Investment Behavior, User Cost and Monetary Policy Transmission – the Case of Hungary

Version 1

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1 Non-technical summary

In this paper we investigate corporate investment behavior using a large panel of Hungarian firms between 1993 and 2002. The standard neoclassical framework is used to derive empirically feasible specifications, however, several other issues beyond the scope of the framework are also addressed.

We follow the line of research carried out previously in the Eurosystem Monetary Transmission Network (EMTN). Our results are, by and large, similar to those obtained within the EMTN. Namely, the effect of user cost changes on investment is significant and robust across several specifications providing strong evidence against simple sales-accelerator models of investment. Firms' cash-flow proved to be a significant determinant of corporate investment, which suggests that financial variables do matter for firms.

2 Introduction

Understanding investment behavior has been an important topic on the economic agenda for some time. Empirical and theoretical models of business investment has been developing rapidly since the 1960's. The interest and need for understanding investment behavior emanated from various reasons. First, it is widely accepted that investment volatility is a prime contributor to aggregate output fluctuations. Also, anemic investment expenditures might signal various economic problems that might need solutions from economic policy makers. While having a clear picture of business investment characteristics is interesting on its own right, this paper seeks to empirically investigate corporate investment behavior in order to shed some light on how monetary impulses are transmitted to the Hungarian nonfinancial corporate sector, namely, to what extent and how business investment reacts to monetary policy decisions.

However, the implication of our approach is that it is *not* the existence of the traditional interest rate channel that is in focus of the paper. The traditional interest rate channel portrays the transmission of a money supply shock to investment and output (see Mishkin (1996)). Rather, what we intend to gauge is to what extent changes in the user cost of capital – of which the interest rate is only a determinant – affect corporate investment behavior. It is of high relevance because being a small open economy, Hungary is widely viewed as a country where the main channel of transmission is the exchange rate and the role of mechanisms operating via the interest rate level is often downplayed.

Several previous studies have tried to capture the relationship between interest rates and investment but those using aggregate data have been rather unsuccessful in this respect. The ambiguity of results and the failure to detect significant linkages between variables can be attributed to a number of reasons. First, aggregation itself obscures effects that could otherwise be important at the firm level and, as a result, significant parameter estimates are rarely obtained on aggregate data. Second, the endogeneity of aggregate investment and the user cost of capital cause simple OLS parameter estimates to be inconsistent and good instruments are difficult to find at the aggregate level. Third, financial market imperfections are not explicitly taken into account in aggregate models of investments, yet their role is widely accepted in the literature.

Our investigation is micro-founded in the sense of both model development and estimation. Applying a micro-approach provides at least partial solutions to the problems mentioned above. Heterogeneity across firms provides for large variance of the observations, which can be exploited in the identification and estimation procedures. Also, endogeneity can be tackled since valid instruments are easier to obtain at the firm level. Financial market imperfections are also incorporated in our model and its effects are estimated.

This paper is part of a broader project within the Magyar Nemzeti Bank aimed at mapping various transmission mechanisms of monetary policy. In our work, we followed the line of research carried out in the Eurosystem Monetary Transmission Network in order to obtain results which are derived in a rigorous framework and are comparable to previous European results.

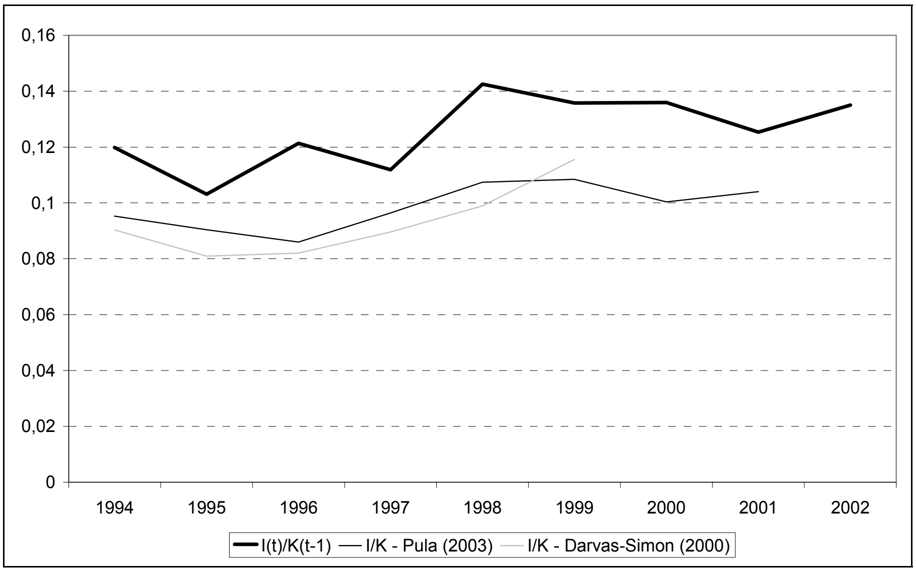
The paper is organized as follows. In the next section stylized facts are presented along with previous studies of capital formation in Hungary. The theoretical model is discussed and the optimization problem of a representative firm is solved in Section 4. Estimable specifications are derived in Section 5. Section 6 overviews the neoclassical framework and addresses its shortcomings and certain other issues that cannot directly be tackled within the framework though proved to be important. Characteristics of our data and the way we constructed key variables are presented in Section 7. Our estimation strategy and results are exhibited in the next Section and Section 9 concludes. Further data details are provided in the Appendix.

3 Business cycle, investment and monetary policy in Hungary– Stylized facts

3. 1 Previous studies of investment and capital

To our knowledge, two former investigations carried out capital stock estimation on Hungarian data. Both studies of capital formation produced similar conclusions both in qualitative and quantitative terms (Figure 1). Pula (2003) estimated aggregate investment (corporate plus public) series using Central Statistics Office (CSO) survey data. He used CSO data only on investments put into operation[1] and investment[2] in his calculations. Our calculation approach is close to that of Pula (2003) in the sense that we derive investment using changes in balance sheet capital data, that is, we accounted for only those investments that were already put into operation.

Figure 1: Previous results of investment rate series



However, there are two differences that may account for the gap between the two. First, his dataset consisted of firms employing more than 5 persons on average while our dataset is somewhat broader as will be seen in the dataset description. Second, CSO surveys fixed capital formation which covers the purchase and production of new tangible assets. On the contrary, we used balance sheet data on intangibles as well. These differences might explain why our investment rate is higher. Yet, despite differences, the two imply similar conclusions regarding both the level and the dynamics of investment.

[1] In CSO terminology, investments put into operation are investments brought into proper use, as well as their part independently put into use.

[2] Investment comprises new acquisition, establishment, production of new tangible assets, the expansion, change of the function, conversion, reconstruction of existing tangible assets, the substitution of which were used up, woth the exclusion of cultivation, maintenance and renewal of the natural forests. The continuous maintenance and repair of the tangible are not part of investment.

The other study by Darvas et al. (2000) produced aggregate investment broadly similar to that of Pula. However, they used investment data instead of investments put into operation. Further discussion of previous results can be found in Pula (2003).

3. 2 Determinants of Hungarian investment – stylized facts

As regards macroeconomic conditions, the first few years of the 1990's can be characterized with volatile inflation, real interest rates and an appreciating real exchange rate. The macroeconomic environment was rather unstable emanating largely from the structural changes which were induced by the transition process. To avoid loss of competitiveness stemming from adjustments in market prices, policy makers recurrently decided to realign the nominal exchange rate, which, in turn fuelled inflation expectations. Without these exchange rate adjustments, however, the huge current account deficit inherited from the 1980's would have caused the already heavy debt burden to increase further. Also, economic policy faced necessary reforms on the fiscal side. Against this backdrop came the comprehensive economic reform package in 1995, which eliminated economic imbalances and promoted macroeconomic consolidation afterwards. As an immediate result of the measures, both the budget and the current account deficit halved, which obviously was a favourable consequence. However, economic growth and investment dampened at the same time.

In light of these events it is not surprising that investment activity was more intense in the second half of the period under investigation. The onset of the 1990's was the very time of the transition to market economy when firms were driven to remarkably revaluate their capital stock as existing capital goods inherited from the planned economy have become obsolete.

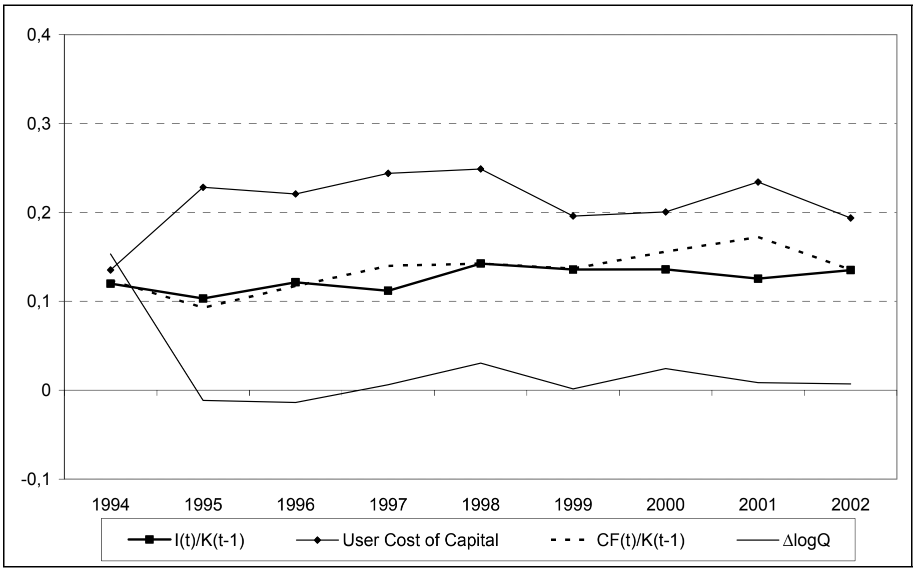
This is reflected in the fact that the investment rate peaked after the middle 1990's. In these years (1997-1998), foreign direct investment culminated pumping heavy inflows of fresh capital to the Hungarian corporate sector and fuelling buoyant investment activity.

From 1999 onwards, the slightly decreasing but still stable investment rate suggests companies might begin to foresee their profit opportunities deteriorating with the nearing recession and they gradually began to refrain from actively investing in new capital goods and, accordingly, rather accumulated cash-flow. This can be seen from the increasing cash-flow-to-capital ratio.

However, the increase in the investment rate in 2002 supports the view that – although some slack in economic activity could still be felt that year – Hungarian firms engaged in heavy investment at the end of 2002[3].

