (2014) and Buettner and Hoenig (2016), among others, this research gap is still visible. It is also noticeable that the literature has focused on major western countries like the US, the UK, Germany and France, and has typically used small and highly selective samples of firms with limited firm heterogeneity, studying only large or quoted manufacturing companies for example. There is equally a lack of studies that consider the dynamics and determinants of corporate investment in the aftermath of the global financial crisis (GFC), especially under the subsequent ultra-low real interest rates. One rare exception is Melolinna et al. (2018), who use data for the UK.

This study extends the empirical evidence on the determinants of corporate fixed investments in the three directions noted above. It uses an extensive firm-level dataset that contains the universe of business statements for Estonian firms in 1994-2020 from administrative records, and so it provides new and detailed estimates for the determinants of investment with high statistical precision. The dataset combines and enhances several strengths of earlier works, as the estimation sample of about 135 thousand firm-year observations that it gives rise to represents an increase in magnitude over the largest earlier examples (cf. Chirinko et al., 1999; Dwenger, 2014); it features a relatively long panel spanning a quarter of a century (cf. Gilchrist and Zakrajsek, 2007); and it captures firm heterogeneity to its full extent, by covering small and medium size firms as well as large ones (cf. Masso, 2002), and non-financial companies in both the manufacturing and non-manufacturing sectors (cf. Chirinko et al., 1999). Finally, the data allow different asset types to be distinguished, and cover both tangible and intangible fixed assets (cf. Bond et al., 2005).

Estonia offers an interesting case study for multiple reasons. First, it is similar to other Central and Eastern European countries, as it went through a drastic transition from being a centrally planned economy to becoming a liberal market economy, and its institutions rapidly converged towards the West, as it joined the EU in 2004 (Fuchs-Schündeln and Schündeln, 2020). Second, it has experienced several business cycles along the way, with rapid growth from the mid-1990s that was brought to a halt by the Russian crisis in 1998, which was followed by another episode of sustained high growth rates until the next large external shock occurred in the GFC. After an initial burst of recovery in late 2010 and 2011, growth rates then remained sluggish in comparison to what they were before the crisis. Third, investment by business, which is a major, though volatile, component of GDP, has shown a puzzling slowdown since the mid-2010s in both historical and international comparison, and has become less cyclical.[1] Fourth, the Estonian economy stands outs for the large share of micro and small firms in it, which are often excluded from studies of investment. And finally, Estonia adopted an unusual corporate tax system in 2000, where only distributed earnings are subject to corporate income tax and all retained earnings are excluded, which has important implications for the user cost of capital.

I focus on long-term structural determinants of investment dynamics by employing and comparing different types of reduced-form models, which have generally outperformed structural models in previous studies (Bond and Van Reenen, 2007). The primary interest here lies in the role of the user cost of capital and the quantity and price elasticities of demand for capital. I seek to establish specifically how sensitive elasticity estimates are to various estimation strategies employed in the earlier literature and how these vary across firms and over time.

I find that the capital stock is modestly responsive to changes in output and the user cost of capital, with elasticities less than 0.5 in absolute size, and that commonly used estimation strategies yield broadly similar results that bring into question some of the earlier findings. Elasticities do differ by firm size, but sectoral variation appears surprisingly limited. User cost elasticities also exhibit notable variation over time, while output elasticities are much more stable. I also find that investments in machinery and equipment are more elastic than investments in buildings and structures.

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[1] Business fixed investment reached nearly one quarter of GDP before its share collapsed in the Great Recession, later stabilising at around 15%, which was a level previously seen back in the mid-1990s (see Figure B.1 in Appendix B). Between the mid-1990s and mid-2010s, the business investment rate was also notably higher than the EU-27 average levels, with Estonia placed among the top five countries except during the two recessions.

The plan of the paper is as follows. Section 2 introduces the theoretical background and discusses empirical strategies. Section 3 describes the data source and how the key variables have been derived. Section 4 presents the empirical analysis and discusses the results. The final section concludes.

2 Modelling framework

2.1 Theoretical background and empirical strategies

In the neoclassical tradition, demand for capital is derived from the first-order conditions for firms maximising their discounted flow of profits. In combination with a CES production function using a single type of capital K and labour inputs L, $F(K,L) = A(aK^{\psi} + (1-a)L^{\psi})^{\nu/\psi}$, where a is the share parameter, ψ the substitution parameter and ν the degree of homogeneity of the production function, such an investment model would imply that the long run, desired capital stock of a firm ($K^*_{i,t}$) is a log-linear function of the planned level of output (Y) and the user cost of capital (C):[2]

$$\ln K^*_{i,t} = \alpha_i + \left(\sigma + \frac{1-\sigma}{\nu}\right) \ln Y_{i,t} - \sigma \ln C_{i,t} \tag{1}$$

Higher planned production and a lower user cost of capital are expected to increase the desired capital stock. Under a CES function, the user cost elasticity of the capital stock, $-\sigma$, coincides in absolute terms with the elasticity of substitution between capital and variable inputs, $\sigma = 1/(1-\psi) \geq 0$.

The Jorgensonian user cost of capital is a summary measure for the implicit capital rental price, which accounts for the financial cost of capital, or the cost of funds, asset depreciation and capital taxation (Auerbach, 1983).[3] For firm i with asset a, it can be expressed as (see e.g. Auerbach, 1983; Chirinko, 2002; Hassett and Hubbard, 2002)

$$C_{i,a,t} = \frac{p^I_{a,t}}{p_t}(\rho_{i,t} + \delta_a - \pi^I_{a,t}) \left(\frac{1 - k_{a,t} - z_{a,t}}{1-\tau_t}\right) \tag{2}$$

where p^I is the price index for investment goods, p is the price index for output, π^I is the expected inflation rate for investment goods, ρ is the nominal firm-specific cost of funds, δ is the rate of economic depreciation, k is the rate of investment tax

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[2] For simplicity, I approximate the single capital input with the total capital stock or structures or equipment in turn as one of its main subcomponents. This has been a standard approach in the empirical literature, though it requires strong assumptions (Bond and Xing, 2015).

[3] To avoid ambiguity, the term *cost of capital* is avoided here. As pointed out by Creedy and Gemmell (2017, p. 202), it has been used inconsistently in the literature and can refer to either the user cost of capital or the cost of funds.

credit, z is the present value of tax depreciation allowances and τ is the corporate tax rate. A schematic derivation can be found in Appendix A.

Without capital adjustment costs and dynamic considerations, the firm would achieve $K^*_{i,t}$ immediately; with dynamics, the stock demand for capital can be transformed into a flow demand for investment (Chirinko, 1993). Dynamics are introduced implicitly in reduced-form models and are explicitly specified in the optimisation problem in structural models such as the Q and Euler model. Structural models have however been less successful empirically than hoped for, allowing reduced-form models to remain useful, as they can offer a flexible empirical approximation of a potentially very complex underlying process (Bond and Van Reenen, 2007).

I consider three main types of reduced-form models for the long-term relationship between the desired and observed capital stocks (see Bond and Van Reenen, 2007):

- an autoregressive distributed lag model, $a(L)\Delta k_t = b(L)\Delta k^*_t$,
- an error correction model, $\alpha(L)\Delta k_t = \beta(L)\Delta k^*_t + \lambda(k^*_{t-s} - k_{t-s-1})$,
- a partial adjustment model, $\Delta k = \lambda(k^*_{t-s} - k_{t-s-1})$,

where k^* and k denote the desired and observed capital stock in log terms, $x(L)$ is a polynomial in the lag operator L, and λ measures the speed of adjustment.

The distributed lag model (DLM) in first differences assumes that changes in the desired capital stock are implemented gradually, allowing short-term and long-term impacts to be distinguished. An autoregressive DLM also includes the lagged dependent variable. A special case of the DLM is the traditional accelerator model, which assumes that the desired capital stock is simply proportional to output, so $\sigma = 0$. Chirinko et al. (1999) for the US and Dwenger (2014) and Buettner and Hoenig (2016) for Germany are some examples.

The error correction model (ECM), which is linked to co-integration techniques, is essentially a re-parametrisation of the autoregressive DLM and nests models of both the accelerator and the partial adjustment type. As such it combines the long-run theoretical formulation with empirically determined short-run dynamics (Bond et al., 2003, p. 154). Its specification also resembles that of the Euler model, allowing for closer comparisons with structural models (Mairesse et al., 1999, p. 36). It has been employed by Bond and Meghir (1994) for the UK; Mairesse et al. (1999) for France and the US; Bond et al. (2003) for Belgium, France, Germany and the UK; Bloom et al. (2007) for the US; and Dwenger (2014) and Buettner and Hoenig (2016) for Germany.

Finally, the partial adjustment model (PAM) is a special case of the error correction model. It is the simplest, but also the most restrictive specification, as it assumes the change in the capital stock in the current period is proportional to the gap between the existing and desired capital stocks in an earlier period. Recent examples of applications include Gilchrist and Zakrajsek (2007) for the US and Melolinna et al. (2018) for the UK, who employed it in both a static and autoregressive form.

The empirical studies mentioned above, which all estimated reduced-form investment equations with firm-level data, are summarised in Table B.1 in Appendix B. Their sample sizes are relatively small, varying from a few hundred firms to a few thousand, and the largest ones contained about 25 thousand firm-year observations (Chirinko et al., 1999; Dwenger, 2014). The samples also provided only limited firm heterogeneity, usually focusing on large manufacturing firms, while all except Melolinna et al. (2018) covered a period before the Great Recession. The typical static model specification is based on DLM and the dynamic specification typically on ECM, while PAM has featured in both versions. Not all the studies have included the user cost of capital explicitly in the model, and some have instead assumed that the associated variation can be captured by year-specific and firm-specific effects. However, this would not yield an estimate of user cost elasticity, and it appears insufficient once I consider the user cost of capital in finer detail and allow for firm-specific developments over time.

2.2 Econometric specifications

I estimate and compare three types of reduced-form empirical model. The particular econometric specifications are as follows. The distributed lag model with autoregressive components:

$$\Delta k_{i,t} = \sum_{h=1}^{m} \theta_h \Delta k_{i,t-h} + \sum_{h=0}^{n} \beta_h \Delta s_{i,t-h} + \sum_{h=0}^{n} \gamma_h \Delta c_{i,t-h} + \xi_{i,t} \tag{3}$$

where $k_{i,t}$ is the log of the net capital stock, $c_{i,t}$ is the log of the user cost of capital, $s_{i,t}$ is the log of sales, and $\xi_{i,t} = \mu_t + \eta_i + \epsilon_{i,t}$ combines time fixed-effects μ_t, firm fixed-effects η_i, and a disturbance term $\epsilon_{i,t}$. The error correction model, based on ADL(m,n):

$$\begin{aligned}\Delta k_{i,t} = {} & \sum_{h=1}^{m-1} \theta_h \Delta k_{i,t-h} + \sum_{h=0}^{n-1} \beta_h \Delta s_{i,t-h} + \sum_{h=0}^{n-1} \gamma_h \Delta c_{i,t-h} \\ & + \theta'_m k_{i,t-m} + \beta'_n s_{i,t-n} + \gamma'_n c_{i,t-n} + \xi_{i,t}\end{aligned} \tag{4}$$

The partial adjustment model:

$$\Delta k_{i,t} = \theta k_{i,t-1} + \beta s_{i,t} + \gamma c_{i,t} + \xi_{i,t} \tag{5}$$

I further transform the dependent variable from a change in the log net capital stock Δk, which is essentially the net investment rate, into the gross investment rate I/K, as is often done.[4]

The long-run elasticity of capital with respect to sales ε^s and user cost ε^c for the models can be expressed as:

$$\varepsilon^s_{DLM} = \left(\sum_{h=0}^{n} \beta_h\right) / \left(1 - \sum_{h=1}^{m} \theta_h\right); \qquad \varepsilon^s_{ECM} = -\frac{\beta'_n}{\theta'_m}; \qquad \varepsilon^s_{PAM} = -\frac{\beta}{\theta} \tag{6}$$

$$\varepsilon^c_{DLM} = \left(\sum_{h=0}^{n} \gamma_h\right) / \left(1 - \sum_{h=1}^{m} \theta_h\right); \qquad \varepsilon^c_{ECM} = -\frac{\gamma'_n}{\theta'_m}; \qquad \varepsilon^c_{PAM} = -\frac{\gamma}{\theta} \tag{7}$$

Note that the baseline specifications do not impose constant returns to scale ($\nu = 1$), which would imply $\varepsilon^s = 1$ and hence $\theta'_m = -\beta'_n$ for the error correction model and $\theta = -\beta$ for the partial adjustment model.

