Monetary Transmission in Germany: New Perspectives on Financial Constraints and Investment Spending

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Abstract

In order to obtain a better understanding of monetary transmission, this paper assesses the importance of the interest rate and credit channels on business fixed investment in the German manufacturing sector. Our panel of financial statements contains 44,345 observations for 6,408 firms.

We uncover a rather solid interest channel. A transitory increase in nominal interest rates by 100 basis points would depress investment demand by almost 4% within the first year. Using our direct measure of creditworthiness, we can also document a balance-sheet channel. Relative to unconstrained firms, financially constrained firms exhibit increased sensitivity to internal funds, and decreased sensitivity to the user cost as well as to market demand. Furthermore, changes in the rating of firms seem to affect investment demand in a way that is consistent with the presence of a balance-sheet channel. Quantitatively, however, this balance-sheet channel seems to be of secondary importance.

JEL Codes: E5, E2

Keywords: Monetary Transmission, Firm Investment, User Cost, Finance Constraints, Credit Channel

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1. Introduction

From a theoretical as well as from a policy perspective, it has always been important to understand the mechanism by which monetary policy influences the factor demand of firms. This is the place in the chain of monetary transmission where the "real" effects kick in. The nature of this mechanism has important structural implications, especially if one considers the possibility that monetary policy might partly operate through the availability of external finance: in this case, the effect of monetary policy might be asymmetric. It is the weakest firms that will be hit hardest by a monetary contraction. And young, innovative start-ups with little collateral and little reputation are especially weak.

Studying the interaction between the financial sphere and factor demand, the neoclassical point of departure is provided by the theorem of Modigliani and Miller (1958, 1961). With perfect capital markets, the value of a firm is independent of its financial structure, and the decisions on factor demand and financing can be separated. The former will depend only on "real" factors such as production technology, installation costs, and current and future values of capital-good prices, interest rates and demand.

In such a setting, the prime variable that lends itself to influencing by the central bank is the user cost of capital, although secondary influences might come from the demand side. It is common usage to label this the interest-rate channel.[1]

With imperfect capital markets, however, the access of firms to external finance might differ according to the importance of information asymmetry, uncertainty and agency problems. These problems create a wedge between the costs of external finance and the opportunity costs of internal finance. As the sources of finance are no longer perfect sub-

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[1] For business fixed investment in the United States, see the surveys by Chirinko (1993a, 1993b), who concludes that the response of investment to its user cost is low. Contrasting (high elasticity) interpretations can be found in Taylor (1995) and in Hassett and Hubbard (1997).

stitutes, the amount of internally generated funds can matter to the investment decision. Furthermore, it is conceivable that a change in the risk-free interest rate, induced by a monetary contraction, will lead to *additional* effects on the costs of external finance. The real value of collateral may be reduced, whereas the default probability rises, as higher interest payments act as a drain on cash flow. Lenders might react by demanding higher premiums or by imposing quantitative limits.[2] This has been called the financial accelerator,[3] and its effect may well differ between firms.

Since the work of Fazzari, Hubbard and Peterson (1988), the predominant approach to the investigation of the role of financial factors has been an indirect one. A subsample of firms is classified as being financially constrained according to some *a priori* criterion. The analysis starts with the observation that, for financially constrained firms, the liquidity generated internally is a relevant explanatory variable for investment demand, whereas in the "pure" case of a financially unconstrained firm it is not. Fazzari, Hubbard and Peterson and several other authors proceed to estimate separate investment equations and then test whether the current cash flow is of higher importance for the investment demand of the firms deemed to be as especially constrained, compared with the rest of the sample. Thus the effect of financial constraints is identified by the "excess sensitivity" to current cash flow.

This approach has been forcefully criticised by Kaplan and Zingales (1997). These authors maintain that there is no theoretical reason why – in a comparison between firms – a larger cost differential between internal and external finance might lead to a higher cash-flow sensitivity, as opposed to just comparing the extreme cases of a constrained firm and an absolutely unconstrained one. A non-monotonic relationship between the cost differential and excess sensitivity is perfectly conceivable. They show further that the sorting criterion used by Fazzari, Hubbard and Peterson – dividend payments – is not very reliable: a detailed firm-by-firm investigation shows that many firms in the group deemed to be 'very constrained' had few problems obtaining external finance. Using the results of their own detailed analysis of firm liquidity, the regressions of Kaplan and Zingales show that the excess sensitivity in their sample actually seems to be a *decreasing function* of the degree of constraint.[4]

From this discussion, we draw two methodological conclusions. Instead of using a potentially misleading *a priori* grouping criterion, we should try to measure the differential ac-

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[2] The latter possibility was first investigated in the seminal paper by Stiglitz and Weiss (1981).
[3] The term was invented by Bernanke, Gertler and Gilchrist (1996). For recent surveys of the theory of the credit channel, see Bernanke and Gertler (1995) or Bernanke, Gertler and Gilchrist (1999).
[4] The discussion was continued in Fazzari, Hubbard and Peterson (2000) and Kaplan and Zingales (2000).

cess to external finance directly. The obvious way is to use rating data. A low rating means that commercial banks will either demand a higher risk premium or that they will not extend credit at all. Differences in investment behaviour between firms of good standing and those of bad standing allow us to infer the relevance of financial constraints. If, then, an excess sensitivity for constrained firms can be confirmed, this can be regarded as a preliminary empirical validation of the Fazzari, Hubbard and Peterson approach. We can then use excess sensitivity in other sample splits to test for the presence of group-specific financial constraints.

Furthermore, we can also exploit the effect of *changes* in the rating, as long as we control for endogeneity. In a neoclassical, Modigliani-Miller world, the costs of capital do not depend on the volume of credit and the associated credit risk. The interest rate might contain a risk premium, but that does not more than compensate both the borrower and the lender for the fact that under certain conditions, the borrower will not pay back the full amount under certain conditions. Under the alternative given by the financial accelerator hypothesis, however, there are financial frictions that lead to expected costs of default. These will ultimately have to be borne by the borrower. Together with the default probability, the external finance premium becomes a function of the total volume of finance, given net worth. In this world of imperfect financial markets, a rating variable is not only a measure for the perceived risk of bankruptcy, but also for the costs of external finance. According to the financial accelerator hypothesis, shifts in the default probability generated by changes in net worth should translate into shifts of capital demand and investment activity.