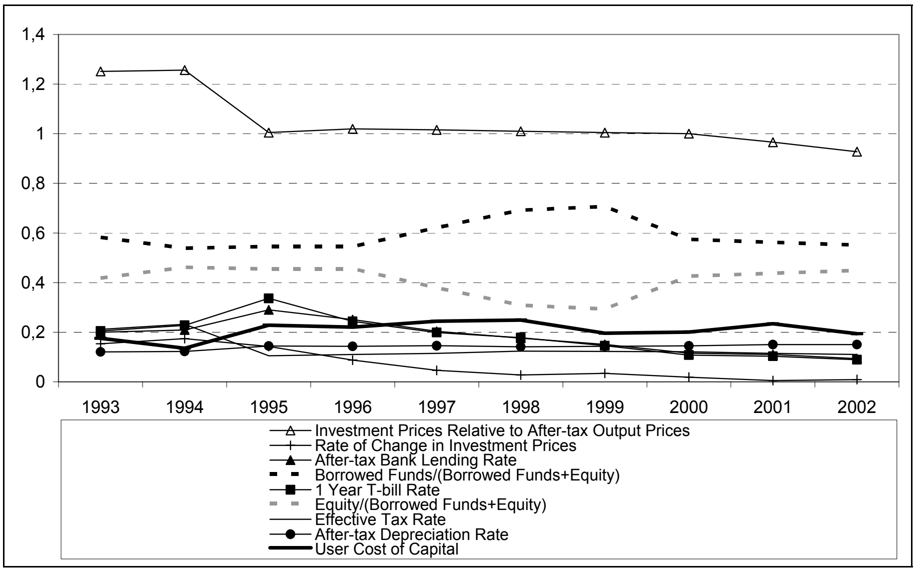
[3] See, e.g., the 2004 February issue of the NBH's Quarterly Report on Inflation for further details.

Figure 2: Investment, User Cost, Cash Flow and Growth of Sales*



**To replicate macro data, we used K(t-1) as weights to calculate averages of I(t)/K(t-1) and CF(t)/K(t-1). For ΔlogQ, weights are Q(t-1) values. However, since it is not evident what variable one should use calculating a weighted average of the user cost, we present hereafter the unweighted averages of the user cost of capital and its components.*

Figure 3: Average User Cost of Capital and its after-tax components I



As we will see in Section 4, theoretical results enforce the intuition that user cost developments are primary determinants of investment behavior. Therefore, we found it instructive to analyse how each of its components evolved in our sample period. Several findings emerge when breaking down the user cost of capital. First, the average cost of capital exhibited moderate volatility throughout the period. In 1993-94, it fell slightly below 15%. However, already in the first year of the macroeconomic stabilisation

(1995), when fiscal reforms and a new monetary regime[4] were introduced, the user cost increased to over 20% and went down under 20% only at the end of the nineties and in 2002. Driving forces behind these movements are analysed below (see Figure 4 and Figure 5).

The most obvious effect was put out by changes in the interest rate level. 1994 saw a rise in the interest rate level but it was not reflected in the cost of capital because other factors, e.g. investment price movements, counterbalanced the elevating effect of interest rates. However, interest rate effects were prevalent in 1995 with a sharp rise in the interest rate level. From 1996 on, the continuously declining interest rates permanently pushed the user cost of capital downwards. The only exception was 2001 when rates remained stable.

Another important determinant was the effect of investment price inflation. Investment prices affect the user cost equation via two terms. The first is the rate of change in investment prices, the other is the investment price level relative to the output price level. Investment price inflation showed a rather smooth path during the period under investigation. Investment prices increased in the first two years of our sample period and have been decreasing ever since with the exception of 1999. The continuous decline might be explained by the general downward inflation trend in the economy. The deceleration in investment price inflation had an elevating effect on the cost of capital, that is, the slower upward investment price movements from the middle 1990's ever reduced the price-gains capital goods holders realized throughout the period. In 1999, however, a temporary 'price' hike took place reinforcing the downward pressure falling interest rates already put on the user cost. These two effects seem to have been strong enough to be apparent in the diminishing average cost of capital in 1999.

The other term involving investment prices is the first term in the user cost equation. It shows how dear investment goods are relative to final goods. This relative price term exhibited a slowly abating pattern in the period under review except that it fell sharply in 1995. This slightly downward trend exerted a diminishing effect on the user cost throughout the whole period.

Changes in corporate tax rates also played a role in user cost developments. Corporate tax rates were cut two times in the 1990's. First, a four percentage point cut took place in 1994 (40% to 36%). This movement was not reflected in the average effective tax rate because of the effects of various tax credits and because the rate of companies unaffected by the tax cut – that is, enjoying total tax exemption – was quite high throughout the decade (more than 30%). However, the more drastic cut in 1995 halving the 36% rate had a measurable effect. Tax cuts influence the user cost via three terms. First, it reduces the first term in the user cost equation $\frac{P_{st}^{I}}{(1-u_{it})P_{st}}$, which, of course, reduces the user cost itself. Second, it augments the after-tax cost of external funds $IR_t(1-u_{it})$ and the after-tax depreciation rate $(1-u_{it})\delta_{it}$. In light of this, the drastic cut in 1995 increased the cost of capital via tax savings on depreciation and interest paid but curbed it by making investment cheaper relative to after-tax output. The effective tax rate remained stable in the rest of the decade.

[4] Crawling peg exchange rate regime with a one-off initial devaluation of the national currency (9%).

Figure 4: Average User Cost and its after-tax components II

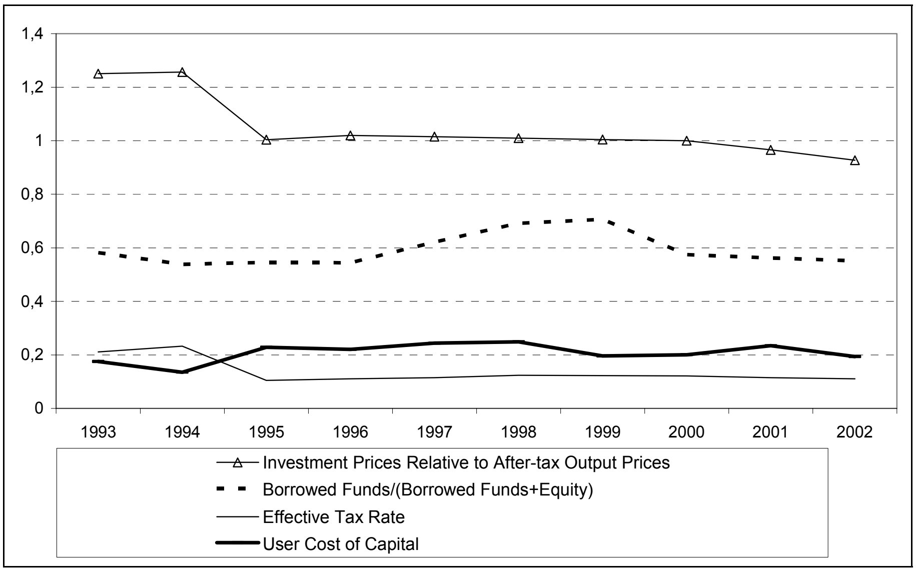
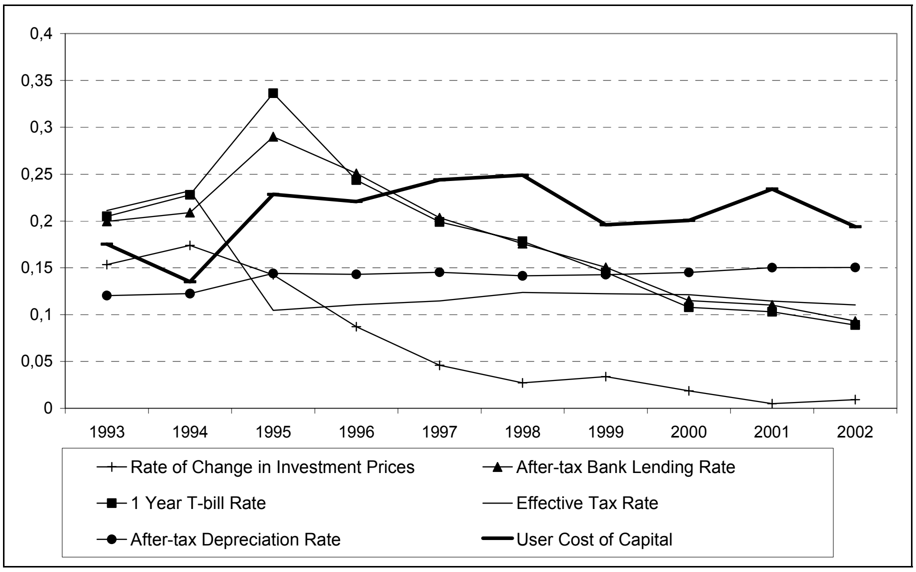


Figure 5: Average User Cost and its after-tax components III



4 Theoretical model

The decision problem we exhibit is a complex optimization of a representetative firm where the firm chooses capital, labor, and financing structure over an infinite horizon. We assume a CES production function where the two inputs, capital and labor can be continuously substituted. A general form of this technology can be written as

$$Q_{it} = F(K_{it}, L_{it}) = A_{it}\left[aK_{it}^{\sigma-1/\sigma} + (1-a)L_{it}^{\sigma-1/\sigma}\right]^{\left(\frac{\sigma}{\sigma-1}\right)\upsilon} \qquad \textbf{[4.1]}$$

where Q_{it} is output (value added), K_{it} is capital stock, L_{it} is employment, A_{it} is the Solow residual, a and $(1-a)$ are shares of the two inputs, σ is the elasticity of substitution between capital and labor, υ is the degree of homogeneity or the volumen elasticity. In the case of homogenous technology this latter parameter is equal to unity but we do not restrict υ to be unity. So the production function is twicely continuously differentiable with

$F_K(t) > 0$, $F_L(t) > 0$, $F_{KK}(t) < 0$ and $F_{LL}(t) < 0$.

That is, the function is strictly monotonous in both capital and labor with decreasing returns to scale in both factors.

Firm *i* chooses the two inputs and financing structure in time *t* so as to maximize the present value of future profits:

$$\max_{\{K_{it}, L_{it}, B_{it}\}} W_{i,t=0} = \int_{t=0}^{\infty} e^{-\int_{s=0}^{t} r_s ds} \pi_{it} dt \qquad \textbf{[4.2]}$$

where W_{it} is the market value of the firm, B_{it} is the value of external funds, r_t is the market interest rate or discount rate and π_{it} is profits. The problem has to limiting constraints.

The first constraint is the budget constraint of the firm saying that expenses can exceed revenues by the amount of borrowed funds:

$$\pi_{it} = (1-u_{it})\left[p_{st}F(K_{it}, L_{it}) - w_{it}L_{it} - i_{it}B_{it}\right] + u_{it}\delta_{it}p_{st}^{I}K_{it} + \dot{B}_{it} - p_{st}^{I}I_{it} \qquad \textbf{[4.3]}$$

where u_{it} is the effective tax rate, p_{st} is the price of output, w_{it} is the price of unit of labor (i.e. wage cost), i_{it} is the interest paid on outstanding bank credits, p_{st}^{I} is the industry specific investment price index, δ_{it} is the rate of depreciation and I_{it} is the investment volumen. As it can be seen from the above formula, depreciation and paid interest is tax deductible in the model.