To estimate the baseline specifications, I employ several panel data estimators, which are discussed in detail along with the results below. In the final stage, I explore firm heterogeneity by interacting all explanatory variables with the variables of interest for firm size, sector and time period, allowing elasticities to vary along the chosen dimension, one at a time.

3 Data

3.1 Data source

I estimate the investment equations using firm-level data that come from the universe of business reports for Estonian firms from the Business Register (*Äriregister*), starting from 1995 and running up to 2020. Every firm in Estonia, no matter its size or turnover, must file an annual report that includes at least a balance sheet and an income statement with comparable figures for the current financial year and the preceding one. Larger firms must also provide a cash flow statement and a

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[4] This transformation relies on the approximation $\ln(1+x) \approx x$, valid for a small x:

$$\Delta k_{i,t} \equiv \Delta \ln K_{i,t} = \ln \frac{K_{i,t}}{K_{i,t-1}} = \ln\left(1 + \frac{\Delta K_{i,t}}{K_{i,t-1}}\right) \approx \frac{\Delta K_{i,t}}{K_{i,t-1}} \approx \frac{I_{i,t}}{K_{i,t-1}} - \delta$$

where I_t/K_{t-1} is the gross investment rate in period t, that is the ratio of gross investment (I) in period t to net capital stock (K) at the end of period $t-1$.

statement of changes in owners' equity. It is not uncommon however for firms to fail to submit business reports on time, meaning within six months after the end of the financial year, or even at all, though this could in principle attract penalties. Delayed or missing reports are often an early sign of a business closure in the future, through insolvency, bankruptcy or otherwise, which limits their negative effect on the effective sample size. I construct time series for the indicators of interest using primarily information that was presented for the reporting period, while information for the previous period is used to extend the series back to 1994, to fill internal gaps in the series where possible, and for cross-validation.

The analysis focuses on for-profit, limited liability, non-financial corporations.[5] The raw sample after data cleaning and harmonisation consists of two million statements for 1994-2020.[6] The number of statements for non-financial firms has grown from about 7 thousand in 1994 to 160 thousand in 2019 (see Figure B.2).[7] The figure also shows the entries and exits of firms found from their first and last reporting period. Exits are a conservative estimate as they only reflect the official status of firms as liquidated, in bankruptcy or closed, and leave aside de facto closures where firms are reporting no business activity or have stopped submitting reports altogether.

The size and composition of non-financial fixed assets are of primary interest, and from them I derive gross investment and net capital stock. As the structure of reports and the classification of assets have changed over the sample period, some aggregation of asset subcategories is needed to retain comparability over time, though this reduces the level of detail. In consequence I distinguish between three subcategories of non-financial fixed assets: (i) land, buildings and structures, (ii) machinery and equipment, and (iii) intangible assets. Figure B.3 shows the composition of the gross fixed capital formation (GFCF) of non-financial corporations found from the national accounts. It indicates that buildings and structures accounted for 30-50% of aggregate gross investment and machinery and equipment for another 40-60% in any given year, meaning these two subgroups were the largest and were of comparable size. Other gross investment is almost entirely related to intellectual property products, and the share of these has increased steadily over time to about 10%

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[5] General and limited partnerships (*täis- ja usaldusühing*), sole proprietorships (*FIE*) and commercial associations (*tulundusühistu*) are excluded, as are foundations (*sihtasutus*), non-profit associations (*mittetulundusühing*) and government institutions.

[6] These are reports for legal entities, not consolidated at the group level. Where there are multiple valid reports for the same or overlapping reference periods, the most recently filed reports were retained. A small number of reports for a period shorter than a year were combined into annual reports, making less than 0.1% of the total.

[7] As at January 2022, the number of reports submitted for 2020 was below the levels in 2018-2019, suggesting that 5-10% of reports may still be due.

in 2020.[8] Other relevant data from balance sheets cover annual profits and total liabilities together with total sales, interest expenses and recorded depreciation.

3.2 Net capital stock and gross investments

I derive gross investment (I) at current prices by inferring net investment spending from annual changes in the book value of fixed assets on balance sheets and adding reported annual depreciation.[9] The value of gross investment in the first year observed is calculated by assuming that all the assets were added in that period. For the analysis, I need to measure the firm's capital stock (K) using the replacement value of fixed assets at constant prices, but the book value of the capital stock in business accounts is a mixture of investments valued at their historic prices, and recorded depreciation may not be the same as actual economic depreciation. To construct a time series for net capital stock at constant prices, I use the Perpetual Inventory Method, in a similar way to how it is employed to construct the capital stock in the national accounts (OECD, 2009).[10] Following this, the net capital stock of asset a in the prices of period t is:

$$K_{a,t} = (1 - \delta_a) K_{a,t-1} (p^I_{a,t} / p^I_{a,t-1}) + I_{a,t} \tag{8}$$

Price indexes for investment goods by asset type a ($P^I_{a,t}$) are constructed from the data in the national accounts, using the GFCF series for non-financial corporations at current and constant prices. These data are nearly identical to those found in the EU-KLEMS database, but they are partly aggregated here to match the grouping of assets with firm-level data. The consumer price index (CPI) and producer price index (PPI) are taken directly from the Statistics Estonia database. As shown in Figure B.4, price indexes for buildings and structures, and intangible assets have risen more steeply since the mid-1990s than the price index for machinery and equipment has, and have been broadly in line with the CPI. The price index for non-financial fixed assets has on the whole followed the PPI more closely.

The geometric rates of economic depreciation (δ) were chosen following the EU-KLEMS 2019 conventions (Stehrer et al., 2019) of 4% for land, buildings and structures, 15% for machinery, equipment and biological assets, and 25% for intangible

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[8] Throughout when using national accounts statistics, I exclude from the figures a mega-investment by Volkswagen Group in late 2020 and early 2021, which was about five times the usual size of *total* intangible assets in a year.

[9] For subcomponents, total depreciation is split in proportion to their book value of net capital stock.

[10] In early years, gross value of fixed assets and accumulated depreciation were recorded separately for tangible assets, while only the net value of fixed assets is available for most years. I therefore use net values as the basis for my calculation in all years.

assets. I use a depreciation rate of 8% for non-financial, fixed assets taken together, like several other papers (Mairesse et al., 1999; Bond et al., 2003, 2005; Dwenger, 2014). To put it in context, the average life of assets (L) can be assumed to vary from 8 years for intangible assets to 50 years for buildings and structures, according to the double-declining balance method ($\delta = 2/L$).

To validate the measure of gross investment constructed from the business accounts, its aggregates are compared with the GFCF series from the national accounts.[11] Figure B.5 shows that despite some differences in coverage[12], the levels and trends of aggregate gross investment match those of the GFCF series reasonably well.

3.3 Cost of funds and the user cost of capital

The measure of the cost of funds (ρ) is based on the framework of King and Fullerton (1984) and reflects the price of capital resources for their use over a certain period and as such shows the rate at which firms ought to discount their after-tax cash flows in nominal terms or the minimum rate of return for an investment project to be profitable. The cost of funds depends not only on the source of finance, which might be new shares, retained earnings or debt finance, but also on the use of profits (Sinn, 1991). For simplicity, I assume that for new share issues or retained earnings, the sole use of future profits is dividends, ignoring alternatives such as further profit retentions or share repurchases.

I follow the notation in Sinn (1991), defining the rate of nominal interest on bonds as i and now distinguishing between the following tax rates: τ_r is the corporate tax on retained profits, τ_d is the corporate tax on distributed profits, τ_{dp} is the personal tax rate on dividends, τ_c is the personal capital gain tax rate and τ_i is the personal tax rate on interest income. The *pre-tax* discount rate ϕ can be derived as follows:

- for new shares, by equating the return from investing in the firm with that

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[11] Gross fixed capital formation (GFCF) consists of "resident producers' acquisitions (less disposals) of *fixed assets* during a given period, plus certain additions to the value of *non-produced assets* realised by the productive activity of producer or institutional unit" (European Commission, 2013, p. 73-74).

[12] According to ESA 2010, fixed capital in *national accounts* refers to a subcategory of non-financial produced assets – fixed assets – which consist of dwellings, other buildings and structures (including major improvements to land), machinery and equipment, weapons systems, cultivated biological resources, and intellectual property products. Non-financial assets in *business accounts* distinguish between current and fixed assets. Fixed assets consist here of tangible, biological and intangible assets, and by including the value of land and goodwill, this is a somewhat broader concept than the one used for the national accounts.

from buying bonds, or its interest rate:

$$\phi(1-\tau_d)(1-\tau_{dp}) = i(1-\tau_i)i \Rightarrow \phi = i\frac{1-\tau_i}{(1-\tau_d)(1-\tau_{dp})}$$

- for retained earnings, by weighing the return from retaining profits and distributing the extra gain in the next period against paying dividends now and investing in bonds:

$$\phi(1-\tau_d)(1-\tau_{dp})(1-\tau_r)(1-\tau_c) = i(1-\tau_i)(1-\tau_d)(1-\tau_{dp}) \Rightarrow \phi = i\frac{1-\tau_i}{(1-\tau_c)(1-\tau_r)}$$

- for debt finance, by using deductible interest:

$$\phi(1-\tau_d) = i(1-\tau_d) \Rightarrow \phi = i$$

The *after-tax* discount rate follows simply here as $\rho = \phi(1-\tau_d)$.

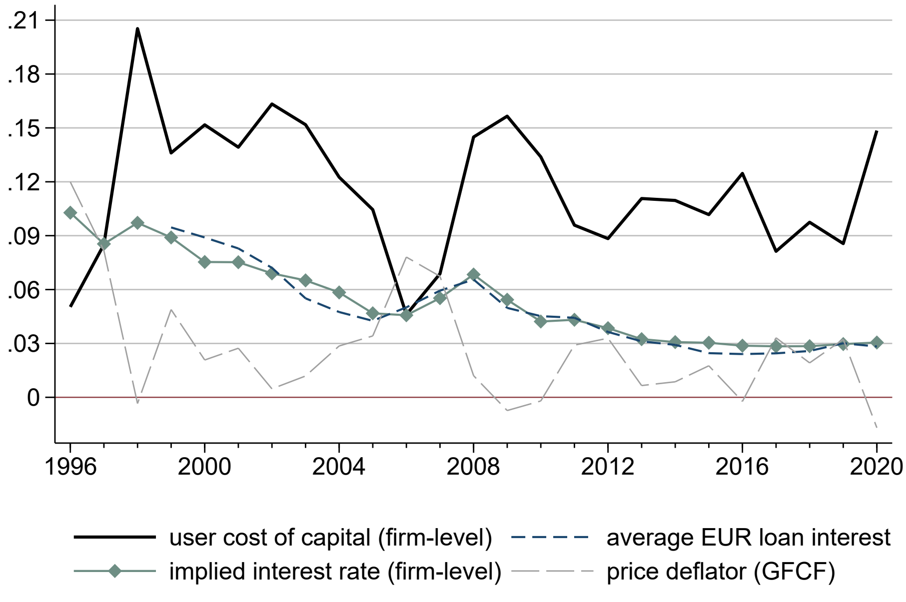
Estonia has had a unified income tax system since 1994 that covers both corporate and personal income, including realised capital gains, and a uniform tax rate applies. The tax rate was initially set at 26%, then lowered gradually to 21% in 2005-2008, and further to 20% in 2014. Double taxation of dividends is avoided as dividends are not taxable at the individual level and the tax liability falls entirely on the firm paying the dividends. A major tax reform in 2000 further exempted corporate retained earnings, leaving only distributed profits and equivalent payments to be taxed. The tax rates in the Estonian case are $\tau_{dp} = 0$ and $\tau_c \approx 0$; $\tau_r = \tau_d = \tau_i \equiv \tau$ (26%) before 2000 and $\tau_r = 0$, $\tau_d = \tau_i \equiv \tau$ (20-26%) since 2000. The cost of funds can then be simplified as shown in Table 1. This indicates that the tax treatment of financing is neutral between new shares and debt. Assuming that the effective personal tax rate on capital gains was close to zero ($\tau_c \approx 0$), retained earnings had only a minor tax advantage, if any, as a source of financing until 2000. Since then lower tax burden on retained earnings has offered a notable advantage over other sources of finance.