Our analysis will proceed in the following way. In Section 2, we will discuss the estimating equation. We use an Autoregressive Distributed Lag (ADL) model relating the investment/capital ratio to current and lagged values of a price variable (the growth rate in user cost), an accelerator variable (the growth rate in sales), and a financing variable (cash flow scaled by the capital stock), as well as lags of the dependent variable. This model provides a solid econometric framework for assessing the interest rate and credit channels.

Section 3 describes the datasets for German firms at our disposal. First, we have an unbalanced panel of financial statement data for the period 1988-1997. After accounting for lags, outliers, and missing observations, we have 44,345 firm/year observations for 6,408 firms for our baseline model. Second, we compute user costs of capital along the lines presented in King and Fullerton (1984), adapting prior work by Fred Ramb (2002, *forthcoming*) for the purposes of this study. Third, as part of its rediscount lending operation, the Bundesbank routinely collected the above-mentioned financial statement data but, importantly, also determined overall creditworthiness through a detailed discriminant analysis. In combination, these datasets provide a unique opportunity to analyse the interest-rate channel – by examining the effects of monetary policy operating through the user cost – and the credit channel – by examining the cash-flow sensitivity of firms, differentiated by their access to external finance.

Section 4 contains our baseline empirical results. Various lag lengths are investigated, and the specification tests favour a model with three lags. The long-run user cost elasticity proves robust to variations in lag length, as well as to alternative formulations of the user cost of capital.

Sections 5 and 6 evaluate the interest-rate channel. At the microeconomic level, the relevant price variable for capital demand is the user cost of capital. It will thus be the long-run effect of a change in this variable that is of interest to us. A rather solid interest-rate channel is identified. The estimates of the elasticity of long-run capital demand with respect to its user cost range between 39% and 52%; our preferred estimate yields 43.5%. This is the "micro-link" of the monetary transmission chain. Economic significance is evaluated by a transitory increase in the capital-market interest rate of 100 basis points. Within the first year, investment demand would drop by almost 4%.

In section 7 and 8, we test for the existence of a credit channel and evaluate its importance. Relative to unconstrained firms, financially constrained firms exhibit increased sensitivity to internal funds and decreased sensitivity to the price incentives embedded in the user cost. This validates the methodology advocated by Fazzari, Hubbard and Peterson. We obtain a very interesting result when we perform the same test on a sample split between large and small firms - there is no excess sensitivity to be reported, in one case the sensitivity of large firms to cash flow is even higher. Apparently, the German house-banking system does not discriminate against small firms! In quantitative terms, the direct income effects of monetary policy turn out to be of secondary importance, compared to the strength of the interest rate channel.

In a last step, we will concentrate on the financial accelerator in the narrow sense. Proponents of this approach maintain that a monetary contraction is able to "weaken" balance sheets, directly via increasing interest expenses and depressing asset prices, indirectly via reducing sales revenue coming from downstream customers. A closer analysis of the balance-sheet ratios that enter the rating of the Bundesbank gives us direct evidence of how this may happen. By using changes in the overall rating variable as an additional regressor, we see how a "weakening" of financial statement items depresses investment demand.

Section 9 contains a summary of our results, and the conclusions that we draw for monetary transmission in Germany.

2. Modelling Investment Spending[5]

In choosing an econometric specification, it is important to distinguish between demand for the stock of capital and demand for the flow of investment. Since the capital stock is a factor of production, the standard tools of microeconomics can be used to relate the demand for capital, conditional on output, to its "price." The definition of this price variable is complicated by capital's durability. The important contribution of Jorgenson (1963) was to relate the price of durable capital to the user cost (or rental price) of capital, defined as a function of the interest, tax, and depreciation rates and relative prices. With a readily measurable user cost, the demand for capital can be analysed as a static optimisation problem.

However, the demand for the flow of investment is more complicated. Investment equals the change in the capital stock in a static environment, and thus can be specified as the change in the determinants of the capital stock. This is the derivation used by Clark (1917) for his accelerator model of investment. Such a formulation does not reflect the "frictions" that introduce an important and complicated set of dynamic elements into the investment decision. These frictions include adjustment costs with changing the capital stock, delivery lags, vintage effects, time-to-build lags, and irreversibility constraints. The interaction between these frictions and durability forces the profit-maximising firm to take a deep look into the future. Consequently, a second important dynamic element affecting the investment decision is expectations of future variables.

The numerous models appearing in the investment literature can be divided into two broad categories, depending on whether dynamic elements are treated explicitly or implicitly. Models are included in the former category if dynamic elements appear explicitly in the optimisation problem and if the estimated coefficients are linked explicitly to the underlying technology and expectation parameters. The implicit category contains those investment models that do not meet these criteria. These different approaches are reviewed below in the light of their usefulness for investigating the monetary transmission mechanism.

The most popular explicit models can be derived from a common optimisation problem. If frictions are modelled in terms of convex adjustment costs, then the first-order conditions

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[5] This section is partly based on a memo by Bob Chirinko. An extensive list of references is contained in Chirinko (1993a, 1993b). We gratefully acknowledge the permission to make use of this memo.

for intertemporal profit maximisation imply a decision rule for investment spending: the investment/capital ratio is a function of the shadow price of capital, which is defined as the discounted sum of current and future returns on the marginal unit of capital. The key problem facing the applied econometrician is that this shadow price is not observed. Investment models based on adjustment-cost frictions differ only in how the applied econometrician solves this unobservability problem. [6]

The first solution exploits the substantial and readily-available information in financial markets to solve the unobservability problem, and the shadow price is equated with the Brainard-Tobin's Q. There are three reasons why we do not estimate a Q model. First, the empirical performance of Q models has generally been disappointing, though recent work with panel data is encouraging. Second, to assess the impact of a monetary impulse on investment, we would have to simulate a difference equation for Q and the investment equation simultaneously over time in a rather difficult multiple shooting exercise (Summers, 1981). The third and most important difficulty with using the Q model is that it requires that firms be listed on the stock exchange. This is a severe restriction that would eliminate most of the firms in our sample, especially smaller firms for which financial constraints may be important.