We note here that the interest rate is assumed to be positively correlated to the amount of funds borrowed. This is because higher leverage increases the risk of default and banks expect higher compensation for this increased risk in the form of higher interest rates. However, it is negatively correlated to the amount of capital since a firm with relatively high proportion of valuable assets is less likely to be non performing on its liabilities. In what follows, we assume that the spread charged by banks (risk premia) for the increased default risk is simply a function of the firms' leverage:

$i_{it} = i_{it}(B_{it} / p^{I}_{st} K_{it})$, where $i'_{it} > 0$ and $i''_{it} > 0$. **[4.4]**

There can be at least two arguments put forward for the $i''_{it} > 0$ assumption. First, neglecting it would imply that the optimizing firm would choose an ever increasing leverage because the change in B_{it} enters the profit function with a positive sign. However, assuming that $i_{it}(B_{it} / p^{I}_{st} K_{it})$ is nonlinear in the leverage means that as banks increase the price of credit at a faster pace than the growth of leverage the cost of borrowed funds goes to infinity before the firm would choose to finance its capital entirely via borrowed funds. Second, it is clear from ordinary calculus that assuming $i''_{it} > 0$ ensures that, in optimum, profits are maximized rather that minized.

The second constraint is the capital accumulation equation[5]:

$$\dot{K}_{it} = I_{it} - \delta_{it} K_{it} \qquad \textbf{[4.5]}$$

We note here that assumptions about the rate of depreciation have important consequences with respect to the final specifications of the model. In the literature it is common to assume that the rate of depreciation is constant over time and across firms. However, many critiques called this hypothesis into question (e.g. Chirinko (1993)). The constant depreciation hypothesis is likely to be erroneus also in the case of Hungary. The modernisation of the production technologies and the incursion of ICT in the production made existing capital assets less and less valuable and implied continously increasing depreciation rate during the catching up process. These considerations call for a depreciation rate which varies over time. By the same token, it can be argued that it is unlikely that capital assets in different industries are subject to the same rate of depreciation. It is more reasonable to assume that this rate is heterogenous across industries or firms. Drawing on these, we assume that the rate of depreciation is both time and firm specific[6] as shown in equations [4.3] and [4.5].

Substituting [4.3] and [4.4] into [4.2] and differentiating with respect to the decision variables we arrive at the first order necessary conditions (FONC).

The FONC for the external funds gives the following equation:

$$r_t - (1 - u_{it}) i_{it} = (1 - u_{it}) \frac{B_{it}}{p^{I}_{st} K_{it}} i' . \qquad \textbf{[4.6]}$$

This condition states that the optimal leverage is a result of counterweighting tax advantages of taking on more credit against the increasing interest rate because of the higher leverage. Since the right hand side of the equation is per definitionem positive, the after tax effective interest rate is smaller than the discount rate in optimum. Hence,

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[5] We assume that the accounting rate of depreciation is equal to the economic rate of depreciation.

[6] Nevertheless, our derivations are invariant to this assumption. It only plays a role when deriving empirically estimable equations.

the access to bank credit and the related tax advantages (tax-deductibility of interest paid) reduce the effective cost of investment and thereby increase the demand for capital.

The FONC for the capital stock gives

$$(1-u_{it})p_{st}F_K(K_{it},L_{it}) = p^I_{st}r + p^I_{st}\delta_{it}(1-u_{it}) - \dot{p}^I_{st} + (1-u_{it})\frac{\partial i_{it}}{\partial K_{it}}B_{it}. \qquad \textbf{[4.7]}$$

After rearranging and plugging [4.6] into this FONC, the *Jorgenson condition* is obtained, which states that, in optimum, the marginal product of capital is equal to the marginal cost of capital, that is, the user cost. This equation determines the optimal stock of capital.

$$F_K(K_{it},L_{it}) = UC_{it}, \qquad \textbf{[4.8]}$$

where

$$UC_{it} = \frac{p^I_{st}}{p_{st}(1-u_{it})}\left[\left(1-\frac{B_{it}}{p^I_{st}K_{it}}\right)r + \left(\frac{B_{it}}{p^I_{st}K_{it}}\right)(1-u_{it})i_{it} - \frac{\dot{p}^I_{st}}{p^I_{st}} + (1-u_{it})\delta_{it}\right]. \qquad \textbf{[4.9]}$$

If we abstract from borrowing possibilities and taxes $(B_{it}=0\,,u_{it}=0)$, the formula for the user cost becomes the one published by Hall-Jorgenson (1967). Taking borrowing possibilities and tax aspects of the optimization into account, one arrives at the definition of Hayashi (2000, p.80)

Economic policy exerts its influence on corporate investment behavior via the user cost of capital in this model. Tax policies are captured by the firm specific effective tax rate and directly influence the cost of capital. Monetary policy, however, does not have a direct effect on the user cost. To make the role of monetary policy clear in this model and to highlight how monetary impulses are transmitted to the real economy, we can think of the mechanism as a three step process in which each step is embodied by a partial elasticity parameter. We have to stress here that this decomposition is valid only if we stipulate in each step the „all-else-equal" condition. That is, if we consider the ceteris paribus effects of changes in variables. Minding this, we can write the decomposition as

$$\varepsilon^{K_{it}}_{m} = \varepsilon^{K_{it}}_{UC_{it}} \times \varepsilon^{UC_{it}}_{r_t} \times \varepsilon^{r_t}_{m}.$$

where $\varepsilon^{K_{it}}_{m}$ is the elasticity of the capital stock with respect to the monetary policy interest rate. This is what concerns monetary policy makers at the end of the day. $\varepsilon^{K_{it}}_{UC_{it}}$ is the elasticity of the capital stock with respect to the user cost of capital, $\varepsilon^{UC_{it}}_{r_t}$ is the elasticity of the user cost with respect to the market interest rate and $\varepsilon^{r_t}_{m}$ is the elasticity of the market interest rate with respect to the policy interest rate.

The mechanism via monetary policy affects the capital stock is then straightforward. First, a change in the policy rate causes market rates to change, which in turn feeds into the user cost of capital. Firms faced with a different user cost then react and adjust their capital stock. The aim of the empirical models presented below is to estimate $\varepsilon^{K_{it}}_{UC_{it}}$, that is, how responsive is the stock of capital to changes in the user cost of capital. However, the specifications presented hereafter can be used to capture effects of financial market imperfections, which give rise to an additional monetary transmission channel. Before presenting what these effects stem from and how they are measured, we describe how we derived empirically feasible equations from theoretical ones.

5 Empirical models

With the optimality conditions at hand, one needs empirically feasible equations. One way to obtain estimable specifications is to substitute the partial derivative of the CES function in [4.1] with respect to capital into [4.7] and take logs. After rearranging, the following long-run demand for capital is obtained.

$$k_{it} = \left(\sigma + \frac{1-\sigma}{\upsilon}\right) q_{it} - \sigma uc_{it} + \sigma \log(\upsilon\alpha) + \frac{\sigma - 1}{\upsilon} \log(A_{it}) \qquad \textbf{[5.1]}$$

To be able to perform econometric tests on our model we assumed that the level factor of the production function can be decomposed into a firm specific and a time specific term: $A_{it} = A_i^{\kappa 1} A_t^{\kappa 2}$. In the case of equation [5.1] this decomposition means that the last two terms of the right hand side $\left(\sigma \log(\upsilon\alpha) + \left((\sigma-1)/\upsilon\right)\log(A_{it})\right)$ can be broken down to an idiosyncratic fixed effect (η_i) and a time specific effect (η_t).

Obviously, the long-run optimum stock of capital (k_{it}) is unobservable, hence we have to characterize the adjustment process of capital. We assume that capital adjustment can be described using its own previous values and the lags of the user cost and the output. The autoregressive distributed lag equation derived in this manner serves as the basis of our econometric analysis in which (*p,q*) are the parameters of the ADL specification:

$$k_{it} = \sum_{p=1}^{p} \omega_p k_{i,t-p} + \sum_{q=0}^{q} \phi_q q_{i,t-q} + \sum_{q=0}^{q} \sigma_q uc_{i,t-q} + \eta_i + \eta_t \qquad \textbf{[5.2]}$$

Using this equation, one can derive the long run parameters of the user cost and output[7]:

$$\sigma_{LT} = \frac{\sum_{q=0}^{q} \sigma_q}{1 - \left(\sum_{p=1}^{p} \omega_p\right)}, \quad \phi_{LT} = \frac{\sum_{q=0}^{q} \phi_q}{1 - \left(\sum_{p=1}^{p} \omega_p\right)} \qquad \textbf{[5.3]}$$

In this framework, an additional channel of monetary policy transmission can be captured. This channel is generated by market frictions and is called the credit channel in the investment literature (see e.g. Mishkin (1996)).

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7 We note here that [2.2] is a reduced form of some underlying model of the capital stock. Hence, in this specification partial elasticities and, hence, long-run parameters embody the effects of both expectations and technology parameters that are not explicitly specified in the model. Therefore, one should exercise caution when interpreting parameter estimates as pure adjustment characteristics. Despite the problem has long been known, it is not yet a wide-spread practice in applied investment research to tackle these issues explicitly (see, for example, Abel-Blanchard (1986), Chirinko (1993)or Angeloni et al (2002)). Since we intend to produce parameter estimates that are derived in a comparable framework in order to evaluate our results with respect to previous European studies of investment, we did not address these issues in this paper. We refer the interested reader to the Lucas crtitique mentioned in the model overview and the survey of Chirinko (1993).

Studies of the credit channel and, as part of it, the balance sheet channel, are based on the observation that the classic hypothesis of Modigliani and Miller is not valid. That is, external and internal sources of funds are not perfect substitutes for the firm. In this view a wedge arises between the cost of these funds in capital markets because of market imperfections such as asymmetric information, agency problems, moral hazard and adverse selection[8]. These imperfections bring about a transmission channel which traditional models could not capture. At the centre of these arguments is the statement that a firm with a smaller net worth is more exposed to the effects of adverse selection and moral hazard and the supply of external funds is inelastic. This is because the only information available for creditors to judge whether a firm is a timely and reliably solvent borrower is its net worth. A firm with a smaller net worth is less able to cover its liabilities in the event of a default and, as a consequence, creditors are less willing to provide financing. Thus, asymmetric information in financial markets make certain firms financially constrained. The moral hazard aspect of asymmetric information, in turn, is highlighted by the owners willingness to take on risks. When their share in the firm is smaller the potential loss they face is smaller and hence, their propensity to launch riskier investment projects is greater. Riskier projects are obviously more likely to fail and therefore, if the financial leverage of a firm increases it causes creditors propensity to finance to dampen. Thus, asymmetric information drives a wedge between the firm specific interest rate and the market rate. In other words, firms find it cheaper to invest out of retained earnings than out of borrowed funds. This implies, in turn, that those investment projects yielding the market rate will not be executed because the cost of financing in these cases is greater than the internal rate of return of the project. This is an important implication since, absent information asymmetries, these models would be economically justified to execute. Put it another way, the understanding the effects of these phenomena is important because they have serious economic consequences: their existence may lead to the misallocation of resources.

In this framework, monetary policy can influence firms' balance sheets in several ways. A monetary loosening, for example, causes share prices to rise which directly diminishes the effects of the abovementioned information problems. The approach of measuring the effect monetary policy exerts on firms' balance sheet directly is called the financial accelerator approach. This investigates whether weak balance sheets of firms amplify monetary policy shocks on firm spending (see Vermeulen (2000) for an empirical investigation).