Table 1: After-tax cost of funds in Estonia

Source of finance	Before 2000	Since 2000
New shares	$\rho = i(1-\tau)$	same
Retained earnings	$\rho = i\frac{1-\tau}{1-\tau_c}$	$\rho = i\frac{(1-\tau)^2}{(1-\tau_c)}$
Debt	$\rho = i(1-\tau)$	same

Notes: With multiple sources of finance, ρ is a weighted average. The use of profits for new shares and retained earnings is limited to dividends, ignoring further retentions and share prepurchases.

For firms that have reported interest expenses, I calculate the implied interest rate in nominal terms (i) as a ratio of interest expenses to the sum of short-term and long-term liabilities, like Dwenger (2014) and Melolinna et al. (2018). The resulting distribution can be seen in Figure B.6. For firms without interest expenses, or for which the calculated interest rate falls outside the range of (0,1), I impute the interest rate with a simple linear regression model, where interest expenses are regressed on industry, the log of tenure, and the log of total assets and its squared term for each year separately using observations with an implied interest rate in the range of (0,1).[13] Figure 1 shows that the median values of the interest rates derived from the annual reports of firms have throughout the sample period been well in line with the aggregate statistics published by the central bank for the average annual interest rates on euro-denominated loans for non-financial corporations. To calculate the after-tax cost of funds (ρ) for each source of finance and its average at the firm level, I use the shares in total funds of each of the financing source as weights. Like in other countries (Myers, 2001), internal financing is the dominant source (see Figure B.7). Most of the cross-sectional variation therefore arises from interest rates, and after 2000 it also comes from financing from different sources to varying degrees.



Notes: firm-level indicators refer to median values for non-financial corporations.
The implied interest rates are calculated as the ratio of interest costs to loan liabilities at the firm level.
The average annual loan interest rates for non-financial corporations are published by Eesti Pank.

Figure 1: The user cost of capital and the cost of funds

Sources: Business Register, Eesti Pank, own calculations.

After the cost of funds is obtained, the user cost of capital is calculated with equation 2. As there are no tax credits, then $k = 0$. Cross-sectional variation within

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[13] The results are available upon request.

the same asset category consequently comes solely from the cost of funds. Figure 1 also shows the median values of the user cost of capital over time, ranging from nearly 0.21 in 1998 to less than 0.06 in 2006. Despite a drop of nearly two thirds in nominal interest rates since the late 1990s, the user cost of capital shows only a modest fall and remains volatile because of the inflation component.

3.4 Estimation sample

Like in previous studies, the estimation sample here is restricted to non-financial corporations with a positive net investment rate and excludes large outliers, so $I_{i,t}/K_{i,t-1} \in (0, 1)$. Further selection criteria are based on total net sales (S) and cash flows (CF), which are defined as the sum of annual profit and depreciation $S_{i,t}/K_{i,t-1} \in [0, 25]$, $CF_{i,t}/K_{i,t-1} \in [-5, 10]$, and where observations with $S_i < 0$ or $C_i \leq 0$ are discarded. I finally limit the sample to continuous spells of at least five years, which a firm can have several, to ensure sufficient lags and greater stability for the estimates.[14] This leaves an unbalanced panel of about 137 thousand observations for 15,279 firms.

To show how sample restrictions affect the characteristics of an average firm, descriptive statistics for the raw and estimation samples are compared in Table B.2. All monetary values are expressed in 2020 prices, while net capital stock and gross investment are deflated by the price indexes of investment goods, net sales and the balance sheet total are deflated by the producer price index. The estimation sample includes on average larger firms by net sales, where mean log values are 10.7 and 12.9, balance sheet total, where mean log values are 10.3 and 12.9, and net capital stock, where mean log values are 10.1 and 12.4. Gross investment is also larger in the final sample. The requirement of a continuous spell of at least five years naturally results in a selection of more mature firms, with the average age increasing from 6.4 to 11.1 years. A firm's age is measured from the year when it first appears in the dataset either because it is assigned a valid registration status or it submits a business report.

The substantial shift towards larger firms is also confirmed by a composite size indicator that takes account of the balance sheet total, the annual turnover, and the number of employees. It is based on the EU definition of micro, small, medium and large firms, retaining the original thresholds for the number of employees (of below 10 for micro firms, below 50 for small firms, and below 250 for medium-size firms,

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[14] The minimum number of periods imposed in Bond and Meghir (1994), Bond et al. (2003) and Dwenger (2014) for example ranged from five to eight years. Examples in the earlier literature even include balanced panels of about 15 years (Mairesse and Dormont, 1985; Fazzari et al., 1988). The minimum number of periods seems to have become smaller in more recent studies, while the number of firms in the sample has grown.

but applying reduced thresholds for balance sheet totals and annual turnover of below 100 thousand euros for micro firms, below 250 thousand euros for small firms and below 1 million euros for medium-size firms to achieve more balanced groups within the estimation sample.[15] The share of micro-size firms in the raw sample is still a staggering 76% and the share of large firms is under 5%, while the shares across the four size categories range from 22% to 29% in the estimation sample.

Finally, the table shows that sectoral shifts are generally more muted than those in other dimensions, with the allocation of firms by economic sector following the NACE 2008 classification at level 1, with some sectors merged. The share of manufacturing firms becomes notably larger at 17.3%, and the shares also increase for agricultural firms to 8.3%, transport and storage firms to 8.4%, and hotels and restaurants to 4.8%. The share of firms shrinks for wholesale and retail trade to 15.9%, for professional services to 9.1%, for construction to 8.2% and for arts and entertainment to 2.9%. Finally, the share of firms that have been legally declared closed, in liquidation or in bankruptcy, decreases from 21.3 to 10.9 percent, and the share of companies subject to greater minimum share capital requirements, which is also a rough indicator of the size of a company, increases from 4.1 to 18.6 percent.

4 Econometric estimates

4.1 Panel properties

To better understand the dynamic properties of the key data series, I first estimate separate AR(1) models in levels for $\ln K_{i,t}$, $\ln S_{i,t}$, $\ln C_{i,t}$ and $I_{i,t}/K_{i,t-1}$:

$$y_{i,t} = \rho y_{i,t-1} + \mu_t + (\eta_i + \epsilon_{i,t}) \tag{9}$$

using the OLS, fixed-effects/within-group (FE) and GMM approaches. The estimated coefficients on the lagged dependent variable for each AR1 model are shown in Table B.3 together with cluster-robust standard errors.

Although OLS and FE are not consistent estimators, they can provide useful guidance as to the bounds of the true parameter for the lagged dependent variable, as OLS estimates are upward biased in large samples, and fixed-effect estimates are downward biased (Bond, 2002). The results show that $\ln K$ is highly persistent over time, with its OLS estimate close to unity though statistically different from it, and the FE estimate about 0.87, while $\ln S$ is moderately persistent, and $\ln C$

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[15] With the original EU threshold values of 2 million for micro firms, 10 million for small firms, and 43 (turnover)/ 50 (balance sheet) million euros for medium-size firms, nearly 60% of the estimation sample would be micro firms and only 1.4% large firms.

and I/K are to a limited extent. The highly statistically significant coefficients on the lagged dependent variables confirm the autoregressive nature of each series. To address probable biases that arise from the correlation between the lagged dependent variable and the error term, and are related to unobserved heterogeneity in firm-specific effects and simultaneity, I also employ the difference-GMM (Holtz-Eakin et al., 1988; Arellano and Bond, 1991) and system-GMM approaches (Arellano and Bover, 1995; Blundell and Bond, 1998).[16]

DIF2 and DIF3 show the two-step difference-GMM estimates using the 2nd-4th and 3rd-4th lags of the dependent variable as instruments in the first-differences equation.[17] In all four cases, DIF2 rejects the Sargan-Hansen test for joint validity of the instruments with $p < 0.001$ and the Arellano-Bond test indicates the presence of first-order negative autocorrelation $p < 0.001$, and second-order negative autocorrelation at $p < 0.05$ for residuals in differences. While first-order serial correlation is expected by design, the second-order correlation suggests that residuals in levels are serially correlated of order one and hence that the second lags should be excluded from the set of valid instruments. DIF3, which relies only on the 3rd and 4th lags as instruments, passes the Sargan-Hansen test for $\ln K$ and I/K and the AR test rejects the absence of third-order autocorrelation in all cases, with p values ranging from 0.19 to 0.93. Finally, SYS3 shows the two-step system-GMM estimates, which additionally use the differenced second lag as an instrument in the levels equation, but like DIF2 fail to pass the Sargan-Hansen test and cannot be considered valid. My preferred specification here, DIF3, provides coefficients on the lagged dependent variable that remain between the OLS and FE estimates except for I/K but that is also least precisely estimated.

In the following, I employ and compare two approaches to obtaining a reduced-form investment model – by taking the first differences of and a model of capital stock in levels and by re-parametrising it. Taking the first differences leads to the autoregressive distributed lag (ADL) model of change in the capital stock, and re-parametrising leads to an error correction model, and to a partial adjustment model as its special case. I start, however, from the model of the capital stock in *levels*, observing that consistent estimators for dynamic panel models already feature first-differencing as part of the estimation process, which effectively turns

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[16] Difference-GMM utilises moment conditions $\mathrm{E}[y_{i,t-s}\Delta\epsilon_{i,t}] = 0$ for $s \geq 2$ if $\epsilon_{i,t} \sim MA(0)$ and for $s \geq 3$ if $\epsilon_{i,t} \sim MA(1)$ allowing these lagged levels of the variables to be used as instruments in the first-differences equation; assuming the initial conditions ($\mathrm{E}[\Delta y_{i,2}\eta_i] = 0$) are satisfied, system-GMM adds further moments $\mathrm{E}[\Delta y_{i,t-s}(\eta_i + \epsilon_{i,t})] = 0$ for $s = 1$ if $\epsilon_{i,t} \sim MA(0)$ and for $s = 2$ if $\epsilon_{i,t} \sim MA(1)$, allowing corresponding lagged first differences of the variables to be used as instruments in the levels equation (Blundell and Bond, 2000).

[17] Estimated with XTABOND2 in Stata (Roodman, 2009). Robust standard errors are calculated with Windmeijer's finite-sample correction.

them into investment models too. Note that the dependent variable transformed by the estimator corresponds here to the net investment rate ($\Delta \ln K$), which in the first-differenced and re-parametrised model is substituted for the gross investment rate (I/K) using the approximation $\Delta \ln K \approx I/K - \delta$. All the models include year dummies as time fixed-effects.

4.2 ADL models of capital stock

The ADL model of capital stock is also first estimated with OLS and FE. The estimates for the ADL(1,0) model are shown in Table 2.[18] Like in the simple AR(1) specification, the OLS estimate of 0.97 for the coefficient on the lagged dependent variable is close to one but statistically different from it, while the FE estimate of 0.84 is about 13% lower. The coefficients on log sales (+) and the log user cost of capital (-) have the expected signs and all the coefficients are highly statistically significant. The OLS and FE estimates differ substantially for sales, but the estimates for the user cost of capital are very similar. The implied capital stock elasticity to output (ε^s) ranges from 0.37 for FE to 0.56 for OLS, and the user cost elasticity (ε^c) is also correctly signed and has a plausible value with FE of -0.49, though the OLS estimate is suspiciously large at -2.8.