The second approach solves the unobservable shadow-price problem by transforming the investment-decision rule so that most of the future unobservable variables in the shadow price are eliminated. The resulting Euler equation is a period-by-period arbitrage condition that must hold along the optimal path of capital accumulation. Unlike the Q model, estimation can proceed with both listed and unlisted firms. However, the Euler-equation approach shares the two other difficulties affecting the Q model. The empirical performance of the Euler equation has been disappointing.[7] Furthermore, an estimated Euler equation is not an investment-decision rule. It can be solved forward to yield such a rule, but this solution requires specification of the entire future paths of interest rates and other forcing variables.

The third solution to the unobserved shadow-price problem forecasts the terms constituting the shadow price from period t onward using data available in period t, and then estimates the model's parameters. The two steps can be executed sequentially (Abel and Blanchard, 1986). In this forecasting model, the investment/capital ratio is related to current and lagged values of the exogenous and predetermined variables with the estimated

[6]Some of the other frictions lead to only modest changes in the decision rule. The model of irreversibility and uncertainty of Abel and Eberly (1994) generates a specification where the Brainard-Tobin's Q appears as a polynomial. Time-to-build and delivery lags alter timing relations in the benchmark explicit model.

[7] See Oliner, Rudebusch, and Sichel (1995).

coefficients restricted in several ways by the underlying structural model. Gilchrist and Himmelberg (1995) have successfully estimated a forecasting model on panel data and, in their study, the investment/capital ratio is related to current and lagged values of the sales/capital and profits/capital ratios. Importantly for the purposes of our study, the interest rate is held constant in the Gilchrist and Himmelberg forecasting model, and this restriction would make it difficult to assess monetary transmission channels.

To summarise, the explicit models have the notable advantages of being based on a choice-theoretical framework and having coefficients in the econometric equation that can be identified with technology and expectation parameters. However, given our interest in quantifying aspects of the monetary transmission mechanism and concerns about the fragility of inferences in explicit models, we believe that, given their current state of development, our analysis can best be carried out with an implicit model.

There is a wide variety of implicit models (see Chirinko, 1993a, 1993b). The specification used in this paper defines a desired capital stock in terms of user cost and sales variables having separate elasticities.[8] This demand for the stock of capital is translated into a demand for the flow of investment by relating the percentage change in capital (or the investment/capital ratio less depreciation, I/K - δ) to the current and lagged percentage changes in the user cost (UC) and sales (S). To allow for a general pattern of dynamic responses, lagged dependent variables are included. We also enter current and lagged values of a financing variable, the ratio of cash flow to the capital stock (CF/K), to capture the effects of financing constraints. These considerations lead to the estimating equation as the following autoregressive distributed lag (ADL(L)) model of lag length L:

$$\frac{I_{i,t}}{K_{i,t-1}} = \varphi_i + \sum_{l=0}^{L} \alpha_l \frac{I_{i,t-l}}{K_{i,t-l-1}} + \sum_{m=0}^{M} \beta_m \Delta \log S_{i,t-m} + \sum_{n=0}^{N} \gamma_n \Delta \log UC_{i,t-n} + \sum_{q=0}^{Q} \theta_q \frac{CF_{i,t-q}}{K_{i,t-q-1}} + \lambda_t + u_{i,t} \qquad (1)$$

where the α_l, β_m, γ_n and the θ_q are estimated coefficients, λ_t is a series of time effects that capture aggregate shocks, $u_{i,t}$ is a stochastic error term, i indexes firms, and t indexes time. The φ_i reflect the firm's mix of capital assets, and is firm-specific. More generally, this firm-specific constant term captures all firm-specific effects. The other coefficients do not vary across firms. A derivation of (1) is provided in Appendix A.

[8] This model was developed over several years in a spirited set of exchanges (Jorgenson, (1963); Hall and Jorgenson (1967, 1969, 1971); Eisner and Nadiri (1968, 1970); Bischoff (1969); Coen (1969); and Eisner (1969, 1970)).

Equation (1) has three notable advantages for assessing the monetary transmission mechanism. First, a similar specification has performed well in previous research with panel data for the United States (Chirinko, Fazzari, and Meyer, 1999) and Germany (Harhoff and Ramb, 2001). Second, a user-cost variable appears in the specification. This is important because it provides a direct avenue for considering the interest-rate channel of monetary policy. The user cost varies both through time and across firms, and thus panel data can be very useful in estimating user-cost coefficients. Third, as will be seen below, the ADL(L) in (1) has long-run properties, conditional on the parameter values, which are easy to evaluate and to interpret. The major concern with implicit models is the Lucas Critique. Investment specifications based on an explicit optimisation problem are immune to this critique because the coefficients appearing in the econometric equation are related to separately-identified technology and expectation parameters. While undoubtedly correct theoretically, some empirical evidence indicates that the Lucas Critique is not quantitatively important.[9]

We close this section on model selection with a brief discussion of an alternative implicit model, the Error Correction Model (ECM) that was introduced into the study of investment spending by Bean (1981) and, in a panel context, by Bond, Elston, Mairesse and Mulkay (1997); for a derivation, see Appendix A. This specification nicely combines long-run restrictions between the levels of capital and the other explanatory variables in the error-correction term and short-run dynamics in the adjustment terms. The difficulty with using an ECM is practical. Applications to date on panel data have not fared well; see Mairesse, Hall, and Mulkay (1999) for estimates with French and United States firms, and Harhoff and Ramb (2001) for estimates with German firms.[10] Our own experiments with this approach were plagued with difficulties in finding valid instruments and with a high sensitivity of the results on specification and instrumentation choices; to boot, the results frequently lacked economic sense. In Appendix A we show that this problem might be due to firm-specific technological progress that leads to firm-specific growth in the level of the target capital stock. In this case, it might be problematic to use an estimation equation based on levels. Instability with firm-panel data, coupled with the fragility of ECM estimates in other studies, suggests some caution in using an ECM specification with panel data at this time.