Mishkin (1996) puts forward an argument also for indirect monetary policy effects in this context. He argues that monetary policy exerts its influence on investment via the price level and inflation. Since credit agreements are contracted in nominals, a shock in inflation diminishes the real burden born by borrowers. However, the real value of assets of the borrower does not diminish because it is determined by supply side factors. Moreover, changes in the nominal interest rate modifies firms' cash-flow having direct effects on investment for the financially constrained firms.

Since the publication of the seminal paper of Fazzari-Hubbard-Petersen (1988) it is usual to control for these financial constrains by entering cash-flow in the regressions.

[8] This wedge may arise even if these asymmetric information problems are unimportant because of transaction costs such as registration fees and other administrative costs for new issues of bonds or stocks.

Fazzari-Hubbard-Petersen (1988) originally applied cash-flow as a proxy for the firms' own funds to control for its effects on investment. However, using cash flow as a proxy for own funds in equations similar to [5.2] might give rise to multicollinearity, since cash-flow is correlated to future profits and future profitability (Chatelain et al. (2001), Vermeulen (2001)). Yet, extant firm-level databases' cross-section dimension provides for a huge amount of observations which mitigates the multicollinearity problem.

The cash-flow augmented equation is

$$k_{it} = \sum_{p=1}^{p} \omega_p k_{i,t-p} + \sum_{q=0}^{q} \phi_q q_{i,t-q} + \sum_{q=0}^{q} \sigma_q uc_{i,t-q} + \sum_{q=0}^{q} \beta_q \frac{CF_{i,t-q}}{p^I_{s,t-q} K_{i,t-q-1}} + \eta_i + \eta_t + \varepsilon_{it} \quad \textbf{.[5.4]}$$

One might argue that this specification is not a proper one because it is not the control variable – investment or the investment ratio –, but the optimal capital stock that enters [5.3]. To have the control variable $\left(I_{it}/K_{i,t-1}\right)$ in [5.3] we use $\Delta k_{it} = \ln(I_{it}/K_{i,t-1} - \delta_{it} + 1)$, which can be calculated from the discrete version of the capital accumulation equation [4.5]. Approximating the right hand side of $\Delta k_{it} = \ln(I_{it}/K_{i,t-1} - \delta_{it} + 1)$ with its first order Taylor series, we arrive at

$$\Delta k_{it} = \frac{I_{it}}{K_{i,t-1}} - \delta_{it} .$$

This equation says that capital stock changes are an overall result of investment and depreciation. When investment is equal to the loss of value in the capital stock the real capital stock does not change and there is no net effect of investment. This is usually called replacement investment. If investment is greater (lower) than the depreciation value, the real capital stock increases (decreases) and investment has a positive (negative) net effect on the capital stock. Let I^r_{it} denote replacement investment and I^n_{it} net investment. Then, the overall investment is

$$I^r_{it} + I^n_{it} = I_{it} .$$

This distinction between replacement investment and net investment is quite common in the literature (Chirinko 1993, Letterie-Pfann 2003). However it is not so common to address this distinction explicitly in estimated equations. To be more accurate, equation [5.4] specifies net changes in the real capital stock, while equations explaining the ratio of investment with respect to capital tipically try to explain overall investment. This can be done using the simplifying assumption of constant rate of depreciation. However, if this latter condition does not seem to hold, which is likely in our case (see considerations after the capital accumulation equation in Section 4), the investment rate specification should be modified.

To see this, suppose that capital adjusts according to an ADL(2,1) structure. Subtracting $k_{i,t-1}$ from [5.4] and using the previous relationships $\Delta k_{it} = \frac{I_{it}}{K_{i,t-1}} - \delta_{it}$ and $I^r_{it} + I^n_{it} = I_{it}$ and knowing that $\frac{I^r_{it}}{K_{i,t-1}} = \delta_{it}$, we have that

$$\frac{I_{it}^{n}}{K_{i,t-1}} = (\omega_1 - 1)\frac{I_{i,t-1}^{n}}{K_{i,t-2}} + (\omega_2 + \omega_1 - 1)k_{i,t-2} + \sum_{q=0}^{1}\phi_q q_{i,t-q} + \sum_{q=0}^{1}\sigma_q uc_{i,t-q}$$

$$+ \sum_{q=0}^{1}\beta_q \frac{CF_{i,t-q}}{p_{s,t-q}^{I} K_{i,t-q-1}} + \eta_i + \eta_t + \varepsilon_{it} \ . \qquad \textbf{[5.5]}$$

As we have already mentioned, most of the studies assume that the rate of depreciation, that is, the rate of replacement investment, is constant. In this case, the index *n* could be dropped from $\frac{I_{it}^{n}}{K_{i,t-1}}$ and standard estimation methods can be applied using $\frac{I_{it}}{K_{i,t-1}}$ only, as the constant depreciation rate cancels out due to differencing. This is done by, for example, (Chatelain-Tiomo (2001)). If the constant depreciation assumption does not seem to hold, that is, the depreciation rate depends on both *i* and *t*, the two are not equivalent. We examined the effects of this simplifying assumption, too.

Another specification we estimated is a modified version of [5.5]. This equation is obtained by first differencing [5.4], using the Taylor-approximation described above and plugging the level of cash flow to this differenced equation. As a result, net investment is explained by its lagged value(s), the difference of output and user cost and the level of cash-flow. As a result, firm-specific fixed effects cancel out and the equation is:

$$\frac{I_{it}^{n}}{K_{i,t-1}} = \sum_{p=1}^{p}\omega_p \frac{I_{it}^{n}}{K_{i,t-p}} + \sum_{q=0}^{q}\phi_q \Delta q_{i,t-q} + \sum_{q=0}^{q}\sigma_q \Delta uc_{i,t-q} + \sum_{q=0}^{q}\beta_q \frac{CF_{i,t-q}}{p_{s,t-q}^{I} K_{i,t-q-1}} + \Delta\alpha_t + \Delta\varepsilon_{it} \ .$$

[5.6]

Equations similar to [5.6] were estimated by (von Kalckreuth (2001)). However, there is an important difference between [5.6] and the one in (von Kalckreuth (2001)). In his estimations a fixed effect is added to the differenced equation. He argues in favour of this specification that not only the productivity level but also its growth rate might be firm specific. This would mean that firms were able to achieve significantly different productivity growth at the individual level even during a short estimation period. This assumption is not quite common in the literature and it seems especially strong in our case in light of the short timespan of our panel. Also, if fixed effects were present in the differenced equation [5.6], using standard difference-based estimators, such as Anderson-Hsiao's and GMM, would lead to differencing twice and hence would result in further loss of observations.

6 A brief overview of the neoclassical framework and its shortcomings

The goal of this selective overview is to bestow our analysis in the field and to present the problems and findings of previous studies that lead to the extant empirical frameworks in applied investment studies. In the first part of this section, we restrict our attention to the neoclassical framework. A comprehensive survey of investment studies up to the beginning of the nineties can be found in, for example, Chirinko (1993). The second part of the section deals with several additional issues which could not be addressed within the neoclassical framework.

We start with discussing the key assumptions and findings of the neoclassical framework because prior to Jorgenson's model, (Jorgenson 1971) no rigorous framework existed for undestanding investment demand. While there have been many different approaches in undestanding investment spending, several issues have repeatedly been encountered by researchers. We concentrate on three of these issues overviewing previous results.

First, the assumption of continuous substitutability of the two input factors, capital and labor implies that the firm is able to adjust its capital stock in both directions, be it either investment or disinvestment. Thus, firm can freely increase or decrease its capital stock until its marginal product is equal to its marginal cost. Put it differently, adjustment takes place until the marginal q-value introduced originally by James Tobin in 1969 is equal to 1. Thus, rapid changes in the capital stock are not „punished" meaning that adjustment is without costs in the model. As a consequence, the firm can achieve the optimal capital stock instantaneously and the decision problem becomes static[9]. The absence of adjustment costs has been challenged many times ever since with the acceptance of assuming convex adjustment costs (e.g., Hayashi (1982), Letterie-Pfann (2003) among others). However, taking adjustment costs into account does not invalidate the Jorgenson condition, it only increases the marginal cost of capital.

Second, the inharmonious treatment of delivery lags of investment and immediate adjustment of the optimal capital stock was another source of criticisms of the neoclassical framework. Empirical models usually assume that optimal capital stock is achieved according to an ADL process. Hence, dynamic adjustment is introduced in the model, but the particular form of this adjustment process does not follow from any of the key assumptions. Also, if optimal capital adjustment is instantaneous, the investment path generated by a delivery lag distribution may not be optimal.

Finally, treatement of expectations is resulted in further critisism of the neaoclassical model. a vast amount of effort has been made to develop and estimate models which explicitly tackle the problem highlighted by Robert Lucas in his seminal article. Nevertheless, its practical success and the applicability in policy practice have not been unambiguous. There are various arguments why the role of explicit models has had so little direct impact on current policy evaluations. First, as stated by Chirinko (1993), pp.

[9] This is why Hayashi () has called the optimal policy as "entirely myopic". In other words, since capital is a variable factor input, the oprimal policy is only to maximize the current return every moment in time without regard to the future.

1900, in its original form the Lucas critique „was user unfriendly” and „cast in an unfamiliar technical language”. Also, explicit models performed rather poorly when confronted with data.

We now turn our attention to issues that could not be addressed within the neoclassical framework. Two important aspects of investment decisions are touched on in the rest of this section. The first issue concerns the question as to what extent investment decisions are reversible. The second is related to the timing aspects of investment decisions, namely, how the realistic possibility of postponing current investment affects traditional investment decision rules.

Costs of capital adjustment are augmented when capital can be sold only at a price considerably lower than its purchase price or cannot be sold at all. This phenomena is referred to as the irreversibility of investment. Pyndick (1991) sets out two main arguments. First, capital is firm or at least industry specific in most cases and it is not likely that there is a liquid secondary market at hand. Beyond the limited demand, the resale price of capital is also negatively affected by the fact that the potential buyer is not likely to use the acquired asset in the same market conditions. If the firm wants to sell its capital goods, the buyer is likely to face the same market conditions in output markets and hence, it might not be worth to buy the asset at all. The difference between the resale price and the purchase price of capital can also be significantly negative if capital is not firm or industry specific. This difference is generated by asymmetric information between the seller and the buyer and is referred to as ”lemon price”-effect after Akerlof (1970). Because of all these factors investment costs are sunk for the firm and do matter in the optimization problem. The budget constraint [4.3] shows that the neoclassical model does not take the potential difference between the resale and the purchase price into account: the value of p_{st}^{I} is independent of whether the firm invests $\left(I_{it} > 0\right)$ or disinvests $\left(I_{it} < 0\right)$.