The last two columns show the estimates obtained with the two-step difference-GMM approach. DIFex uses lags 3-6 of $\ln K$ as GMM-style instruments and treats $\ln S$ and $\ln C$ as exogenous, while DIFen treats $\ln S$ and $\ln C$ as endogenous and uses the third and higher lags for all three variables. Both specifications pass the Sargan-Hansen test for joint validity of the instruments comfortably, with p-values of 0.81 and 0.16. The Arellano-Bond test indicates the presence of first and second-order negative autocorrelation for residuals in differences at $p < 0.001$, but clearly fails to reject the absence of third-order autocorrelation with $p > 0.2$. The second-order correlation suggests once again that residuals are MA(1) and that second lags would be invalid instruments. The estimates of DIFen involve a trade-off, the coefficient on the lagged dependent variable is estimated more precisely, but the coefficients on $\ln S$ and $\ln C$ are much less precise and as a consequence ε^c is also less precisely estimated.[19] As both sets of difference-GMM estimates pass diagnostic tests, my preferred specification for the model of capital stock is DIFex, which offers greater precision.

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[18] Experimenting with further lags of the dependent variable and covariates suggested few substantive changes, but reduced the effective sample. I therefore retain a more parsimonious model.

[19] DIFen also uses a very large number of instruments and it proved difficult to reduce them without causing problems with diagnostics. Various attempts with the system-GMM approach, which could provide further efficiency gains, failed to produce a specification where the additional moments would pass the (difference) Hansen test.

Table 2: ADL(1,0) model of capital stock

	OLS	FE	DIFex	DIFen
L.ln K	0.9725***	0.8445***	0.8345***	0.8467***
	(0.0006)	(0.0028)	(0.0115)	(0.0078)
ln S	0.0154***	0.0574***	0.0345***	0.0340***
	(0.0005)	(0.0015)	(0.0017)	(0.0100)
ln C	-0.0781***	-0.0765***	-0.0826***	-0.0370**
	(0.0022)	(0.0023)	(0.0026)	(0.0136)
constant	0.1426***	1.0495***		
	(0.0398)	(0.0511)		
ε^s	0.5608***	0.3688***	0.2086***	0.2218***
	(0.0119)	(0.0104)	(0.0166)	(0.0626)
ε^c	-2.8404***	-0.4919***	-0.4991***	-0.2415**
	(0.0895)	(0.0171)	(0.0402)	(0.0911)
Year effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.993	0.895	.	.
N	119,967	119,967	102,271	102,271
N instruments	.	.	112	852
AR1 (p-value)	.	.	0.000	0.000
AR2 (p-value)	.	.	0.000	0.000
AR3 (p-value)	.	.	0.270	0.237
Hansen (p-value)	.	.	0.812	0.165

Notes: dependent variable $\ln K$; ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses. FE=fixed-effects; DIFex=two-step difference-GMM with exogenous covariates (IV style), lags 3-6 of $\ln K$ used as GMM instruments; DIFen=two-step difference-GMM with endogenous covariates, third and higher lags of $\ln K$, $\ln S$ and $\ln C$ used as GMM instruments.

4.3 ADL models of the investment rate

I proceed with a model of the net investment rate obtained by first-differencing the capital stock model. As this removes firm-specific effects in levels, OLS estimates can already provide consistent estimates for specifications without the lagged dependent variable. Table 3 shows estimates for such models, where the first column contains only contemporaneous terms for $\ln S$ and $\ln C$ and the second column includes their lags up to the third period as well. The static version without the lagged dependent variable is similar to Chirinko et al. (1999), Mairesse et al. (1999) and Dwenger (2014).

All the individual coefficients again have the expected signs and are highly statistically significant (only the sum of coefficients is shown here). Estimated elasticities are very low at about 0.05 in absolute size for the specification containing only contemporaneous terms for the covariates. Adding lags up to the third for sales and the user cost of capital increases the elasticities in absolute size through a cumulative

Table 3: ADL(m,n) model of the investment rate

	OLS(0,0)	OLS(0,3)	OLS(1,0)	OLS(4,3)	FE(4,3)
$\sum_j Lj$.I/K			0.2052***	0.2769***	-0.2544***
			(0.0032)	(0.0057)	(0.0118)
$\sum_j Lj.\Delta$ ln S	0.0565***	0.2070***	0.0532***	0.1588***	0.1644***
	(0.0017)	(0.0052)	(0.0018)	(0.0053)	(0.0083)
$\sum_j Lj.\Delta$ ln C	-0.0530***	-0.1702***	-0.0693***	-0.1613***	-0.1815***
	(0.0019)	(0.0074)	(0.0022)	(0.0079)	(0.0095)
constant	0.3004***	0.1983***	0.2272***	0.1499***	0.3201***
	(0.0378)	(0.0286)	(0.0541)	(0.0413)	(0.0458)
ε^s	0.0565***	0.2070***	0.0669***	0.2196***	0.1310***
	(0.0017)	(0.0052)	(0.0022)	(0.0071)	(0.0067)
ε^c	-0.0530***	-0.1702***	-0.0872***	-0.2231***	-0.1447***
	(0.0019)	(0.0074)	(0.0028)	(0.0110)	(0.0076)
Year effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.051	0.081	0.098	0.115	0.099
N	136,287	83,248	119,851	66,866	66,866

Notes: dependent variable I/K; ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses.

effect, so $\varepsilon^s = 0.21$ and $\varepsilon^c = -0.17$.[20] Including the lags of the dependent variable as well has only a limited effect on the other parameters and is mainly visible in a modest increase in the user cost elasticity, shown in the third and fourth columns. While the first differences of capital stock are purged of firm specific effects in levels, the OLS and FE estimates of the coefficients on the lagged dependent variables are still likely to be biased because of the correlation with the first difference of the idiosyncratic error term. For ADL(4,3), the sum of coefficients on the lagged dependent variables is about +0.28 with OLS and -0.25 with FE, suggesting there is indeed a potentially significant bias. Smaller coefficients on the lagged dependent variables also lower significantly the elasticities estimated with FE, even though the FE estimates of the coefficients on sales and the user cost of capital are similar to those of OLS. It may also be noted that employing FE means double-differencing in levels, which would be appropriate if the firm-specific effects were in linear trends of the capital stock rather than levels.

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[20] Including further lags has a minimal effect on the coefficients of the terms included previously (not shown here) suggesting their complementarity, whereas the lagged variables in the model of the capital stock (in the previous subsection) tended to work partly as substitutes due to collinearity.

4.4 Error correction models of the investment rate

The error correction model combines the ADL model in differences with a long-term error-correction mechanism. Unlike the ADL model in differences, this is obtained by re-parametrising the ADL model in levels, and so the residual term remains untransformed. The estimation of elasticities is based on the composite error correction component, focusing on the long-term relationship and abstaining from short-term dynamics that may deviate substantively from that relationship. Examples of such empirical investment models can be found in Mairesse et al. (1999), Bond et al. (2003), and Bond et al. (2005), which use firm-specific and time-specific effects to control for variation in the user cost of capital, and Dwenger (2014) and Buettner and Hoenig (2016), which explicitly include the user cost of capital in their models.

The results for ECM(2,2) are shown in Table 4. OLS and FE are once more used for their simplicity and to illustrate potential biases. The estimated coefficients on the lagged dependent variable again differ substantively between OLS at +0.15 and FE at -0.16, while the estimates of the other variables are correctly signed and statistically significant, and the resulting elasticities are similar to those obtained with OLS and FE for the capital stock model (cf. Table 2).

The last two columns again show consistent estimates obtained with the two-step difference-GMM. With DIFex, $\Delta \ln S$ and $\Delta \ln C$ are treated as exogenous covariates, IV style, and lagged I/K is instrumented with its 3rd-4th lags in GMM style. With DIFen, $\Delta \ln S$ and $\Delta \ln C$ are treated as endogenous variables and also instrumented with their 3rd-4th lags in GMM style. In both cases, the signs of the coefficients are as expected and the Arellano-Bond tests confirms the validity of the specifications, though the Hansen test rejects it except at the $\alpha = 0.001$ level.

The results in column DIFex are essentially similar to those in the previous column obtained with FE, apart from those for sales terms, where the coefficients are all smaller in size, reducing the output elasticity to 0.15. DIFen estimates differ more and yield a relatively high estimate of the output elasticity at 0.51, but a low and less precise estimate of the user cost elasticity at -0.12. With DIFen, the user cost terms and elasticity only achieve statistical significance at the $\alpha = 0.1$ level. Again, on the grounds of precision, I prefer the DIFex specification over DIFen.

I also estimate the ECM(2,2) specification separately for two subgroups of tangible fixed assets, looking at land, buildings and structures (Table B.4), and machinery and equipment (Table B.5). Bearing in mind that the samples are different due to the varying levels of detail on fixed assets, the key insight is that investment in equipment is much more elastic than investment in structures. This confirms the previous findings in the literature obtained with aggregate data (Schaller, 2006; Bond and Xing, 2015; Fatica, 2018).

Table 4: ECM(2,2) model of the investment rate

	OLS	FE	DIFex	DIFen
L.I/K	0.1519***	-0.1648***	-0.1497***	-0.1613***
	(0.0037)	(0.0047)	(0.0256)	(0.0238)
Δ ln S	0.0640***	0.0630***	0.0416***	0.1239***
	(0.0019)	(0.0021)	(0.0023)	(0.0286)
L.Δ ln S	0.0522***	0.0747***	0.0435***	0.1352***
	(0.0018)	(0.0026)	(0.0036)	(0.0302)
Δ ln C	-0.1041***	-0.0968***	-0.0931***	-0.0395°
	(0.0029)	(0.0030)	(0.0034)	(0.0217)
L.Δ ln C	-0.0618***	-0.0797***	-0.0738***	-0.0310°
	(0.0029)	(0.0037)	(0.0049)	(0.0170)
L2.ln K	-0.0223***	-0.1900***	-0.2382***	-0.2590***
	(0.0006)	(0.0042)	(0.0234)	(0.0238)
L2.ln S	0.0110***	0.0696***	0.0362***	0.1333***
	(0.0005)	(0.0027)	(0.0048)	(0.0329)
L2.ln C	-0.0577***	-0.0732***	-0.0715***	-0.0306°
	(0.0029)	(0.0045)	(0.0061)	(0.0167)
constant	0.2511***	1.4556***		
	(0.0458)	(0.0724)		
ε^s	0.4930***	0.3661***	0.1519***	0.5145***
	(0.0152)	(0.0128)	(0.0128)	(0.1034)
ε^c	-2.5884***	-0.3854***	-0.3002***	-0.1182°
	(0.1303)	(0.0246)	(0.0309)	(0.0642)
Year effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.119	0.179	.	.
N	102,163	102,163	84,498	84,498
N instruments	.	.	75	161
AR1 (p-value)	.	.	0.000	0.000
AR2 (p-value)	.	.	0.511	0.439
AR3 (p-value)	.	.	0.765	0.635
Hansen (p-value)	.	.	0.024	0.005

Notes: dependent variable I/K; ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses. FE=fixed-effects; DIFex=two-step difference-GMM with exogenous covariates (IV style), lags 3-4 of I/K used as GMM instruments; DIFen=two-step difference-GMM with $\Delta \ln S$ and $\Delta \ln C$ terms as endogenous covariates, lags 3-4 of I/K, $\ln S$ and $\ln C$ used as GMM instruments.

Finally, I explore the effect of certain parameter restrictions as these lead to some interesting special cases and provide an additional robustness check. Table 5 shows estimates for ECM(1,1), ECM(1,0) and ECM(1,0) restricted to constant returns to scale, and compares them with earlier estimates for ECM(2,2). I use the fixed-effect estimator as the lags of the dependent variable do not feature in the three new specifications, and the FE estimates were relatively close to the DIFex estimates in the previous table. I also constrain the effective sample to match that of ECM(2,2), so that the model fit using adjusted R^2 can be compared directly.