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[9] See the empirical assessments by Chirinko, Fazzari, and Meyer (1999).

[10] In a study similar to ours, Chatelain and Tiomo (2001) also report problems. Gaiotti and Generale (2001) seem to obtain a rather coherent picture.

3. Datasets

3.1. Financial Statements (Unternehmensbilanzstatistik, UBS)

The Bundesbank’s financial statement database (Unternehmensbilanzstatistik; UBS) constitutes the largest source of accounting data for nonfinancial firms in Germany.[11] This collection of financial statements originates from the Bundesbank’s function of performing credit assessments within the scope of its rediscount-lending operations, through which the Bundesbank purchases trade bills issued by nonfinancial firms from creit insitutions. When a bill is presented to the Bundesbank, the creditworthiness of the presenting firm, as well as all other firms that have held this bill, needs to be determined. In the case of default, under German law, liability for payment of the bill falls on any firm that has held the bill.

The Bundesbank's branch offices collect about 70,000 annual accounts per year on a strictly confidential basis. These data are initially subjected to a computer check for logical errors and missing data. Approximately 15,000 accounts have to be excluded because they are incomplete, are consolidated accounts, or are for firms in sectors for which no meaningful results can be generated owing to the small amount of available data. Additional checks and corrections for errors are undertaken in the Statistical Department at the Bundesbank’s Central Office in Frankfurt before finalising the UBS database. According to turnover-tax statistics, the UBS represents roughly 75% of the total turnover of the West German manufacturing sector, albeit only 8% of the total number of firms. The sample used in estimation is much smaller because of data cleaning, outlier control (the upper and lower 1% tails of sales growth, cash flow divided by the capital stock, and the overall rating ratio discussed below, and the upper 2% tail of the investment-capital ratio), first-differencing, missing values, and the necessity of lag lengths (three periods for the ADL(3) model discussed in Section IV) and contiguous observations. We thus have available a dataset comprising 44,345 firm/year observations for 6,408 firms. In 1996, these firms had 2,593,100 employees, representing about 45% of all employees in the manufacturing sector. In the same year, total turnover was DM 963.6 billion, which is 50.8% of sector turnover.

The dataset extends from 1988 to 1997. The beginning year is chosen because the definitions of many important financial statement data were changed in 1986 by the directive

[11] On investment demand, the UBS data-base has been utilised by Harhoff and Ramb (2000) in a user-cost study, and by von Kalckreuth (2000) in a study on investment and uncertainty, also see Deutsche Bundesbank (2001). Detailed descriptions are presented by Deutsche Bundesbank (1998), Friderichs and Sauvé (1999), and Stöss (2001).

harmonising financial statements in the European Union. For many firms, the changes were not instituted in 1987, and the amount of data available in the UBS is unacceptably low in that year. Also for reasons of comparability, the dataset used in estimation only contains firms located in the former Western Germany.

Table 1 contains summary statistics for the variables entering the regression model (1) and three different specifications of the user-cost variable, which is presented in both levels and growth rates. These specifications are discussed in the next sub-section, further details on the variables are given in Appendices B and C. Tables 2 and 3 complement this information with a description of the sample composition with regard to size and rating categories, both showing the mean value of the variables for the various groups and a cross tabulation. It becomes clear that small firms have only a marginally worse rating than large firms, and that they are not overrepresented in the group of firms initially rated as bad risks. Table 4 presents the size distribution of the firm/year observations by mean employment, and documents the remarkable representation of small firms in the UBS database. The median and mean number of employees is 119 and 405, respectively. Nearly one-half of the observations pertain to firms with 100 employees or fewer.

3.2. User Costs

The user cost of capital (UC) is the key “price” term in our model, and it is the variable through which the interest-rate channel of monetary policy operates. As a first approximation, the user cost is composed of three elements,

$$UC = R * P * T, \tag{2}$$

where R, P, and T represent rental, price, and tax terms, respectively. The rental term contains two components, the opportunity cost of funds, measured by the real long-term interest rate ($r = \rho - \pi$, the nominal discount rate (ρ) less the expected rate of inflation (π) in the price of investment goods), and the economic rate of depreciation (δ). This initial formulation of the user cost needs to be expanded to reflect relative prices and taxes. The P term is the price of investment goods relative to the price of output. The two key taxes are the rate of income taxation (τ, reflecting both federal and Länder rates, as well as the “solidarity surcharge”) and the present value of the stream of current and future tax-depreciation deductions (A).[12]

[12] Note that the pattern of tax depreciation defining A is determined by law, and likely differs from the economic depreciation pattern defining δ. The tax term in the user-cost formula usually reflects investment-tax credits determined as a percentage of the price of a purchased asset. During our sample period, no such credits were granted to German firms. Apart from entering the T term, taxes also affect the discount rate entering the R term, as discussed later in this subsection.

Equation (2) summarises the price incentives that a profit-maximising firm faces when evaluating the acquisition of the marginal unit of capital. However, the user-cost variable used in this study is much more complicated. These important details are provided in Appendix B. Here we note the important issue that the nominal discount rate in the R term varies by the assumed source of finance and, in this study, we use three different specifications of this discount rate and hence the user cost of capital.

The nominal discount rate depends on whether the marginal source of funds is from retained earnings, debt finance, or new share issues. Taxing at both the personal and the business level leads potentially to large differences in discount rates. However, as shown in Appendix B, the split-rate system with full imputation that prevailed in Germany from 1977 to 2000 led to an equality between the costs of debt and new equity finance. Hence the only difference in discount rates is between internal funds and external funds. In order to construct a representative user cost of capital, we follow King and Fullerton (1984), and define the user cost as a weighted sum, where the weights reflect the usage of internal and external finance. We use two different weighting schemes. For UC(1), the weights are based on the flow of the sources of internal and external finance in a given year. This approach has the advantage of reflecting ongoing financing decisions, but the disadvantage of not being directly linked to a well-defined marginal decision. Our second user cost, UC(2), weights the costs of internal and external finance by balance-sheet proportions. These stock weights were used by King and Fullerton (p. 14), and reflect the marginal source of finance for an equiproportionate expansion of the firm. This scheme has the advantage of reflecting a long-run marginal decision, but may be misleading if current sources of finance differ from the average patterns that existed previously. For either UC(1) or UC(2), the interest rate is the average yield on industrial obligations of all maturities issued by German residents.