The model disregards uncertainty. In the framework it is assumed that firms are able to accurately estimate future output prices, investment prices, costs and interest rates. In an uncertain environment, the possibility to postpone investment becomes valuable. Delaying investment is valuable because new information can arrive over time and uncertainty is readuced. Postponing investment and waiting provides the firm with a call option of which the price it takes into account when deciding about investment. If the firm invests today, it loses the option of investing tomorrow and the opportunity cost of investing today increases the cost of investment. Pyndick (1991) pointed out that irreversibility, uncertainty and the possibility to wait together call for an amendment of the ”naive net present value rule”. That is, in optimum, the marginal product of capital has to be greater than its marginal cost. Uncertainty increases the value of waiting (call option) and decreases the propensity to invest now (expandability). Hence, stability and predictability might be as – or even more – important investment incentives as taxes or interest rates.

Abel et al. (1996) relaxes the total irreversibility assumption. In their simple model the firm can resell its capital later but at a price that is not known at time of the resale decision. This provides for another possibility called the put option. The option to sell later, which is associated with the partial irreversibility case, increases the propensity to invest today. In the end, the optimal decision to invest is determined by these two options.

Adjustment costs, unceratinty, irreversibility and expandability are not explicit in the model presented in the paper. One might argue that this makes our analysis very simplified and unrealistic but in our view, the neoclassical framework is a clear and rigorous starting point in understanding corporate investment behavior. It is relatively easy to derive empirically testable hypotheses in this model. Moreover, the recent research in the European Monetary Transmission Network used similar framework so comparing our conclusions to previous results is straightforward.

7 The data

Our database consists of the corporate tax returns of double entry book keeping firms between 1992 and 2002. However, the investment ratio is stable only from 1993 so we did not use data in 1992 for the analysis.[10]

We excluded several groups from the analysis: financial intermediaires, firms in public administration, compulsory social security and education, firms in health and social work and private households with employed persons.

We also filtered out missing observations for employees, capital and depreciation for the whole database. Where enough information was available, we corrected false data. Using the last two variables we constructed real capital stock for estimation purposes. The steps of this calculation are presented in the next subsection.

We reduced the database further because we thought very small firms' investment behavior is significantly different from other firms. We found that very small firms' tax return data are imperfect and unreliable in many cases. Hence, we excluded firms where the number of employees was lower than two. We also excluded observations where the number of employees was lower than five in three consecutive years. As a result, firms in the final sample with number of employees greater than two and smaller than five in a specific year employ more than five in the previous two or the next two years. Thereby we excluded the smallest firms while best preserved the panel structure of our data.

We cleaned the other variables on the reduced sample. We corrected for false data using the following rules:

- If the calculated real capital stock is negative.
- If sales revenue is negative.
- If the calculated user cost is negative.
- If the depreciation rate is greater than 1.
- If the debt to assets ratio is greater than 1.

We also checked for outliers. For the cash-flow $\left(CF_{it} / p_{st}^{I} K_{i,t-1}\right)$, depreciation rate $\left(\delta_{it}\right)$, logarithm of user cost $\left(\ln UC_{it}\right)$ we defined threshold values each year as the 1st and 99th percentiles of the distribution. For the investment rate $\left(I_{it} / K_{i,t-1}\right)$ these values were the 1st and 95th percentiles. For the change in the capital stock $\left(\Delta \ln K_{it}\right)$, change in sales $\left(\Delta \ln Q_{it}\right)$, the change in the user cost $\left(\Delta \ln UC_{it}\right)$ and the change in employment $\left(\Delta \ln L_{it}\right)$ we used the Chebyshev method: an observation was considered to be outlier if the absolute deviation of a variable from its mean in a specific year was greater than five times its standard deviation:

[10] This suggests that capital revaluations during and after the transition period had still been in process in 1992.

$$|y_{it} - \bar{y}_t| \rangle 4 * \sigma_{y_{it}} .$$

As a result of all this, our unbalanced panel consists of 73,649 firms' data between 1993 and 2002 with 308,850 observations. After industry- and size-based filtering the size of the database collapsed to 31% of the initial data set. The final number of observations is 78% of this smaller database, which is 24% of the whole population.[11]

Table 7-1: Number of observations

Year	Number of firms in the population	Number of firms in the analysis	Number of omitted firms in per cent of the population
1993	66 409	18 729	72%
1994	79 794	22 660	72%
1995	90 726	24 447	73%
1996	105 728	26 495	75%
1997	120 480	29 214	76%
1998	130 835	32 835	75%
1999	139 141	35 563	74%
2000	151 913	37 478	75%
2001	184 703	39 406	79%
2002	199 798	42 023	79%
Total number of observations	1 269 527	308 850	76%

The descriptives of the variables used in the analysis are summarized in table Table 7-2, definitions and further details are provided in the appendix. Out of these, we give a detailed presentation of our capital stock and user cost data in the next subsection.

Table 7-2 : Descriptiv statistics of the variables, 1993-2002

Variable	Mean	Sd.	Minimum	25%	Median	75%	Maximum
I/K	0.437	0.704	-0.603	0.037	0.175	0.541	5.724
logK	8.911	1.999	0.989	7.572	8.783	10.137	19.857
logQ	10.477	1.545	-0.144	9.427	10.393	11.399	19.829
logUC	-1.750	0.918	-11.764	-2.038	-1.665	-1.313	-0.301
CF/K	0.734	2.686	-14.990	-0.002	0.224	0.846	58.329

[11] Obviously, the final number of observation used in the estimations varied because different number of lags of variables were needed at different specifications.

7. 1 Capital stock

We encountered several problems measuring the capital stock, which is the sum of tangibles and intangibles. Ideally, the capital stock should be registered on market prices. However, according to Hungarian accounting rules, the capital stock enters the balance sheet on book value and the amount of depreciation also should be accounted against book value. If the market value of the capital asset on the firm's balance sheet differs from its book value, the firm can decide whether it adjusts the value of the capital assets registered on its books. Furthermore, we have no information on the composition and age structure of the firm specific capital stock. Putting all this together, we are given a capital stock which is an amalgam of capital assets with different age and valued at different prices and the raw capital stock data cannot be considered to be valued either at current or constant prices.

We therefore compiled capital stock data using the idea of the perpetual inventory method (PIM). The idea behind the PIM is that having an initial condition the capital accumulation equation is used to calculate the stock of capital.

$$K_{it} = \sum_{j=0}^{t} g(t,i) \times I_{i,t-j}, \qquad \textbf{[7.1]}$$

where K_{it} is the after-depreciation real capital stock at the end of each year, I_{it} is real investment in year t and $g(t,i)$ is a function that specifies the depreciation of the extant capital stock and new investment. The above equation says that the capital stock can be calculated if we know the initial stock and the net effect of investment and depreciation. If $K_{i,t-1}$ is net investment cumulated up to period *(t-1)*, that is, the before-depreciation capital stock in time *t*, then the capital stock in time *t* is

$$K_{it} = (1-\delta_{it})K_{i,t-1} + I_{it}. \qquad \textbf{[7.2]}$$

This is nothing but the discrete version of the continuous capital accumulation equation [4.5] defined in the dynamic optimization problem of the firm. We defined the initial condition of the capital stock as the value in the year the firm entered the database and expressed it in 1992 prices.

To calculate the real capital stock we needed firm-level investment data. We used capital stock data registered according to accounting rules because the database did not contain data on investment directly. We refer to this capital stock data as accounting capital. Investment is calculated based on [7.2]: it is equal to the after-depreciation difference between the accounting capital stock in year *t* and (*t-1*):

$$\bar{I}_{it} = \bar{K}_{it} - \bar{K}_{i,t-1} + \delta_{it}\bar{K}_{i,t-1} = \bar{K}_{it} - \bar{K}_{i,t-1} + DEP_{it}, \qquad \textbf{[7.3]}$$

where $\bar{I}_{it}$ *and* $\bar{K}_{it}$ is investment and accounting capital at the end of year *t*, DEP_{it} is the value of depreciation write-off in year *t*. Then, deflating investment with the industry specific investment price index, we arrive at real investment:

$$I_{it} = \frac{\bar{I}_{it}}{p_{st}^{I}}. \qquad \textbf{[7.4]}$$

With the knowledge of the initial condition we can construct firm level real capital stock using real investment and the depreciation rate. Our database contains only contains year-end data, which causes another measurement problem. If we define the effective rate of depreciation as the ratio of accounted depreciation in year *t* and the accounting capital stock of the previous year-end $\left(\delta_{it} = DEP_{it} / \overline{K}_{i,t-1}\right)$, we apparently overestimate the realistic depreciation rate for actively investing firms. This is due to the fact that investment as well as disinvestment occurs throughout the whole year seriously affecting accounted depreciation. If a firm invests, it can account an amount of depreciation already in the year of investment and, correspondingly, in the case of disinvestment it can benefit from registering the value of depreciation up to the point of disinvestment. To avoid unrealistically high depreciation rates we assume that investment occurs at the beginning of each year and disinvestment occurs at the end of each year. The capital accumulation equation and the depreciation rate in the two cases is the following:

(1) in case of investment $\left(I_{it} > 0\right)$ $\delta_{it} = \dfrac{DEP_{it}}{DEP_{it} + \overline{K}_{it}}$ and $K_{it} = \left(1-\delta_{it}\right)\left(K_{i,t-1} + I_{it}\right)$

because the total capital stock against which the firm writes off depreciation is the January 1 stock after investment, and

(2) in the case of disinvestment $\left(I_{it} < 0\right)$ $\delta_{it} = \dfrac{DEP_{it}}{\overline{K}_{i,t-1}}$ and $K_{it} = \left(1-\delta_{it}\right)K_{i,t-1} + I_{it}$.

We might assume, as an alternative, that investment and disinvestment takes place in the middle of the year. In this case the firm writes off half of its depreciation on the new investment and half of its depreciation on the disinvestment kept for six months. Hence, without regard to the sign of I_{it}, the depreciation rate and the capital stock at the end of the year can be calculated as

$$\delta_{it} = \frac{2DEP_{it}}{DEP_{it} + \overline{K}_{it} + \overline{K}_{i,t-1}} \text{ and } K_{it} = \left(1-\delta_{it}\right)K_{i,t-1} + \left(1 - \frac{\delta_{it}}{2}\right)I_{it}.$$

We carried out our estimations using variables calculated in this manner but results were robusts to these modification. Therefore, these results are not published in this paper.

7. 2 User cost

Following [1.8] in the derivation, we defined the user cost as

$$UC_{it} = \frac{P_{st}^{\ I}}{\left(1-u_{it}\right)P_{st}}\left[IR_t\left(1-u_{it}\right)\left(\frac{B_{it}}{B_{it}+E_{it}}\right) + LD_t\left(\frac{E_{it}}{B_{it}+E_{it}}\right) - \frac{\Delta P_{s,t+1}^{\ \ I}}{P_{st}^{\ I}} + \left(1-u_{it}\right)\delta_{it}\right]$$

where B_{it} is the sum of long and short term liabilities, E_{it} is own funds, IR_t is a weighted average of bank lending rates with maturities over one year, LD_t is the one year benchmark t-bill rate, u_{it} is the effective tax rate, P_{st}^{I} is the industry specific investment price index[12], P_{st} is the industry specific price deflator (PPI or GDP deflator, depending on industry) δ_{it} is the effective depreciation rate.