ECM(1,1), which excludes the first lag of the dependent variable and the second lags of the covariates, provides very similar results to ECM(2,2), in both the estimated coefficients and elasticities, at the expense only of a marginally smaller R^2. Further restricting $\ln S$ and $\ln C$ to contemporaneous terms only leads to ECM(1,0), the partial adjustment model, as in Gilchrist and Zakrajsek (2007) and Melolinna et al. (2018). This still provides a surprisingly good fit as adjusted R^2 again decreases only marginally, and yields a slightly smaller output elasticity of 0.36, though a notably higher user cost elasticity in absolute terms at -0.50. In the final step, I also impose constant returns to scale (CRS), implying that $\varepsilon^s = 1$ and $-\beta_{\ln K_{t-1}} = \beta_{\ln S_t}$, and allowing these terms to be combined into $\ln S_t/K_{t-1}$. This leads to a much higher estimate of the user cost elasticity ($\varepsilon^c = -0.93$) but also worsens the model fit notably, with adjusted $R^2 = 0.13$, demonstrating that the assumption of constant returns to scale is not valid.

4.5 Firm heterogeneity and variation over time

The estimates of the user cost elasticity ($\varepsilon^c = -\sigma$) range from -0.3 to -0.5 across the preferred specifications for different models, suggesting that the underlying production function is between that of Leontief ($\sigma \to 0$) and that of Cobb-Douglas ($\sigma \to 1$), in line with much of the literature. Chirinko (2008) focuses on estimates related to the first-order condition for capital and concludes that the best international evidence available at the time suggested σ in the range of 0.4 and 0.6 and strongly rejected the assumption of $\sigma = 1$, which the Cobb-Douglas function implies. More recent work using aggregate or sectoral cross-country data also remains broadly in that range (Bond and Xing, 2015; Fatica, 2018), but recent studies using firm-level data have come up with user cost elasticities close to unity (Gilchrist and Zakrajsek, 2007; Dwenger, 2014; Buettner and Hoenig, 2016).[21] This could be explained by differences in the sample composition if the responsiveness varies with firm size, as those studies focused on larger firms.

The estimated output elasticities (ε^s) lie in the range of 0.15-0.35, which is notably smaller than the unity, that would be implied by constant returns to scale ($\nu = 1$). Attempts to uncover the return to scale parameter, $\nu = (1 + \varepsilon^c)/(\varepsilon^s + \varepsilon^c)$, led to highly volatile and unstable estimates. In particular, when the denominator

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[21] Knoblach et al. (2020) carried out an extensive meta-analysis of the US studies, covering a wide spectrum of functional forms of the estimation equations, not just the first-order condition for capital, and reported a mass of estimates of the elasticity of substitution between 0.3 and 0.7. Their long-run estimate of meta-elasticity for the aggregate US economy ranged from 0.45 to 0.87.

Table 5: ECM(m,n) models of the investment rate

	FE(2,2)	FE(1,1)	FE(1,0)	FE(1,0)+CRS
L.I/K	-0.1648***			
	(0.0047)			
Δ ln S	0.0630***	0.0625***		
	(0.0021)	(0.0021)		
L.Δ ln S	0.0747***			
	(0.0026)			
Δ ln C	-0.0968***	-0.0970***		
	(0.0030)	(0.0030)		
L.Δ ln C	-0.0797***			
	(0.0037)			
L2.ln K	-0.1900***			
	(0.0042)			
L.ln K		-0.1913***	-0.1896***	
		(0.0041)	(0.0039)	
L2.ln S	0.0696***			
	(0.0027)			
L.ln S		0.0718***		
		(0.0025)		
ln S			0.0674***	
			(0.0021)	
ln S/K				0.0991***
				(0.0023)
L2.ln C	-0.0732***			
	(0.0045)			
L.ln C		-0.0782***		
		(0.0037)		
ln C			-0.0950***	-0.0920***
			(0.0030)	(0.0029)
constant	1.4556***	1.4140***	1.4122***	0.0181
	(0.0724)	(0.0718)	(0.0715)	(0.0503)
ε^s	0.3661***	0.3755***	0.3555***	
	(0.0128)	(0.0123)	(0.0113)	
ε^c	-0.3854***	-0.4089***	-0.5010***	-0.9283***
	(0.0246)	(0.0206)	(0.0184)	(0.0355)
Year effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.179	0.178	0.177	0.135
N	102,163	102,163	102,163	102,163

Notes: dependent variable I/K; ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses. For comparability, subsequent specifications are restricted to use the same sample as the first one.

$(\varepsilon^s + \varepsilon^c)$ is close to zero, it results in a very high absolute value of ν and sign instability.[22]

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[22] Dwenger (2014, p. 174) and Bond and Xing (2015, Table 4) also obtained ε^s clearly below

Elasticities would be expected to vary with business characteristics such as firm size and economic sector, and over time, reflecting different production technologies and opportunity sets. Elasticities might also depend on the type of assets because of differences in how they contribute to production processes, ease of adjustments, and duration. To explore potential heterogeneities, I re-estimate a simple ADL(1,1) model with FE, which was shown in Table 5 to have performed reasonably well, interacting all the covariates with the variable of interest.

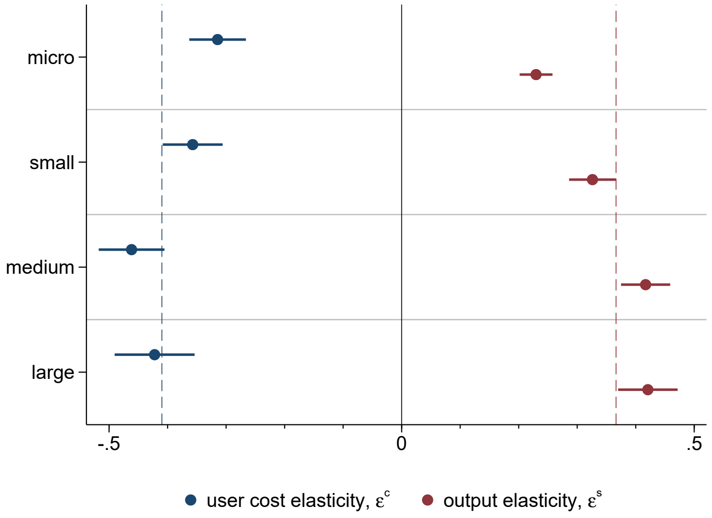

Figure 2: Estimated output elasticities and user cost elasticities by firm size

Source: Business Register, own calculations.

First, comparing firms with a composite size indicator (explained in Section 3.4) shows that output elasticity is substantially higher for larger firms, increasing from 0.23 for micro-size firms to 0.42 for medium and large-size firms (Figure 2). The vertical dash lines in the figure mark the FE estimates of the elasticities obtained with ADL(1,1) without interactions. Although the point estimates of user cost elasticity also suggest that larger firms have more elastic responses, the differences are smaller in size and are mostly not statistically significant. Similar results were obtained with quartile groups of each underlying sub-indicator for number of employees, balance sheet total, and annual sales separately.

Second, I find some sectoral variation, though it is perhaps less pronounced than might be expected, with user cost elasticities ranging from -0.2 to -0.5 apart from in agriculture and mining, and output elasticities ranging from 0.2 to 0.5 (Figure

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one and interpreted it as implying increasing returns to scale ($\nu > 1$). While $\varepsilon^s = \sigma + \frac{1-\sigma}{\nu} < 1$ would indeed suggest that, assuming $0 \leq \sigma < 1$ and ν is positive, it is important to emphasise that $\nu = (1-\sigma)/(\varepsilon^s - \sigma) > 0$ requires in turn $\varepsilon^s > \sigma$ (unless $\sigma > 1$). This however was not the case in those two studies and nor is it here, and hence firm conclusions cannot be drawn about the implied returns to scale.

3). Gilchrist and Zakrajsek (2007) is another rare example where elasticities are estimated by sector with firm-level data, and those authors obtained a somewhat broader range of values for the US, but with much less precision because the sample was smaller. I obtain high estimates in absolute terms for both elasticities in agriculture, and transport and storage, and low estimates in real estate, and hotels and restaurants. The user cost elasticity is also high in the combined sector of mining, energy and water, though statistical precision is very low because the sample is small. The output elasticity is also higher than the average in manufacturing and lower than the average in professional services. Overall, no sector exhibits elasticities close to unity and across sectors there appears to be no obvious pattern, such as a steady relationship with capital intensity. Neither is there any clear difference between goods and service industries, suggesting that the focus on manufacturing firms in the earlier literature may have been overly conservative.

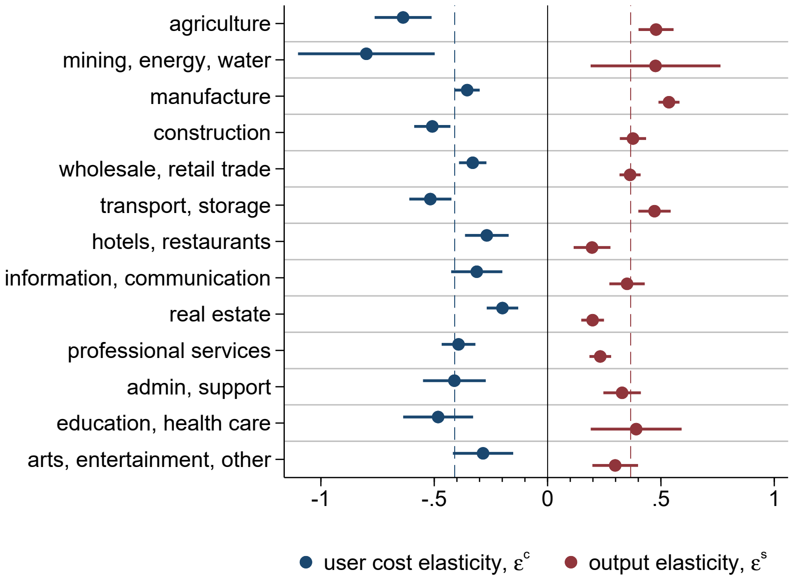

Figure 3: Estimated output elasticities and user cost elasticities by sector

Source: Business Register, own calculations.

Third, I estimate changes in elasticities over time by interacting all the covariates with year dummies. Yearly estimates of the elasticities for total non-financial fixed assets show substantial intertemporal variation in the user cost elasticities with values ranging from near zero to near minus unity (Figure 4). Although the statistical precision is low, the dynamics appear to be loosely related to price developments, as the responses are more elastic when inflation is low and less elastic when it is high, with a correlation coefficient between ε^c and an annual change in the GFCF deflator of 0.60. There is no clear evidence, however, that the user cost elasticity has become less responsive since the GFC, as the results in Melolinna et al. (2018) suggested.

Output elasticities, meanwhile, seem to be related to business cycles as they have more elastic responses when economic growth is fast, and are less elastic when it is slow, with a correlation coefficient between ε^s and the annual GDP growth rate of 0.57, even though the economic importance of this is limited given that estimates vary in a relatively narrow range from 0.33 to 0.45. Unlike estimates of the user cost elasticity, yearly estimates of output elasticity have become statistically more precise over time as the effective sample size has increased. I also provide annual estimates separately for structures (Figure B.8) and equipment (Figure B.9). Yearly elasticities for equipment are in line with those for total non-financial fixed assets, in both their levels and their dynamics. The elasticities for structures are notably lower (as already shown above) and slightly more fluctuating.

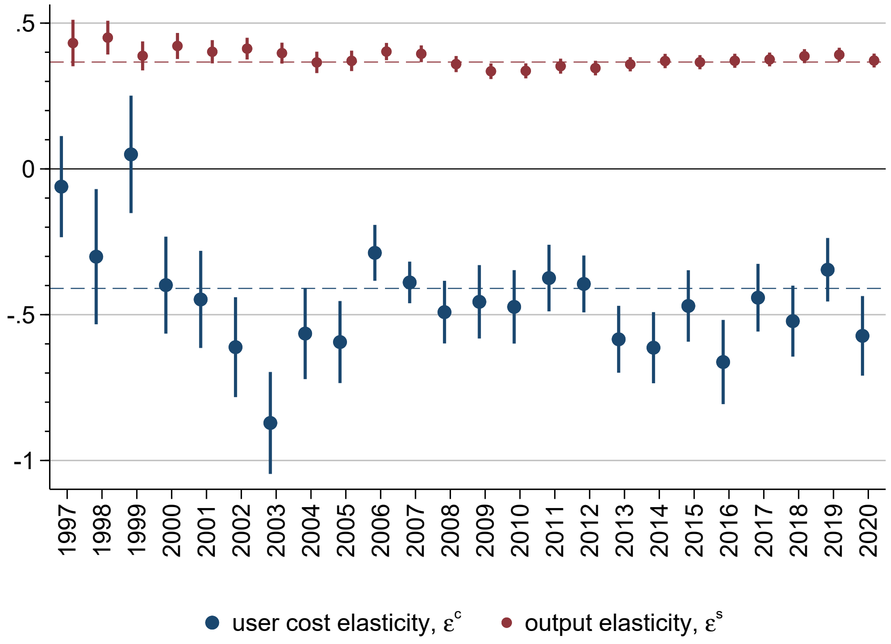

Figure 4: Estimated output elasticities and user cost elasticities by year

Source: Business Register, own calculations.