The third user cost used in our study, UC(3), uses an apparent interest rate calculated from total interest payments divided by outstanding debts. This measure introduces firm-specific variation, but does not reflect a pure cost of finance. Rather, it contains the default risks that will be impounded into average financing costs, thus making it difficult to distinguish between interest-rate and credit channels. With respect to the summary statistics in Table 1, UC(1) and UC(2) are rather similar, as they sum up the same items using different weights only. Standard deviation for UC(3) is higher as a consequence of the greater dispersion of apparent interest rates.

3.3. Overall Rating Ratio (ORR)

Based on the UBS data, the Bundesbank computes an Overall Rating Ratio (ORR or Gesamtkennzahl) of creditworthiness, using discriminant analysis. The following information is used to calculate discriminant functions in the manufacturing sector; for the details, see Appendix B:

1. equity/pension provision ratio;
2. return on total capital employed;
3. return on equity;
4. capital recovery rate;
5. net interest-payment ratio;
6. accounting practice.

These ratios are examined by the Bundesbank's Department of Credit, Foreign Exchange, and Financial Markets for outliers. The rating data are not passed to commercial banks, but rather constitute internal ratings for the rediscount purposes of the Bundesbank. The ORR ranges between -99.9 and 99.9 and, in our study, it has been transformed so that it varies between 0 and 1. The discriminant analysis determines two critical values of the ORR variable that classify firms into one of three categories: high risk of default, low risk of default, or indeterminate. The proportion of distressed firms in the UBS appears representative, and compares favourably with the percentage of failed firms in the overall economy (Deutsche Bundesbank 1998, Stöss 2001).

4. Baseline Empirical Results

We begin the empirical work by examining the performance of our Autoregressive Distributed Lag (ADL) estimating equation (1) to variation in lag length. All estimates are computed by GMM with the equation first-differenced to eliminate firm fixed effects.[13] The instruments are the undifferenced values of all regressors, lagged at least two periods and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta logS_{i,t-m}$, $\Delta logUC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where m is as large as possible, given data availability), as well as a constant and year dummies. The ADLs are evaluated with the Sargan-Hansen statistic for testing overidentifying restrictions and the Lagrange Multiplier statistic (LM(2)) for testing second-order residual serial correlation. If the first-differenced model is correctly specified, the overidentifying restrictions will be sustained, and the residuals between periods t and t-2 should be uncorrelated. Since one of our primary substantive interests is the response of capital formation to the interest rate embedded in the user cost, we present long-run elasticities for each specification. The Long-Run User-Cost Elasticity (η_{uc}) is the long-run percentage change in the capital stock as a reaction to a permanent increase in the level of its user cost, given by a one percentage point blip in the growth rate, $\Delta \log UCC$, see Ap-

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[13] All estimates are computed with DPD (Ox version 2.20 for Windows), and are the "two-step estimates" based on a weighting-matrix that is a function of the initial GMM parameter estimates.

pendix A. It is given as the sum of the coefficients on the user-cost variables divided by one minus the sum of the coefficients on the lagged dependent variables, that is:

$$\eta_{UC} = \sum_{h=0}^{L} \gamma_h \Bigg/ \left(1 - \sum_{h=0}^{L} \alpha_h\right) \qquad (3)$$

The standard error of η_{uc} is computed by the delta method. Table 5 contains the long-run user-cost elasticity for three different user costs for lag lengths of two, three, and four periods. A clear pattern emerges. For a given user cost, the Sargan-Hansen statistic reaches a minimum at lag 3, and the LM(2) statistic rises uniformly with the lag length. Our primary interest is in UC(1) (flow weights) and UC(2) (stock weights), and the ADL(3) is clearly the preferred specification. For UC(3), the LM(2) statistic is 0.031 for the ADL(3), and the specification tests, considered jointly, suggest that the ADL(4) model is more appropriate. For the sake of comparability with the models using alternative user costs, and to avoid losing a substantial part of the sample because of the longer lag, we estimate models with only three lags.

The estimated impacts of monetary policy via the user cost are robust to variations in the lag length. For UC(1) or UC(2), η_{uc} varies very little. The maximum change is 0.139 (between the ADL(3) and ADL(4) models for UC(1)), which is less than one standard error. For our preferred ADL(3) specification, the point estimate is about 0.40. Similar results hold for UC(1), except for the ADL(2) model, which is decidedly rejected by the specification tests.

Table 6 presents the complete list of coefficient estimates, their sums, and the associated p-values for the ADL(3) model for the three user costs. We also give the long-run effects for the other two explanatory variables. Similar to (3), the long-run sales elasticity of capital demand, η_{UC}, relates the sum of changes in the logarithmic capital stock to a once-and-for-all increase in the level of real sales, i.e., a one-time increase in its growth rate. With respect to the cash-flow capital ratio, however, we prefer to think of a one-time increase in the level of cash flow per unit of capital.[14] Again, the long-run effect of this, ϕ_{CF}, is given as the sum of subsequent changes in the logarithmic capital stock, see Appendix A. Technically speaking, ϕ_{CF} is a semielasticity of long-run capital demand with respect to CF/K. It is easy to see that it is equal to the long-run change in the level of the

[14] Our investment equation allows for long-run effects of a transitory change in cash flow on the capital stock. A *permanent* change in the cash-flow - capital ratio, however, would be a thought experiment of doubtful value: On the face of it, there could be no steady state level for the capital stock, as its growth rate is permanently shifted. But the long-run level of profitability is determined by the same technology that also underlies the other parameters of the investment function. A shift in the profitability of real capital thus cannot be carried out in isolation. I thank Daniele Terlizzese for a long and careful discussion of the problems involved.

capital stock as a reaction to cash-flow injections, that is: a long-term marginal propensity to spend on capital goods:

$$\phi_{CF} = \frac{\sum d\, I/K}{d(CF/K)} = \frac{dK/K}{d(CF/K)} = \frac{dK}{dCF} \qquad (4)$$

The sums of the coefficients on all four regressors – user-cost growth, the lagged dependent variable, sales growth, and cash flow relative to the capital stock – are statistically significant at the 1% level.[15] All three of the long-run effects defined above are also significant at the 1% level.