Since the firm finances its investment finances using both external funds $\left(B_{it}/(B_{it}+E_{it})\right)$ and internal funds $\left(E_{it}/(B_{it}+E_{it})\right)$, the user cost of capital is determinded by the interest rates of borrowed funds, the return on equity and the shares of these sources of capital componens in the firm's liabilities. Opposed to the theoretical formula where the denominators contain physical capital, we used the sum of external and internal funds in our calculations. This is justified by the fact that the optimal rate of external funds depending on tax advantages is a function of the accounting leverage.

The return on equity was derived using benchmark t-bill rates. This obviously underestimates the cost of own funds. Namely, we it is standard that the expected rate of return on a risky project is greater than the risk free rate. The difference between the two is the risk premium. However, the risk premium is difficult to measure so for the sak of simplicity we consider the benchmark rate as a proxy for the opportunity cost of equity.[13]

The cost of borrowed funds are generally measured by the interest paid. Calculating and apparent interest rate, which is the ratio of interest paid and total stock of debt, would be evident. However, there is no separated data for debt in the firms' liability stock prior to 1999. Dividing interest paid by the sum of short and long term liabilities significantly underestimates the real interest burden[14], which demonstrates the huge share of non-interest bearing liabilities (e.g. accounts payable) within overall liabilities. Consequently, we used the weighted average of bank lending rates assuming all the firms can borrow at similar conditions.

[12] As yet, the Central Statistics Office has not published industry specific price indices for the period prior to 1999, hence we calculated them as weighted averages of domestic sales prices of machinery investment, import prices of machinery investment and construction investment prices where the weights were the domestic, import machinery investment and construction investment proportions of each industry.

[13] Three year rates are only available since 1996, the five year rates since 1997 and the most compelling ten year rate since 1999. Therefore we used the one year benchmark rate uniformly between 1992 and 2002.

[14] The variable created in this fashion oscillated between 4 and 6% on average.

8 Estimation and results

Our first model based on [5.3] was the ADL(1,1) in levels of the log of the capital stock.

$$k_{it} = \sum_{p=1}^{2} \omega_p k_{i,t-p} + \sum_{q=0}^{1} \phi_q q_{i,t-q} + \sum_{q=0}^{1} \sigma_q uc_{i,t-q} + \sum_{q=0}^{1} \beta_q \frac{CF_{i,t-q}}{p^I_{s,t-q} K_{i,t-q-1}} + \eta_i + \eta_t + \varepsilon_{it} \qquad \textbf{[8.1]}$$

where ε_{it} is a white noise term, uncorrelated across firms and in time. Individual effects (η_i) are stochastic so both the lags of capital and the other variables can be correlated to η_i. Because of the endogeneity problem, some transformation is needed to get rid of these individual effects.

The well-known within estimator handles this with mean-differencing but it will still produce inconsistent parameter estimates in the presence of lagged dependent variables and other endogeneity problems, particularly in panels with short time period. The lag of the mean-differenced dependent variable ($\tilde{k}_{i,t-1} = k_{i,t-1} - (T-1)^{-1} \sum_{s=1}^{T-1} k_{is}$) and the mean-differenced error term ($\tilde{\varepsilon}_{it} = \varepsilon_{it} - (T-1)^{-1} \sum_{s=2}^{T} \varepsilon_{is}$) are by all means correlated. If $\omega_1 > 0$, the term $-(T-1)^{-1} k_{it}$ in the former and the term ε_{it} in the latter are negatively correlated and, also, the term $k_{i,t-1}$ and the term $-(T-1)^{-1} \varepsilon_{i,t-1}$ are negatively correlated. These negative correlations supress the positive correlation between other terms ($-(T-1)^{-1} k_{i,t-1}$ and $-(T-1)^{-1} \varepsilon_{i,t-1}$, for example). As a result, the overall negative correlation between $\tilde{k}_{i,t-1}$ and $\tilde{\varepsilon}_{it}$ leads to significantly underestimated within parameter estimate of the lagged dependent variable (Nickell (1981)).

From Nickell (1981) we know that the inconsistently estimated parameter of the lagged dependent variable impacts the parameter estimates of the other variables as well. The direction of the bias depends on the sign of the correlation between the lagged dependent variable and the other explanatory variables. Continuing to assume that $\omega_1 > 0$, if this correlation is positive the parameter estimate of the other explanatory variable is biased downwards and vice versa.

The endogeneity of explanatory variables give rise to inconsistency of the estimates, too. A shock to the capital stock affects the firm's output because it is clear from the production technology specification that a positive shock to the capital stock causes output to increase. A capital shock also might modify the cost of capital. A change in the capital stock might alter the leverage of the firm and, according to [4.4] the bank lending rate and the user cost. Taking these factors into account, the endogeneity of cash-flow cannot be ruled out because a firms's cash-flow is a positive function of sales revenue. However, cash-flow and leverage are negatively correlated. These effects do not necessarily cancel out each other but the direction of the bias cannot be foreseen.

Individual effects can be eliminated by first differencing as well. As opposed to the within transformation, the error term values for every time period do not appear in the equation in this case and the strict exogeneity of explanatory variables is not required. In the case of dynamic panel data models, however, OLS estimation on first differences of variables still produces inconsistent parameter estimates. This is because the lagged dependent variable $\left(\Delta k_{i,t-1}\right)$ and the differenced error term $\left(\Delta\varepsilon_{it}\right)$ are negatively correlated. The negative correlation comes from the opposite sign of the (*t-1*) terms. This negative correlation causes the parameter estimate of the lagged dependent variable to be biased downwards with the extent being generally higher than that of the within estimates.

Consistent parameter estimates can be obtained using appropriate instruments for the endogenous variables. Anderson-Hsiao (1981, 1982) suggests the first differenced two stage least squares (2SLS) estimator. Maintaining the initial assumption that there is no autocorrelation in the disturbance term and assuming that the capital stock and all the explanatory variables are uncorrelated to future disturbances, lags (*t-2*) and earlier of the variables – both levels and differences – are all valid instruments. Empirical research showed, however, that using levels of variables as instruments produce generally more efficient estimates than differences. Another advantage of using level instruments is that we do not lose additional observations due to lagged differencing, that is, we have more instruments given the number of observations.

Also, lagged values of the employment level were used as possible excluded instruments. Since labour is one of the main determinants of production, the number of people employed is suitable candidate. However, the two input factors are evidently interrelated and thus present labour usage may be correlated with the error term, which violates the orthogonality condition. Moreover, some recent empirical research have documented significant dynamic interrelation between the two input factors (Dixit (1997)). This means that the correlation between the demand for capital and the demand for labour is not restricted to one period but adjustment dynamics in one factor affect adjustment in the other factor over a period of more than one year. The fact that labour adjustment may precede investment implies that lagged employment is also correlated with the present error term. Nevertheless, it is reasonable to assume that this correlation does not hold if the time span between investment and labour decisions is large enough. Therefore, we assume that the error term in *t* is uncorrelated with employment in *(t-2)* and earlier, which means that present investment decisions do not affect firm's labour policy two years before. Consequently, the level of employment in *(t-3)* and earlier are possible instruments as well. Evidently, the validity of these instruments was tested using appropriate statistical methods (*"difference-in-Hansen test"*), just as the validity of the other instruments used in the regressions.

We summarized our estimation results of the firs specification in Table 8.1. The parameter estimates of the Within estimator (first two columns) appear to be significant for all variables. However, as we mentioned earlier, we know that the parameter estimate of the lagged dependent variable is biased downwards because of the incorrect assumption of strict exogeneity. In spite of the downward bias, the magnitude of the parameter estimate (0.609) of the lagged dependent variable points to quite high persistence in capital stock dynamics. The estimates of both sales and user cost parameters are of the expected sign. This is also true for cash-flow. However, the magnitude of cash-flow parameter estimates shows that firms' investment is not highly sensitive to the financial position. The results obtained using First-differenced estimates (second and third columns) are, by and large, in line with the Within estimates. There are two differences, though. First, in line with the theoretical considerations, it is apparent that the parameter estimate of the lagged dependent variable is more downward biased (0.18) than the within estimate. Second, the parameter estimate of lagged sales is of higher magnitude in this estimation.

In the 2SLS estimates, we instrumented endogenous variables by all the available observations for each variable back to time (*t-5*) in order to improve the accuracy of our estimations.[15] However, we found that including lag (*t-2*) of sales resulted in invalid instrument matrices, so we used (*t-3*) to (*t-5*) lags of this variables as instruments. One can argue in favour of omitting lags (*t-2*) of this variables that, for example, current output is correlated with future output, that is, current output can be interpreted as a proxy for future demand conditions. Therefore, investment choc in time *t* is correlated with lagged output. Of course, this implies that earlier lags of sales might also be somewhat correlated with the current capital stock. However, we found that using lags (*t-3*) and earlier as instruments did not result in categorically invalidating the instrument matrix and can be accepted as valid instruments. Also, employment *(t-3)* to *(t-5)* was used as excluded instruments (see consideration above). The use of employment as excluded instrument improves significantly the acurancy of our estimate without violating the orthogonality condition. As a result, the marginal significance level of the Hansen J-statistic in our final specification was 0.062, the absence of correlation between the differenced error term and the instrument is thus accepted at 5% significance level. Based on the Arellano-Bond AR2 test for second order serial correlation in the residuals, we could not reject the null of zero serial correlation[16]. Moreover, diagnostic tests and parameter estimates seemed to be robust to changes in the lag structure used in the instrument matrix.

The 2SLS parameter estimate of ($logK_{t-1}$) is 0.71, which is higher than that of either the Within or First-difference. This relatively high persistence in the capital stock is in line with our expectations. However, the parameter of the second lag of capital was not significantly different from zero. This suggest that only the lag (*t-1*) plays a role in the adjustment process of capital. 2SLS results show that the sensitivity of capital stock change with respect to contemporaneous sales is higher (0.5) than previous biased estimates. The parameter of lagged sales did not appear to be statistically different from zero.

The estimate of the contemporaneous user cost parameter is statistically significant. The order of magnitude (-0.223) suggests that user cost changes are main determinants of corporate investment. This provides evidence against simple sales-accelerator models that include only sales and exclude user costs. The lagged parameter estimate (-0.016) is lower in absolute value than that of time *t* user cost and almost significant at usual marginal significance levels. As is generally the case in the empirical literature, the cash-flow capital ratio enters the equations with a significantly positive sign. Contemporaneus cash-flow has a greater effect on current investment, while the significance level of past values of cash-flow is much higher than that of current cash flow.

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[15] Since cash-flow contains lagged capital in the denominator, we fixed the maximal number of lags used as instrument to four in order to save observations.

[16] If the AR(2) test showed nonzero correlation, the consistency of the Andeson-Hsiao estimates would be called into question. This is because the second order serial correlation of differenced error terms means that (t-2) shocks are reflected in the capital level at time (t) and hence second lags of the endogenous variables would not be orthogonal to the differenced error term.