5 Conclusions

Using firm-level panel data to investigate the determinants and dynamics of business fixed investment in Estonia, I find that the gross investment rate is positively related to changes in production output and negatively to the user cost of capital, providing strong empirical support for the standard neoclassical theory of factor demand. The extensive dataset allows key parameters, the elasticity of capital stock to output, and the user cost of capital, to be estimated with high statistical precision, and how sensitive the estimated elasticities are across different models and specifications to be explored.

I find that the main estimates fall in a relatively narrow band, as the output elasticity ranges from 0.15 to 0.35 and the user cost elasticity from -0.2 to -0.5. It is notable that the most parsimonious approach in the form of a partial adjustment model corroborates the high end of the elasticity estimates. Both elasticities are in absolute terms clearly less than unity and so they do not support a production function with constant returns to scale.

Exploring heterogeneity across firms reveals modest variation in elasticities by economic sectors and various size indicators of the firms, with larger firms having higher output elasticities on average. Distinguishing between the types of fixed assets, I find that investment in machinery and equipment is more sensitive to output and the user cost of capital than investment in buildings and structures is. I also find that output elasticities are relatively stable over time and appear to be only slightly pro-cyclical, while user cost elasticities are more volatile and have a stronger correlation with price developments than with GDP growth.

While the user cost of capital proves to be an essential factor for business investments, the combination of low interest rates and low capital tax rates in Estonia limits for the time being the scope for encouraging investment much further through policies aimed at lowering the user cost. The existing tax system is also shown to favour the accumulation of capital and to encourage investment in general, but it does not specifically promote research and development activities, which are seen as increasingly vital for further advancements in productivity and economic growth.

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Appendixes

Appendix A Derivation of the user cost of capital

Denote with F firm output, p the price of output, p^I the price of capital goods, τ classical corporation tax at a constant rate, k the rate of investment tax credit, $D_u(t-u)$ the depreciation deduction at date t per unit of investment made at an earlier date u, ρ the nominal discount rate, and I gross investment. Assuming that capital depreciates at a constant geometric rate of δ, the equation of motion for the capital inputs is

$$I_t = \dot{K}_t + \delta K_t$$

and the firm maximises its value as cash flows at time s:

$$\max \int_s^\infty \left[(1-\tau_t)p_t F(K_t) - (1-k_t)p_t^I I_t + \tau_t \int_{-\infty}^t D_u(t-u)p_u^I I_u \,\mathrm{d}u\right] e^{-\rho(t-s)}\,\mathrm{d}t$$

The last term for depreciation allowances can be rearranged to separate a part ($\bar{D}$), which does not affect decisions from date s onwards and so can be ignored in the optimisation process. The remaining part for depreciation allowances is simplified by changing the order of integration.

$$\begin{aligned}
& \int_s^\infty \left[\tau_t \int_{-\infty}^t D_u(t-u)p_u^I I_u \,\mathrm{d}u\right] e^{-\rho(t-s)}\,\mathrm{d}t \\
= & \int_s^\infty \left[\int_s^t \tau_t D_u(t-u)p_u^I I_u \,\mathrm{d}u + \int_{-\infty}^s \tau_t D_u(t-u)p_u^I I_u \,\mathrm{d}u\right] e^{-\rho(t-s)}\,\mathrm{d}t \\
= & \int_s^\infty \left[p_t^I I_t \int_t^\infty \tau_u D_t(u-t)e^{-\rho(u-t)} \,\mathrm{d}u\right] e^{-\rho(t-s)}\,\mathrm{d}t + \bar{D}
\end{aligned}$$

Denoting

$$q_t = \left[1 - k_t - \int_t^\infty \tau_u D_t(u-t)e^{-\rho(u-t)}\,\mathrm{d}u\right] p_t^I$$

the optimisation problem can then be rewritten as

$$\max \int_s^\infty L(t, K_t, \dot{K}_t)\,\mathrm{d}t = \max \int_s^\infty \left[(1-\tau_t)p_t F(K_t) - q_t I_t\right] e^{-\rho(t-s)}\,\mathrm{d}t$$

Solving the Euler equation

$$\frac{dL_t}{dK_t} - \frac{d}{dt}\left(\frac{dL_t}{d\dot{K}_t}\right) = 0$$

yields:

$$\frac{dF_t}{dK_t} = \frac{q_t}{p_t}\frac{(\rho + \delta - \dot{q}_t/q_t)}{(1-\tau_t)} \approx \frac{q_t}{p_t}\frac{(r+\delta)}{(1-\tau_t)}$$

where r denotes the cost of funds in real terms.

Appendix B Supplementary figures and tables

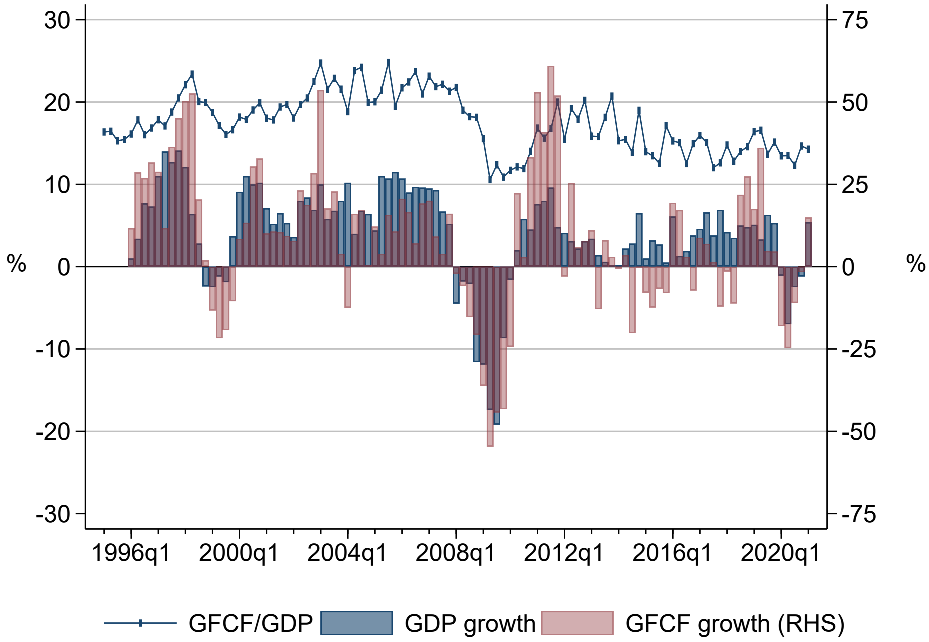
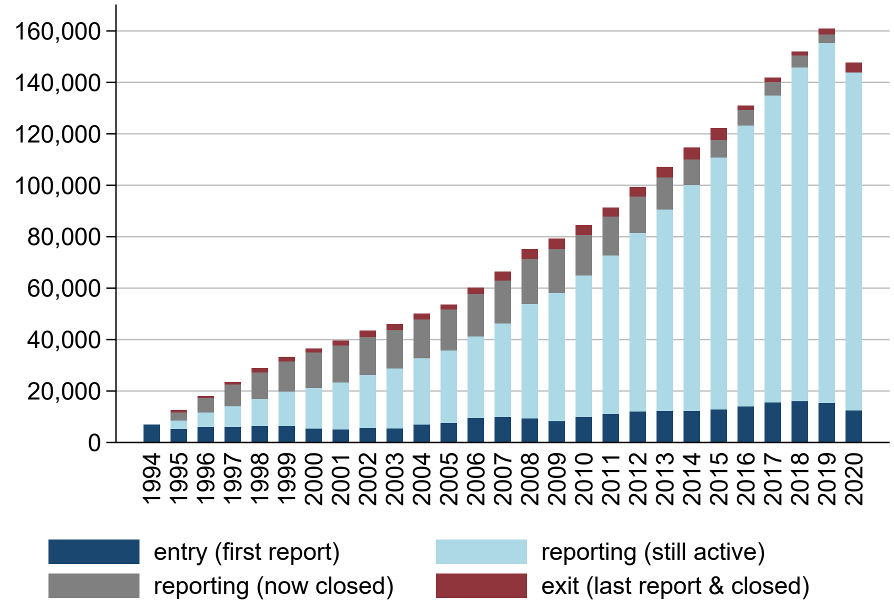


Figure B.1: Gross fixed capital formation of non-financial corporations and GDP

Sources: Statistics Estonia, own calculations.



Notes: Firms which entered and exited in the same period are included in the entry group.
Firms still active include all those that remain registered even if their last report was filed before 2020.

Figure B.2: Reports of non-financial corporations by firm status

Sources: Business Register, own calculations.

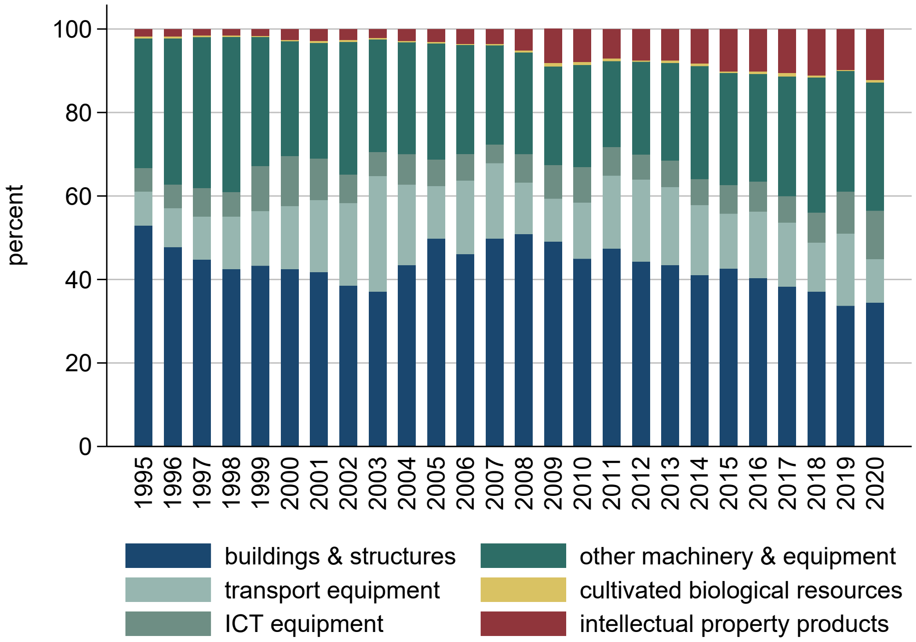


Figure B.3: Composition of GFCF of non-financial corporations

Sources: Statistics Estonia, own calculations.