The sales coefficients turn out to be rather small. This is a rather common result in the panel literature, see, e.g., Chirinko, Fazzari and Meyer (1999). Possible reasons are faulty deflators, measurement problems, bad instruments and irreversibility. We do not observe sales of real capital in the case of downturn, and when sales go up, there might be a threshold value for profitability that has to be surpassed.[16] In order to gauge the importance of this potential bias for the estimated user cost elasticities, we reestimated our preferred specification, the ADL(3), imposing constant returns. Thus, the sales elasticity was constrained to be one and the same set of instruments was used. Under this assumption, estimated user cost elasticities increase somewhat, to -0.620 for UC1, -0.635 for UC2 and to -0.75 for UC3 (not shown). We cannot tell, however, whether the restriction is valid, and in all three cases, the Sargan statistics give us reason to prefer the free estimate.

5. Testing the Interest Rate Channel

Uncovering a significant interest-rate channel of monetary policy has proved elusive. In the ADL investment model, the interest-rate channel operates through the user cost and, as Tables 5 and 6 reveal, there is a statistically significant relation between the user cost and investment. The ϕ_{UC}'s for different user costs range from 0.39 to 0.52, and are statistically significant at the 1% level. The distributed lag coefficients for user cost decline sharply, and most of the impact of the user cost is transmitted to investment after two years. The lagged dependent variable has only a modest effect on ϕ_{UC}, raising this elasticity by about 10%-15%.

Table 7 explores the interaction between the cash flow and user-cost variables. In our baseline specification, the cash-flow variable is included to capture short-term financing

[15] In Table 4, the sums of the coefficients for a given explanatory variable differ from their long-run effect, which also accounts for the dynamic impact of the lagged dependent variable.

[16] For investment under irreversibility, see, e.g., Dixit and Pindyck (1994), and, for an empirical exploration with the Bundesbank data set, von Kalckreuth (2000).

effects.[17] Constraining now the cash-flow coefficients to zero, the user-cost elasticities rise by 12 to 14 percentage points. This effect and the same magnitude have been observed previously in U.S. data by Chirinko, Fazzari, and Meyer (1999), who argued that it was due to an "income effect" induced by financing constraints. Chatelain and Tiomo (2001) and Chatelain, Generale, Hernando, von Kalckreuth and Vermeulen (2001) had the same experience with the various national data sets they used.

For a firm operating in frictionless capital markets, a user-cost change induces substitution effects only. However, interest costs and available internal finance are also affected by interest rates embedded in the user cost. Fluctuations in internal finance can affect the behaviour of financially constrained firms over and above the effects arising from substitution alone. A higher interest rate may have standard incentive effects on the demand for capital and investment but, for financially constrained firms, the resulting decline in cash flow could reduce investment more than if the firm operated in perfect capital markets. The existence of these "income effects" is consistent with our findings in Tables 6 and 7. In the regressions without cash flow (Table 7), ϕ_{UC} captures both the conventional substitution effect as well as the income effect induced by financing constraints, which affect investment in the same direction. When we add cash flow, however, the estimated ϕ_{UC} can be interpreted as the user-cost elasticity holding cash flow constant; that is, as a measure of the conventional substitution effect alone. These results suggest the importance of exploring the impact of finance constraints, a task that we pursue in Sections 8 and 9.

There are several insignificant coefficients in the distributed lags that may affect the precision of the estimated coefficients and elasticities. To obtain more precise estimates, we proceed to remove those variables in Table 6 whose coefficients have a p-value that is greater than, or equal to, 0.10. For two of our three models, the trimmed specification is identical, and includes one lag of the dependent variable, the current value of cash flow, the current and one lagged value of the user cost, and the current and two lagged values of sales. [18] These trimmed estimates are presented in Table 8. The point estimates for most variables remain quite robust, and are estimated more precisely. One exception is the user-cost elasticity for UC(3) which changes from -0.521 to -0.378. On the other hand, UC(2) increases from 0.392 to 0.504. Smaller changes occur for UC(1) – the estimated elasticitiy now is 0.435. These trimmed models will be the primary focus of the discussion in the next sections. In the following tables, the trimmed estimates will be presented as Table "a" and the untrimmed (i.e., lag 3 for all variables) estimates as Table "b".

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[17] More generally, current cash flow may be of importance for the formation of expectations.

[18] The model with the user-cost variable UC(3) needs two lags for user costs and cash flow, respectively.

6. Evaluating the Interest Channel

To evaluate the economic significance of the interest channel of monetary policy in our ADL model, we compute the change in the time path of capital formation that would be forthcoming from a contractionary monetary policy. The computations are based on the estimated investment equation and the user-cost definition. We assume that the nominal long-term interest rate is a variable at the control of policymakers, and evaluate the impact of a 100-basis-point rate hike for one year.

The long-term rate usually is not considered an instrument of monetary policy. An increase of the money market rate by a certain amount can lead to a smaller or larger reaction of the long-term rate, depending on whether agents perceive the underlying change as transitory or permanent. If agents expect further increase in the future, the reaction of the long-term rate might even be stronger than the underlying change on the money market. Analysing the dynamics of the interest rate structure in any further detail, however, is beyond the scope of this paper. Our analysis evaluates the interest channel taking the effects on the financial markets as given.

In terms of our explanatory variables, this translates into a positive change in the log of user cost of capital during one year, followed by an equally-sized drop in the next year. In our thought experiment, we do not consider the reactions to the investment-price inflation that this policy shock might entail. Furthermore, we want to keep this experiment strictly partial: Second-order effects of investment on the cash-flow capital ratio and sales growth are not considered. It is necessary to emphasize that the analysis in Sections 6 and 8 is not equivalent to a thorough quantification of the dynamic effects of monetary policy. Such an exercise is being done by Angeloni, Kashyap, Mojon and Terlizzese (2001). Our aim is of a more qualitative nature: we want to use the dynamic characteristics our investment equation to make a statement on the relative importance of interest channel and credit channel.