These parameter estimates imply long run coefficients that provide some interesting empirical findings. Nevertheless, it has to be stressed again that some caution is needed when interpreting these coefficients. We noted earlier when we definited long run coefficients that ADL parameters *may* include effects of changes in expectations and technology and they not necessarily embody *only* the adjustment characteristics of variables.

The long run coefficient of sales is practically unity which provides evidence for constant returns to scale in the production function[17]. This result was robust across specifications, as will be seen later. However, one has exercise care in interpreting this as straightforward evidence because we are using sales as a proxy for output and this means output is imperfectly measured. The long run user cost parameter[18] estimate appears to be quite high (-0.828) compared to other estimates. At a glance, it seems to be a high elasticity compared to certain former estimates: estimating a comparable model on French manufacturing data, Chatelain-Tiomo (2001) have found this coefficient to be (-0.16)-(-0.311). Nevertheless, it is not completely out of line with previous result because Chatelain-Teurlai (2004) estimated this elasticity to be even higher for small service sector firms. The finding that our estimated user cost elasticity is below unity implies that the assumption of Cobb-Douglas technology would not have been appropriate in our case.

In the second specification, the ratio of net investment with respect to capital is regressed on a set of variables (see equation [5.5] for a detailed presentation). We present only the consistent parameter estimates hereafter. Diagnostics indicated that this specification was more sensitive to the choice of the instrument matrix compared to the previous specification (Table 8-2). This instability was also reflected in point estimates. We proceeded choosing the instrument matrix in the same manner as we have done in the previous specification and chose all available lags back to *(t-5)* as instruments. However, instead of lags of the investment ratio, we used the lagged levels of capital (*logK*) as instruments in the final model because the specification performed better in terms of diagnostics. The Hansen-J statistic's marginal significance level was 0.084. The AR(2) structure of the residuals can easily be rejected based on the test.

Regarding persistence, we note that it is not the parameter of the lagged investment ratio but that of the $logK_{t-2}$ that determines the true capital persistence in this specification (see equation [5.5]). Although the "apparent" auto-regressive parameter is $(\omega_1 - 1)$, the underlying auto-regressive component remains $(\omega_1 + \omega_2)$. Therefore, the persistence parameter can be obtained by adding 1 to the estimated parameter of $logK_{t-2}$. With a value of 0.47, this specification implies lower persistence for the capital stock than the one obtained in the level estimation (0.71).

The contemporaneous sales parameter is estimated to be over unity (1.38) in this specification while the lagged is negative (-0.83), both being significantly different from

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[17] See the coefficient of output in equation [5.1] describing the long run demand for capital. It can be seen from this that if the coefficient of output is unity then this implies the returns-to-scale parameter υ to be unity as well.

[18] Which is, in the context of our model, also the estimate of the elasticity of substitution between production factors.

zero and greater in absolute terms than in the previous specification. However, the long run elasticity is still practically unity. This corroborates the finding of constant returns to scale, which emerged from the level estimation. Yet, the relatively high and opposite sign short run elasticities suggest that the adjustment process for output is not very plausible. We note, again, the problem mentioned previously that these parameters embody not only adjustment charactersistics but also structural parameter changes.

The user cost elasticites (-0.38 and -0.03) are significant and greater in absolute terms compared to the level estimation results. However, due to lower persistence, the long run coefficient (-0.83) is comparable in magnitude to the previous result. For cash-flow, both parameters are significantly different from zero and greater than previously obtained elasticites. As a result, the long run coefficient of cash-flow is also greater (0.43) than it was in the level estimation (0.23). The greater sensitivity is not necessarily implausible because cash-flow might take up the effects of profitabiliy expectations and future sales since output and cash-flow are correlated.

In sum, this specification was less stable and these results are slightly less plausible than those obtained using the level equation.

The third specification regresses the investment ratio on differences and lagged differences of sales, user cost and the level of cash-flow. This specification proved to be much more robust to different instrument matrices: the orthogonality of instruments could be accepted in all cases (Table 8-2). The marginal significance level of the Hansen-J statistic of our final instrument set is 0.21, this same value for the AR(2) test is 0.59.

Capital persistence in this specification is determined by the sum of estimated lagged dependent variable parameters. In this case persistence is valued to be 0.58, which is comparable to but lower than that of the level estimation (0.71) being still higher than in the second specification (0.47). Although having the same signs as in the second specification, sales parameter estimates are lower in absolute terms (0.78 and -0.352) than those in the second specification (1.375 and -0.826). This suggests parameters can be more plausibly interpreted as adjustment process characteristics. The long run coefficient of sales is robustly close to unity again. The user cost parameters are slightly higher in absolute value (-0.285 and -0.036) but still close to those produced in the level estimation (-0.223 and -0.016). The long run coefficient in this specification was close to those obtained by the two other specifications (-0.76). Regarding cash-flow, the contemporaneous parameter estimate is not statistically different from zero, but the lagged cash-flow appears to have significant explanatory power. This reinforces what one might have suspect already looking at the significance levels obtained in the previous estimations, mainly in the first specification.

To summarize, we believe that our overall sample estimation results are plausible. The parameter estimates are of the expected sign and magnitude. To put results in an international context, we compare long run coefficients from the third specification to what Angeloni et al (2003) estimated using data for Germany; France; Italy and Spain. Despite differences, our parameter estimates are not out of line with those of Angeloni et al. (2003)[19]. For the user cost, their long run elasticities ranged berween (-0.027)-(-

[19] These differences might account for the disparities of results. First, their database contained mostly manufacturing data. Second, they have benefited from a longer time span (1983-99) of their database

0.521), with the estimate for Germany being the highest and for France being the lowest. For cash-flow, the estimate fell between (0.079 for Germany)-(0.301 for Italy). It is only the long run parameter of sales that is consistently lower in their estimation (0.018 for Spain)-(0.387 for Germany).

Heterogeneity across firms might be key from the point of view of cash-flow effects as larger firms are more likely to be less financially constrained than smaller firms. The validity of this hypothesis is examined by splitting the sample. We also used the Arellano-Bond dynamic panel data estimator or "difference-GMM" technique to carry out our estimations on the whole sample but results proved to be unstable to the instrument matrix. However, splitting the sample might well cure this problem.

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letting them use earlier lags both in the ADL structre and as instruments in the estimation. Third, they assert that their sample is biased towards larger firms. This might also be true for our sample but it is hard to assess whether the bias itself causes parameters to be inacceptably out of line with expectations. Last, but not least their specification contains a fixed effect even in the differenced equation. This causes the AR parameters to be smaller because the firm-specific effect takes up the autoregressive characteristics of investment rate dyamics. To understand what this implies and what the considerations are behind including/omitting a fixed effect in the differenced equation, see the discussion of the last equation within the section on empirical models.

Table 8-1: Estimation results – Specification 1

dependent variable: log capital (logKt)

	Within		First-differenced		Anderson-Hsiao 2SLS	
	coef.	*Z stats.*	*coef.*	*Z stats.*	*coef.*	*Z stats.*
$logK_{t-1}$	0.609	*238.65*	0.181	*69.02*	0.710	*12.85*
$logK_{t-2}$	0.056	*23.31*	0.105	*42.55*	0.001	*0.10*
$logQ_t$	0.157	*72.98*	0.161	*72.68*	0.500	*2.76*
$logQ_{t-1}$	0.035	*15.58*	0.100	*43.24*	-0.207	*-1.54*
$logUC_t$	-0.492	*-191.63*	-0.375	*-154.22*	-0.223	*-2.95*
$logUC_{t-1}$	-0.003	*-3.10*	-0.030	*-27.57*	-0.016	*-1.56*
CF_t/K_{t-1}	0.035	*76.60*	0.029	*65.54*	0.053	*1.82*
CF_{t-1}/K_{t-2}	0.015	*32.94*	0.017	*40.22*	0.013	*2.61*
Long-run coef. of sales	0.574		0.366		1.013	
Long-run coef. of user cost	-1.480		-0.567		-0.828	
Long-run coef. of cash-flow	0.152		0.065		0.229	
Hansen J statistic					16.26	*P=0.062*
AR2 test					1.00	*P=0.317*
Wald test for year dummies	5684.16	*P=0.000*	4927.81	*P=0.000*	54.25	*P=0.000*

Source: Apeh 1993-2002

Notes: Capital, sales and cash-flow measured in thousands of HUF. Cash-flow deflated by sectoral investment price index (own estimation), sales deflated by sectoral PPI for industry and GDP deflator for agriculture and services. Year dummies included. Heteroscedasticity-robust standard errors estimates.

Instruments for 2SLS estimation: second to fifth lags of capital and user cost, second to fourth lags of cash-flow, third to fifth lags of sales and employment.

Table 8-2: Estimation results – Specification 2 and 3

dependent variable: net investment rate ($\hat{I}_t/K_{t-1}$)

	2nd specification		3rd specification	
	coef.	*Z stats.*	*coef.*	*Z stats.*
$\hat{I}_{t-1}/K_{t-2}$	-0.352	*-3.86*	0.595	*6.50*
$\hat{I}_{t-2}/K_{t-3}$			-0.016	*-1.49*
$logK_{t-2}$	-0.531	*-3.85*		
$logQ_t$	1.375	*2.59*		
$logQ_{t-1}$	-0.826	*-2.00*		
$logUC_t$	-0.379	*-2.07*		
$logUC_{t-1}$	-0.028	*-1.12*		
$dlogQ_t$			0.781	*2.98*
$dlogQ_{t-1}$			-0.352	*-1.77*
$dlogUC_t$			-0.285	*-2.36*
$dlogUC_{t-1}$			-0.035	*-1.95*
CF_t/K_{t-1}	0.190	*2.92*	-0.005	*-0.13*
CF_{t-1}/K_{t-2}	0.041	*3.93*	0.065	*3.36*
Long-run coef. of sales	1.032		1.019	
Long-run coef. of user cost	-0.765		-0.760	
Long-run coef. of cash-flow	0.433		0.142	
Hansen J statistic	13.91	*P=0.084*	10.97	*P=0.204*
AR2 test	0.12	*P=0.905*	0.54	*P=0.588*
Wald test for year dummies	31.77	*P=0.000*	50.53	*P=0.000*

Source: Apeh 1993-2002

Notes: Capital, sales and cash-flow measured in thousands of HUF. Cash-flow deflated by sectoral investment price index (own estimation), sales deflated by sectoral PPI for industry and GDP deflator for agriculture and services. Year dummies included. Heteroscedasticity-robust standard errors estimates.

Instruments for both 2nd and 3rd specification: second to fourth lags of capital and cash-flow, second to fifth lags of user cost, third to fifth lags of sales and employment.

9 Implications for Monetary Policy

At the end of the theoretical section we described how monetary policy exerts its effects on the capital stock of firms. We decomposed the elasticity of the capital stock with respect to the monetary policy rate into three components. However, we stressed that this decomposition is valid only if all the other variables are kept unchanged. In this section we outline why these relationships have to be interpreted very carefully from the policy point of view and why it is cumbersome to assess how policy rate changes affect investment behaviour in this context.