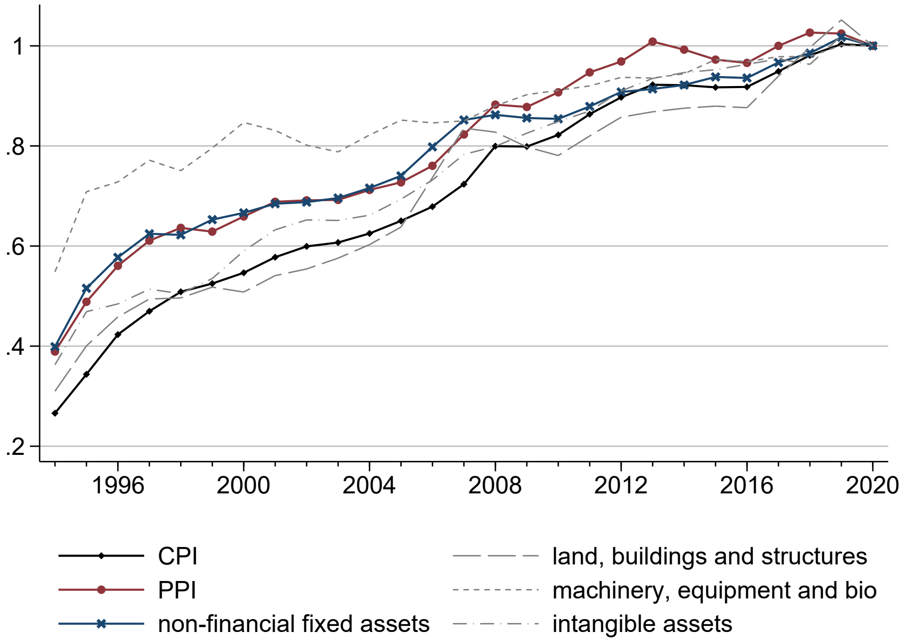
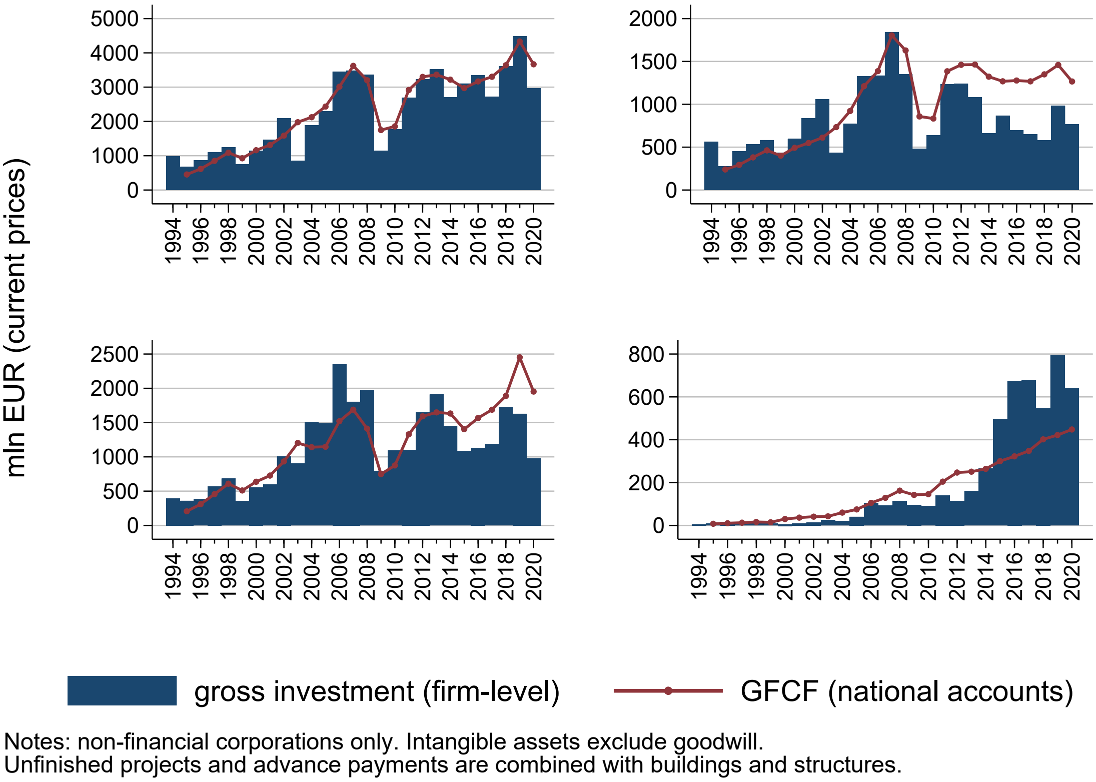


Figure B.4: Price indexes by asset category

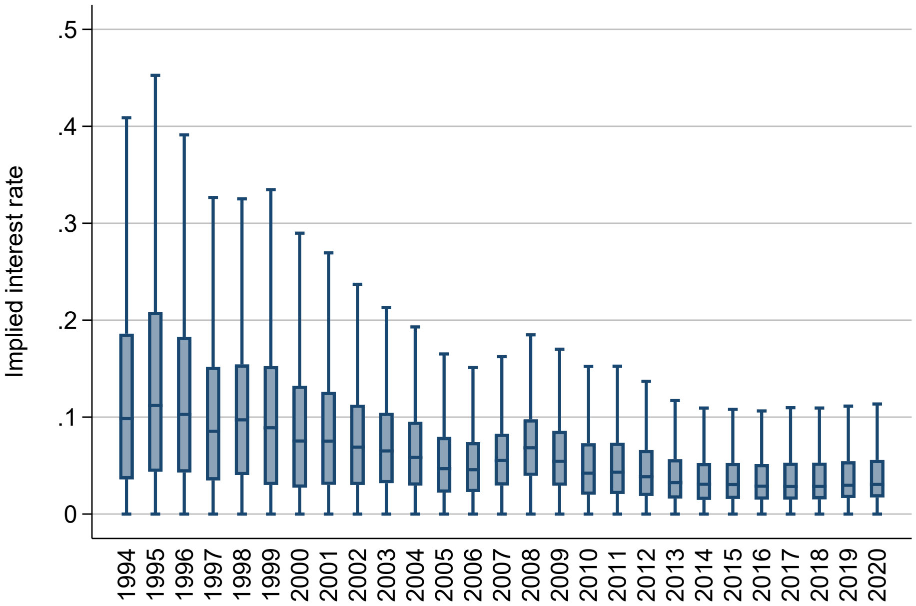
Sources: Statistics Estonia, own calculations.



Notes: non-financial corporations only. Intangible assets exclude goodwill.
Unfinished projects and advance payments are combined with buildings and structures.

Figure B.5: Gross investment (business accounts) and GFCF (national accounts)

Sources: Business Register, Statistics Estonia, own calculations.



Notes: calculated as the ratio of interest costs to loan liabilities at the firm-level.
Statistics calculated using non-imputed values in the range of [0,1] for non-financial corporations.

Figure B.6: Distribution of firm-level implied interest rates

Sources: Business Register, own calculations.

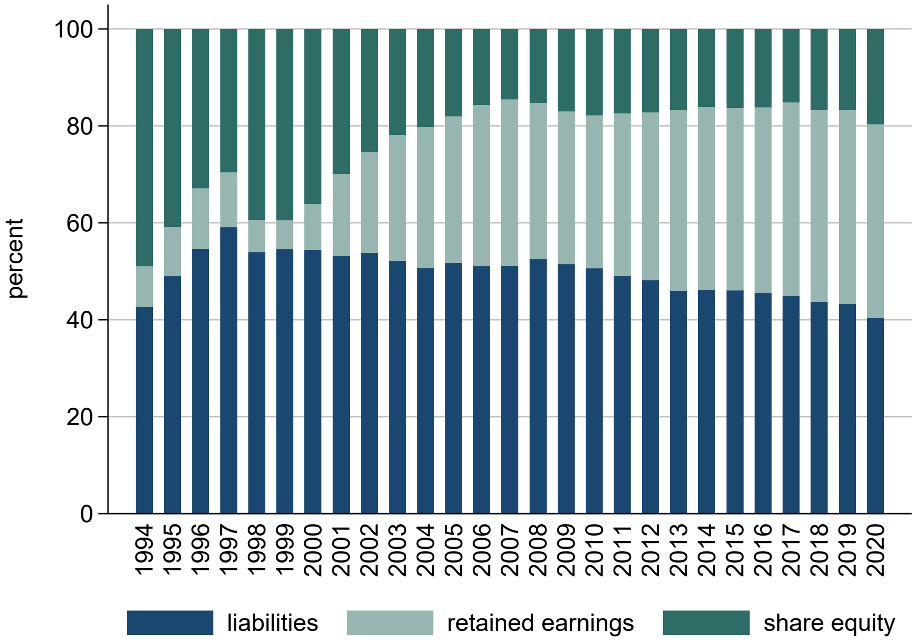


Figure B.7: Funding composition

Sources: Business Register, own calculations.

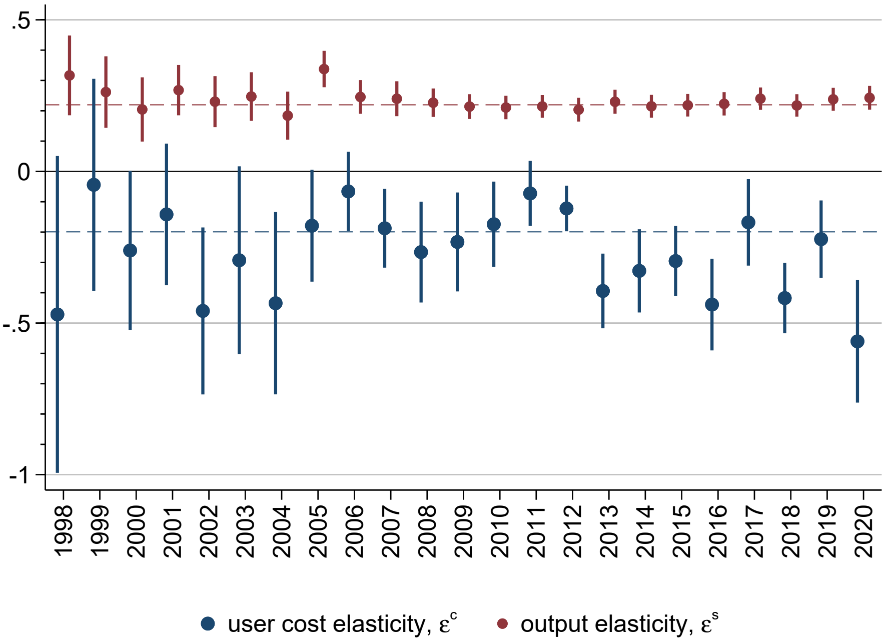


Figure B.8: Output elasticities and user cost elasticities by year for structures

Sources: Business Register, own calculations.

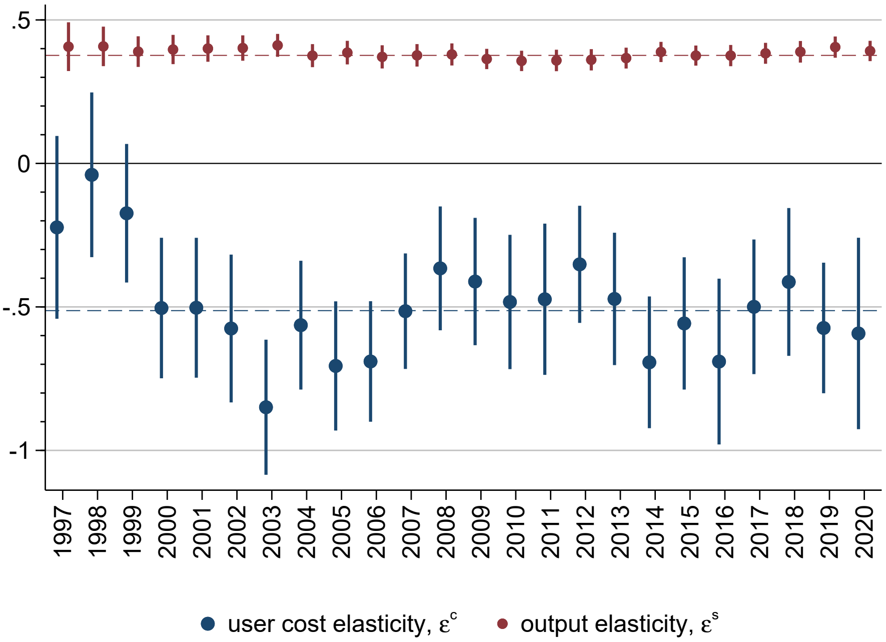


Figure B.9: Output elasticities and user cost elasticities by year for equipment

Sources: Business Register, own calculations.