In order to link monetary policy to capital formation, we first need to look at the dependence of (log) user costs on nominal interest rates. The term $\partial \log UC / \partial i$ is the semielasticity of user costs with respect to the nominal interest rate: For each firm, it is computed using the exact definition of user costs, see Appendices C and D. As a mean value for our ADL(3) sample, we obtain 3.383, which corresponds to an interest elasticity of user costs of almost exactly 0.25.[19] Second, we use the coefficients of our preferred estimate, which

[19] It is interesting to interpret this elasticity in terms of the simplified user-cost formula given in equation (2). With UC = R*P*T and the rental rate equal to the sum of the real long-term rate and the depreciation rate ($R = (i-\pi+\delta)$), the elasticity is equal to $i / (i-\pi+\delta)$. Assuming that $i = 0.07$, $\pi=0.04$ and $\delta = 0.17$, we obtain an elasticity of 0.25.

is the trimmed UC(1) estimate in Table 8. This yields the deviations of the investment-capital ratio from the baseline scenario. Finally, dividing by the mean of the investment-capital ratio, we convert these deviations into relative deviations of gross investment.

The results are presented in Table 12, columns (1) - (5). The assumed temporary increase in nominal interest rates translates into a temporary growth of user costs by 3.38%, which is reversed the year after. In the first year, this translates into a drop of gross investment by 0.7% of the capital stock, meaning a decrease in gross investment by 3.9% of the baseline level. In the second year, there are two conflicting influences on investment demand. Last year's increase of user costs still has an effect via the lagged user cost term and the lagged dependent variable in the investment function. On the other hand, user-costs go down again at the beginning of the second year. The net effect is almost nil. In the third year, the effect of the fall in the user costs in the preceding year dominates, and investment rises above the baseline level. The build-up of real capital, having slowed down as a consequence of the transitory rise in its user costs, is returning to its old path. The effects peter out in the following periods. The total effect of a transitory shock on the long run capital stock, which is obtained by summing up column (4), is nil. In the example, almost the whole effects of the user-cost change make themselves felt in the first year. This is partly a technical consequence of specifying the equation in first differences, together with the assumption that interest rates reverse in full at the end of the first year.

It is interesting to look at the macroeconomic relevance of the interest-rate channel. In 1997, the last year of our estimation horizon, the gross fixed investment of firms (without housing) was 18% of GDP. Thus, if the reaction of investment demand in the manufacturing sector is representative of the entire demand for fixed capital, the decrease in investment within the first year would amount to 0.7% of GDP, even without taking secondary effects on aggregate demand into account.

7. Testing the Credit Channel

As a first step, we sort the firms in our dataset by two characteristics that might identify access to external funding - the overall rating ratio ORR and firm size. As is standard in the literature, our estimation strategy is to sort the dataset by these characteristics, and evaluate whether investment spending is "excessively sensitive" to cash flow for the firms that are believed to be financially constrained. Given our user-cost data and the interest channel that we have identified, we can also examine whether the user-cost elasticity varies systematically.

Table 9a presents estimates of our trimmed models where the firms are classified as having a favourable or unfavourable credit rating. Classification depends on the state in the year before the first investment-capital ratio enters the regression. For our ADL(3), this is the third year of the cleaned sample. Firms that are in the indeterminate category are excluded from these regressions. The table gives us the long-run effects of all explanatory variables for firms with a favourable credit rating at the outset. In the line underneath, the difference in the long-term effects between firms with an unfavourable rating and firms with a favourable rating is presented. Two results stand out. First, the coefficients on the cash-flow term are larger for the unfavourably-rated firms. For all user-cost definitions, the long-term effect of cash flow is at least twice as large for these firms, and for UC(1), our preferred variable, this difference is statistically significant at the 5% level. For those firms with an unfavourable credit rating and presumably higher cost of external finance, investment seems to be excessively sensitive to internal funds.

Unfavourably-rated firms also demonstrate a smaller sensitivity to the user cost. For these firms, the long run effect of user cost changes is insignificantly different from zero in each regression. Thus, because of financial constraints, these firms show little response to the price incentives associated with variations in interest rates. It is interesting to speculate on this reduced sensitivity to price variations. The underlying reason might be that the badly-rated firms are financially "paralysed" - at least at the margin, they are unable to adapt their capital stock to changing economic circumstances. Another, but related, reason might be that these firms obtain an insurance against changes in the cost of credit from their house bank - in return for higher interest charges, of course. In this case, changes in the market rates do not reflect changes in the costs of marginal finance of the firms. Looking at the sales coefficients gives evidence of the first explanation: the sales sensitivity of badly-rated firms is drastically reduced, compared with the firms of good credit standing.[20]

Table 10a sorts the sample by number of employees: a firm is categorised as "small" if it has less than 100 employees on average. It frequently has been hypothesised that small firms will face financing problems because they have less visibility in external capital markets and are poorly positioned to bear the fixed costs associated with external finance. As nearly one-half of our firms have fewer than 100 employees, we should be able to detect small-firm financing problems if they exist. For UC(1) and UC(2), there is no difference in the cash-flow coefficients between small and large firms. For all three user-cost

[20] There is, however, a competing explanation. Badly rated firms might experience episodes of decreasing sales disproportionally often. Because of irreversibility and the fact that we do not observe sales of capital goods, the measured reaction might be weak compared to favourably rated firms.

definitions, the user-cost coefficients are more negative for the small firms. Small firms seem to have access to credit, but are very sensitive to variations in price incentives. However, in spite of being large, the measured differences are statistically insignificant.