In the first phase of the mechanism described at the end of the theoretical section, the monetary authority changes the policy rate which, in turn, spreads into market interest rates. A few considerations are in order here. First, it is not short but long term rates that determine the cost of capital since investment-related credits are typically of long maturity. Hence, long interest rates are taken into account in the user cost of capital.

Second, it is not necessarily true that short term policy rate changes are spread across *all* market interest rates and maturities. According to the expectation hypothesis of the yield curve, long term interest rates are averages of expected values of future short term rates. If monetary policy and economic policy in general is credible then short rate changes are not inevitably reflected in long term interest rates. A pre-emptive monetary tightening intended to prevent the economy from overheating might leave long rates unchanged just because it makes future tightening unnecessary and it is reflected in expectations of future interest rates. And, as a consequence, investment might not react to a tightening because the relevant interest rates have not changed. In this setup, one would wrongly conclude that monetary policy cannot curb investment activity.

Third, if firms finance investment directly from capital markets via, e.g., bond issuance, then monetary impulses might better be transmitted to market interest rates compared to a situation when the primary source of financing investment is provided by banks. In the latter case, if banks are not competing heavily to finance firms, they are less motivated to reduce the price of credit in the case of a loosening. This is the case also, when the key determinant of credit supply is not the central bank[20].

Apart from these, it is difficult to quantify how long term market rates affect the user cost of capital. Since interest rates are part of the user cost, economists tend to derive analytically the elasticity of interest rates with respect to the user cost with the assumption that changes in interest rates do not directly affect other variables. Knowing that this latter assumption is necessarily fictitious and unrealistic, we present, in what follows, some considerations about how long term interest may affect firm's user cost of capital.

In order to derive the desired elasticity, we redefine equation [4.4] as follows:

$$i_{it} = g_{it}\left(B_{it} / p_{st}^{I} K_{it}\right) + r_t \qquad \textbf{[4.4b]}$$

[20] One may think of, for example, to capital inflow from foreign investors here.

This assumption means that borrowing interest rates exceed market rate by a value (risk premia) depending on the firm's leverage.[21] It follows that – if firm's leverage don't change – banks adjust permanently theirs borrowing rates by increasing or decreasing it by the same percentage point as market rates change. Substituting [4.4b] in the user cost definition [4.9] and holding all other variables constant, one can derive the elasticity of long term interest rates to the user cost:

$$\varepsilon_{r_t}^{UC_{it}} = \frac{\frac{p_{st}^I}{p_{st}(1-u_{it})}\left[\left(1-\frac{B_{it}}{p_{st}^I K_{it}}\right)r_{it} + \frac{B_{it}}{p_{st}^I K_{it}}(1-u_{it})r_{it}\right]}{UC_{it}}, \qquad \textbf{[9.1]}$$

or, substituting r_{it} by $\left(i_{it} - g_{it}\left(B_{it}/p_{st}^I K_{it}\right)\right)$:

$$\varepsilon_{r_t}^{UC_{it}} = \frac{\frac{p_{st}^I}{p_{st}(1-u_{it})}\left[\left(1-\frac{B_{it}}{p_{st}^I K_{it}}\right)r_{it} + \frac{B_{it}}{p_{st}^I K_{it}}(1-u_{it})i_{it}\right]}{UC_{it}} - \frac{\frac{p_{st}^I}{p_{st}(1-u_{it})}\left[\frac{B_{it}}{p_{st}^I K_{it}}(1-u_{it})g_{it}\right]}{UC_{it}} \qquad \textbf{[9.1b]}$$

The first part of the above expression is nothing else than the weight of interest rates in the user cost definition. This is how total effect of changes in interest rates on user cost is generally simplified in the empirical investment literature (see for example Chatelain et al. (2001) or Butzen et al. (2001)). Its level depends on the other components of the user cost not present in the numerator, namely on the sign and the magnitude of $\frac{p_{st}^I}{(1-u_{it})p_{st}}\left[(1-u_{it})\delta_{it} - \frac{\dot{p}_{st}^I}{p_{st}^I}\right]$. This suggest that, holding all other variables constant, higher expected investment price inflation implies higher user cost elasticity with respect to market rates. Hence, if expected investment price inflation exceeds after-tax depreciation rate, the fraction at stake is in average higher than 1, which should be the case in most countries with high inflation rate. Nevertheless, the user cost elasticity to market rates can be simplified to the first part of expression [9.1b] only if risk premium (g_{it}) is absent or, more credibly, if the right-hand side of the relation [4.4b] is multiplicative rather than additive, that is, if $i_{it} = g_{it}\left(B_{it}/p_{st}^I K_{it}\right) \times r_t$. Believing in [4.4b] as presented and continuing to assume that market interest rate changes don't affect directly any other variables in the user cost formula, the elasticity usually defined as the first part of the expression [9.1b] is diminished by the weight of risk premium over market rates as it appears in the user cost formula. In this case, borrowing rates change at the same level but by a smaller proportion then market rate. As a consequence, long term market rate variation affect less highly indebted firms' user cost than that of firms with little outstanding bank credits.

As shown, the definition of user cost elasticity with respect to market rates varies with the initial assumption about the relation between market borrowing rates and the risk-free rate. Maintaining our original assumption [4.4b], this elasticity is on average 0.684 for the whole period considered. If a multiplicative rather than an additive relation is

[21] Note that this assumtion don't modify the optimality conditions presented in Section 4.

preferred, the elasticity defined simply as the weight of interest rates in the user cost is on average 0.74 for the period 1993-2002. Evaluating these elasticities on a yearly basis, one may conclude that both decreased significantly during these ten years in line with declining investment price inflation.

As already emphasized, these latter results must be interpreted with caution. One may expect that market interest rates also affect another variables present in the definition of user cost and hence the elasticity presented in [9.1b] should be modified. First of all, changes in interest rates may change the relative costs of financing new acquisitions via debt or by equity. According to [4.6], firm's leverage is a function of the difference between the market interest rate and the after tax effective interest rate. If this latter expression changes, the firm might readjust its debt/equity ratio in the long run so as to regain to optimum. Thus, market rates affect firms' leverage, which in turn affect apparent borrowing rates and hence firms' user cost. Consequently, the elasticity of user cost with respect to the market rate is lower than it would be without the possibility of choosing the financing structure of new investment. In other words, the ability to adjust its leverage gives the firm the ability to attenuate interest rate shocks. Secondly, interest rate changes may influence investment price inflation and also the relative price of investment to output prices. These effects are much more difficult to quantify and are far from the main focus of this paper.

10 Conclusion

We investigated corporate invesment behaviour in Hungary using non-financial firm level data between 1993 and 2002. Using the standard neoclassical framework we estimated several specifications. Assuming that optimal capital stock adjusts according to an ADL structure, we derived a level equation for the stock of capital and two equations for the investment-to-capital ratio. In each empirical equation we used firm specific user cost of capital data along with sales and cash-flow.

The main findings of the investigation are the following. Estimations based on the whole sample show that in the long run the user cost of capital is a significant determinant of investment and the long run sensitivities are, broadly speaking, in line with previous European estimates. The difference of results might be, at least partly, explained by sample differences and certain specification-related issues.

This result invalidates simple sales accelerator models where the only important determinant of investment is output. We also discuss that there are mechanisms, though not obvious, through which long term interest rate changes affect the user cost and, in the end, investment. It has to be stressed, however, that being essentially partial, this model is not able to describe the exact mechanism how monetary impulses are transmitted to the cost of capital and, accordingly, corporate investment.

Another interesting finding of the paper is that the coefficient of output is robustly close unity, which provides strong evidence for constant returns to scale in the production function. To control for financial constrain effects we added cash-flow to the equations. Results show that the financial position of a firm is an important determinant of investment suggesting that credit channel effects might be at work.

Our results provide the first set of microeconomic insights to Hungarian corporate investment behaviour. Drawing on these, further investigations, including splitting the sample and applying more recent frameworks, will be aimed at depicting a more refined picture of investment behavior in Hungary.

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12 Appendix

12. 1 Variables

The variables were constructed from tax return and balance sheet data of double entry book keeping Hungarian companies between 1992 and 2002. Costs and sales revenues were deflated using industry specific production price deflators for manufacturing, energy and mining. For other industries (agriculture, construction and services) we used industry specific GDP deflators. In calculating firm specific real capital stock we used weighted averages of domestic sales prices of machinery investment, import prices of machinery investment and construction investment prices of the industries where the weights were the domestic, import and construction investment proportions of each industry.

Definitions of the variables are listed below.

Number of employed (L): Average number of employed during the year, rounded to the nearest integer.

Capital stock (K): The stock of tangible and intangible assets. There is no data collected for investment in corporate tax returns, hence capital data cannot be constructed by the generally used version of the perpetual inventory method (see Section 7. 1).

Output (Q): Output is proxied by sales revenues of the firm.

User cost of capital(UC): User cost is defined as (see Section 7. 2):

$$UC_{it} = \frac{P_{st}^{\ I}}{(1-u_{it})P_{st}}\left[IR_t(1-u_{it})\left(\frac{B_{it}}{B_{it}+E_{it}}\right)+LD_t\left(\frac{E_{it}}{B_{it}+E_{it}}\right)-\frac{\Delta P_{s,t+1}^{\ I}}{P_{st}^{\ I}}+(1-u_{it})\delta_{it}\right]$$

where:

B_{it} = The sum of short and long term liabilites. It contains: accounts payable, liabilities to owners, sum of short term credits and loans, and other liabilities. Long term liabilities are composed of investment credits and other credits.

E_{it} = Equity is calculated:

subscribed capital
– subsribed capital unpaid
+ capital reserve
+ revaluation reserve
+ profit or loss for the year
+ accumulated profit reserve.

IR_t = weighted average of bank lending rates with maturities over one year

LD_t = one year benchmark t-bill rate

u_{it} = effective tax rate

P_{st}^{I} = industry specific investment price index

P_{st} = industry specific price deflator (PPI or GDP, depending on industry)

δ_{it} = effective depreciation rate

if $I_{it} > 0$: $\delta_{it} = \dfrac{DEP_{it}}{DEP_{it} + \overline{K}_{it}}$

if $I_{it} < 0$: $\delta_{it} = \dfrac{DEP_{it}}{\overline{K}_{i,t-1}}$

where

DEP_{it} = value of depreciation accounted in year *t*

$\overline{K}_{it}$ = accounting capital at the end of year *t*,

Where equity was negative, we assumed $\left(E_{it} / (B_{it} + E_{it})\right) = 0$ and $\left(B_{it} / (B_{it} + E_{it})\right) = 1$. In these cases the user cost is determined entirely by the cost of external funds.

Cash flow (CF): Firms' cash flow was calculated on the basis of Schedule No. 7 to Act C of 2000 On Accounting. We defined cash-flow as:

Income before taxes
+ Depreciation write-off
+ Loss in value and backmarking
– Change in trade debtors
– Change in accrued and deferred assets
– Change in inventories
+ Change in accrued and deferred liabilities
+ Change in short term liabilities
+ Change in long term liabilities
+ Change in subsribed capital (corrected for subscr. cap. unpaid)
– Corporate tax payed or payable
– Dividends and profit sharing paid or payable