Table B.1: Reduced-form estimations using firm-level data

Study	Data	# of firms (obs)	Static	Dynamic	UCC	Estimators
Chirinko, Fazzari, and Meyer (1999)	US 1981-1991	4,095 (26,071)	DLM	–	yes	FE, FD, DIFF/FOD-GMM
Mairesse, Hall, and Mulkay (1999)	FR/US 1971-1979, 1985-1993	407-486 (3,663-4,374)	DLM	ECM	no	OLS, FE, DIFF-GMM
Bond, Elston, Mairesse, and Mulkay (2003)	BE/DE/FR/UK 1978-1989	228-1,365 (1,797-9,485)	–	ECM	no	FE, DIFF-GMM
Bond, Harhoff, and Van Reenen (2005)	DE 1987-1994, UK 1985-1994	246-263 (1,655-1,971)	–	ECM	no	SYS-GMM
Bloom, Bond, and Van Reenen (2007)	US 1972-1991	672 (5,347)		ECM	no	SYS-GMM
Gilchrist and Zakrajsek (2007)	US 1973-2005	896 (6,398)	PAM	PAM	yes	FE, FOD-GMM
Dwenger (2014)	DE 1987-2007	3,968 (24,762)	DLM	ECM	yes	SYS-GMM
Buettner and Hoenig (2016)	DE 1994-2007	490 (2,722)	DLM	ECM	yes	FD, SYS-GMM
Melolinna, Miller, and Tatomir (2018)	UK 2000-2015	178 (1,447)	PAM	PAM	yes	FE, FOD/SYS-GMM

Notes: DLM=distributed lag model, ECM=error correction model, PAM=partial adjustment model; UCC=user cost of capital; OLS=ordinary least squares, FE=fixed-effects/within-group, FD=first-differenced, GMM=generalised method of moments.

Table B.2: Firm characteristics

	Raw sample			Estimation sample		
	mean	std.dev.	count	mean	std.dev.	count
net sales (ln)	10.655	2.309	1,608,929	12.912	1.922	137,716
balance sheet total (ln)	10.334	2.269	1,987,965	12.907	1.846	137,715
net capital stock (ln)	10.119	2.133	1,106,087	12.364	1.794	137,716
gross investments (ln)	9.037	2.332	657,059	9.908	2.186	137,716
user cost of capital	0.146	0.059	1,964,622	0.133	0.064	137,573
age	6.403	5.945	2,025,282	11.132	6.177	137,716
size:						
-micro	0.758	0.428	2,024,216	0.286	0.452	137,716
-small	0.112	0.316	2,024,216	0.216	0.411	137,716
-medium	0.087	0.281	2,024,216	0.274	0.446	137,716
-large	0.044	0.204	2,024,216	0.224	0.417	137,716
sector:						
-agriculture	0.046	0.209	1,933,321	0.083	0.276	135,541
-mining, energy, water	0.009	0.093	1,933,321	0.025	0.156	135,541
-manufacture	0.076	0.264	1,933,321	0.173	0.378	135,541
-construction	0.108	0.310	1,933,321	0.082	0.274	135,541
-wholesale, retail trade	0.196	0.397	1,933,321	0.159	0.366	135,541
-transport, storage	0.055	0.228	1,933,321	0.084	0.278	135,541
-hotels, restaurants	0.031	0.173	1,933,321	0.048	0.214	135,541
-information, communication	0.058	0.234	1,933,321	0.039	0.194	135,541
-real estate	0.103	0.304	1,933,321	0.105	0.307	135,541
-professional services	0.156	0.363	1,933,321	0.091	0.287	135,541
-admin, support	0.061	0.239	1,933,321	0.045	0.206	135,541
-education, health care	0.033	0.178	1,933,321	0.037	0.188	135,541
-arts, entertainment, other	0.068	0.253	1,933,321	0.029	0.168	135,541
legal status:						
-registered	0.787	0.409	2,025,282	0.891	0.312	137,716
-closed	0.213	0.409	2,025,282	0.109	0.312	137,716
legal form:						
-public limited company	0.041	0.198	2,025,282	0.186	0.389	137,716
-private limited company	0.952	0.214	2,025,282	0.812	0.391	137,716
-other	0.007	0.085	2,025,282	0.001	0.037	137,716

Notes: limited liability for-profit non-financial corporations; the sample period is 1994-2020; all monetary series are deflated and stated in 2020 prices; micro-size firms are defined as those that have fewer than 10 employees and either a balance sheet total or annual turnover below 100 thousand euros, the thresholds for small and medium firms are 50 employees and 250 thousand or 1 million euros balance sheet total/turnover; the minimum share capital requirement is 25,000 euros for a public limited company (*aktsiaselts*) and 2,500 euros for a private limited company (*osaühing*); other legal forms include subsidiaries of foreign entities and European entities (EEIG, Societas Europaea).

Table B.3: AR1 models

	OLS	FE	DIF2	DIF3	SYS3
L.ln K	0.9881***	0.8721***	0.8668***	0.8781***	0.9251***
	(0.0003)	(0.0028)	(0.0102)	(0.0169)	(0.0049)
AR1			0.000	0.000	0.000
AR2			0.000	0.000	0.000
AR3			0.193	0.187	0.206
Hansen			0.001	0.586	0.000
L.ln S	0.9807***	0.5955***	0.3783***	0.6983***	0.9150***
	(0.0009)	(0.0086)	(0.0304)	(0.0528)	(0.0116)
AR1			0.000	0.000	0.000
AR2			0.032	0.002	0.000
AR3			0.871	0.767	0.620
Hansen			0.000	0.132	0.000
L.ln C	0.3663***	0.1151***	0.1753***	0.2806***	0.5408***
	(0.0061)	(0.0058)	(0.0083)	(0.0583)	(0.0280)
AR1			0.000	0.000	0.000
AR2			0.019	0.020	0.000
AR3			0.035	0.241	0.889
Hansen			0.000	0.000	0.000
L.I/K	0.2031***	-0.0173***	0.1041***	0.3758***	0.7085***
	(0.0033)	(0.0035)	(0.0045)	(0.0668)	(0.0294)
AR1			0.000	0.000	0.000
AR2			0.000	0.000	0.000
AR3			0.537	0.926	0.683
Hansen			0.000	0.342	0.004
N	120,081	120,081	102,446	102,446	120,081
N instruments			93	69	93

Notes: dependent variables are $\ln K$, $\ln S$, $\ln C$ and I/K; ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses; p-values reported for AR and Hansen tests. All models include time fixed effects. FE=fixed-effects; DIF2=two-step difference-GMM with 2nd-4th lags used as instruments; DIF3=two-step difference-GMM with 3rd-4th lags used as instruments; SYS3=two-step system-GMM with 3rd-4th lags (first-differences equation) and differenced 2nd lag (levels equation) used as instruments.

Table B.4: ECM(2,2) model of the investment rate for structures

	OLS	FE	DIFex	DIFen
L.I/K	0.2305***	-0.0561***	-0.1268***	-0.1112***
	(0.0059)	(0.0074)	(0.0337)	(0.0294)
Δ ln S	0.0172***	0.0145***	0.0098***	0.0140
	(0.0011)	(0.0013)	(0.0013)	(0.0183)
L.Δ ln S	0.0167***	0.0197***	0.0138***	-0.0261
	(0.0011)	(0.0017)	(0.0019)	(0.0189)
Δ ln C	-0.0237***	-0.0196***	-0.0159***	0.0151*
	(0.0016)	(0.0018)	(0.0020)	(0.0077)
L.Δ ln C	-0.0210***	-0.0192***	-0.0148***	0.0137*
	(0.0017)	(0.0022)	(0.0028)	(0.0066)
L2.ln K	-0.0103***	-0.1004***	-0.2283***	-0.2096***
	(0.0005)	(0.0062)	(0.0275)	(0.0241)
L2.ln S	0.0093***	0.0236***	0.0146***	-0.0334
	(0.0004)	(0.0020)	(0.0025)	(0.0205)
L2.ln C	-0.0206***	-0.0172***	-0.0113**	0.0174*
	(0.0017)	(0.0027)	(0.0035)	(0.0068)
constant	0.0136	0.9162***		
	(0.0298)	(0.0709)		
ε^s	0.8944***	0.2349***	0.0638***	-0.1594
	(0.0327)	(0.0201)	(0.0100)	(0.1023)
ε^c	-1.9901***	-0.1715***	-0.0493**	0.0829*
	(0.1702)	(0.0273)	(0.0150)	(0.0339)
Year effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.136	0.111	.	.
N	59,983	59,983	50,231	50,231
N instruments	.	.	75	161
AR1 (p-value)	.	.	0.000	0.000
AR2 (p-value)	.	.	0.750	0.786
AR3 (p-value)	.	.	0.430	0.566
Hansen (p-value)	.	.	0.066	0.011

Notes: dependent variable I/K (land, buildings and structures); ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses. FE=fixed-effects; DIFex=two-step difference-GMM with exogenous covariates (IV style), lags 3-4 of I/K used as GMM instruments; DIFen=two-step difference-GMM with $\Delta \ln S$ and $\Delta \ln C$ terms as endogenous covariates, lags 3-4 of I/K, $\ln S$ and $\ln C$ used as GMM instruments.

Table B.5: ECM(2,2) model of the investment rate for equipment

	OLS	FE	DIFex	DIFen
L.I/K	0.0753***	-0.2612***	-0.2798***	-0.3578***
	(0.0048)	(0.0066)	(0.0579)	(0.0515)
Δ ln S	0.0850***	0.0897***	0.0579***	0.1774***
	(0.0036)	(0.0043)	(0.0048)	(0.0428)
L.Δ ln S	0.0681***	0.1086***	0.0612***	0.2368***
	(0.0030)	(0.0050)	(0.0092)	(0.0589)
Δ ln C	-0.1755***	-0.1552***	-0.1591***	-0.3926***
	(0.0072)	(0.0079)	(0.0087)	(0.0686)
L.Δ ln C	-0.1200***	-0.1398***	-0.1431***	-0.3060***
	(0.0076)	(0.0109)	(0.0136)	(0.0565)
L2.ln K	-0.0175***	-0.2682***	-0.3499***	-0.4472***
	(0.0010)	(0.0080)	(0.0603)	(0.0566)
L2.ln S	0.0101***	0.1038***	0.0526***	0.2412***
	(0.0009)	(0.0055)	(0.0129)	(0.0651)
L2.ln C	-0.1115***	-0.1354***	-0.1466***	-0.2938***
	(0.0076)	(0.0135)	(0.0173)	(0.0564)
constant	0.2543***	1.8751***		
	(0.0365)	(0.0988)		
ε^s	0.5772***	0.3871***	0.1502***	0.5395***
	(0.0310)	(0.0197)	(0.0177)	(0.1163)
ε^c	-6.3845***	-0.5049***	-0.4191***	-0.6571***
	(0.5116)	(0.0513)	(0.0651)	(0.1460)
Year effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.080	0.185	.	.
N	49,270	49,270	39,441	39,441
N instruments	.	.	75	161
AR1 (p-value)	.	.	0.000	0.000
AR2 (p-value)	.	.	0.256	0.415
AR3 (p-value)	.	.	0.009	0.016
Hansen (p-value)	.	.	0.058	0.262

Notes: dependent variable I/K (machinery, equipment and biological assets); ° p<0.1, * p<.05, ** p<.01, *** p<0.001; cluster-robust standard errors in parentheses. FE=fixed-effects; DIFex=two-step difference-GMM with exogenous covariates (IV style), lags 3-4 of I/K used as GMM instruments; DIFen=two-step difference-GMM with $\Delta \ln S$ and $\Delta \ln C$ terms as endogenous covariates, lags 3-4 of I/K, $\ln S$ and $\ln C$ used as GMM instruments.

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No 1
Olivier Damette, Karolina Sobczak, Thierry Betti. Financial transaction tax, macroeconomic effects and tax competition issues: a two-country financial DSGE model