It emerges that being "small" is something essentially different from being badly-rated and credit-constrained in Germany. Whereas our sample split according to rating was able to detect clear signs of credit constraints (which was to be expected), the sample split according to size did not. These results might indicate that the German house banking system is efficiently overcoming the barriers to external finance that could otherwise have constrained small and therefore "opaque" firms in the capital market. These results are compatible to the role of the house-banking system in Germany as described, e.g., by Worms (2001)

As a result from our sample splits, we can conclude that financial constraints seem to play a certain role - the availability of internal finance is a determinant of investment behaviour. But there is more to the balance-sheet channel than these drains on cash flow. A restrictive monetary policy might influence key balance-sheet items in a way that makes commercial banks and other sources of external finance more reluctant to supply credit or equity. Our rating variable, ORR, condenses the information contained in the balance sheet in a rather efficient way. This variable enables us to test directly the influence of a deterioration of the balance on investment demand, using the ORR variable as a regressor in its own right.

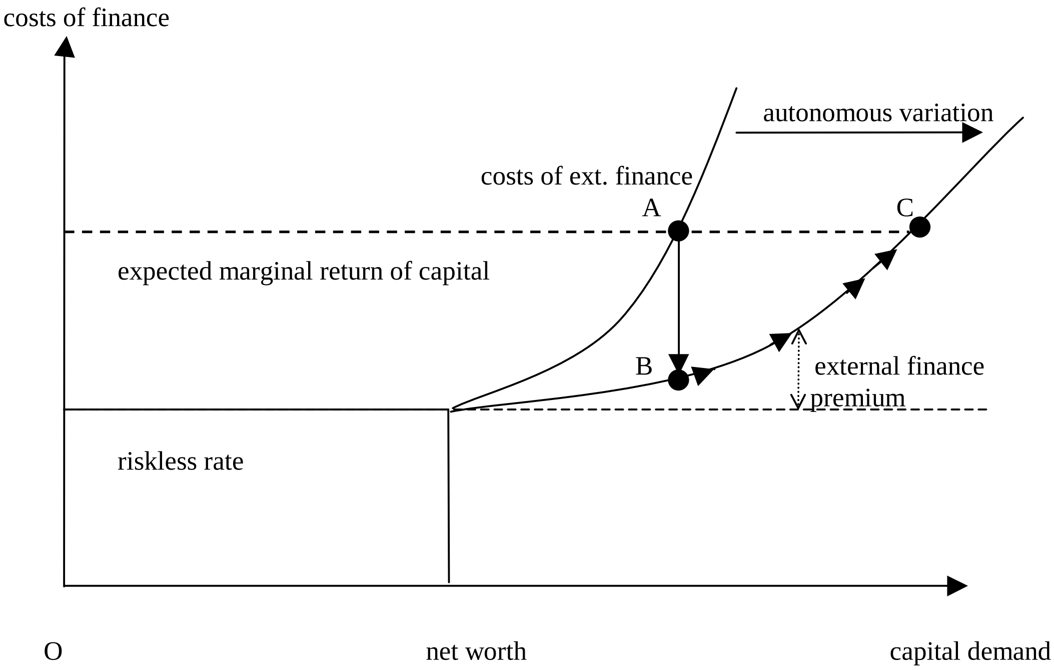

Fig 1: Capital Demand and Costs of External Finance

If we leave the Modigliani-Miller world, and enter a world characterized by financial frictions due to costly state verification or other agency problems, there will be expected costs of default that ultimately have to be borne by the borrower. With higher financing volume, the default probability rises and with it the associated costs of default. These will be internalized to the borrower by the credit contract. The costs of finance depend upon the volume of external finance.[21]

Using a model of costly state-verification, Bernanke, Gertler and Gilchrist (1999) show that the optimal contract provides a monotonically increasing relationship between the capital/wealth ratio and the premium on external funds. A higher premium will be associated with a higher default probability. Fig. 1 demonstrates the basic argument. As soon as the financial volume of firms becomes higher than their net worth – or the amount that can be collected costlessly by borrowers as collateral – the costs of external finance rise above the riskless rate because of the expected bankruptcy costs that have to be borne by the borrower. Firms that are in the ascending part of the schedule are "constrained", their demand for capital depends on their net worth and on those factors that influence the relationship between borrowing and the costs of finance. Important factors might be: distribution of earnings (both mean and variance), monitoring and other ageny costs, and collateralization technology

Our rating variable is a direct measure of *perceived default risk*, as seen from the perspective of the lender. Therefore, it varies with the difference between the riskless rate and the costs for external finance. In dynamic firm equilibrium, default probability and rating are determined by the difference between the riskless rate and the marginal productivity of capital.

What can we say about the relationship between the perceived default probability, measured by our rating variable and capital demand and investment? In firm equilibrium, default probability is *endogenous*. A rise in the difference between expected profitability and the risk free interest rate will be associated by a higher capital/wealth ratio and a higher default probability. If we compare dynamic equilibrium states, where capital stock and default probability jointly depend on productivity, the observed relationship between capital demand and default probability should be positive. This is equivalent to a movement *on* the schedule for costs of finance.

On the other hand, the schedule relating the costs of finance to the total financing volume can *shift* due to a change in net worth or one of the other factors mentioned above. Given

[21] Models of this type are described, among others, in Bernanke, Gertler and Gilchrist (1999) and Bernanke and Gertler (1989).

a certain stock of capital, this will show up in a change in default probability. In Fig. 1, an increase in net worth will shift the cost of external finance schedule to the right. The state of the firm will switch from A to B. The movement towards a new equilibrium in C makes necessary a series of investment (over and above the depreciation rate) or disinvestment (investment rates lower than depreciation). Under the financial accelerator hypothesis, the relationship between investment and *autonomous* movements of current and lagged rating is therefore supposed to be positive. Such a positive relationship can be considered as an independent piece of direct evidence for a propagation mechanism that links investment demand to changes in net worth.

In order to identify autonomous variation, we have two devices. First, we use the time structure of information flows between borrower and lender. For the credit decision that takes place within a given period, the financial statement issued at the beginning of the period, covering the year before, is relevant. The rating based on this statement will be causal for this period's investment decision, but not vice versa. Second, we will use the Arellano-Bond GMM first-difference procedure to minimize endogeneity problems.

Technically, we model the ORR variable as affecting the discount rate as a mark-up:

$$UC' = UC * (1 + g[ORR]), \qquad (4)$$

where g[.] is a decreasing linear function of the credit rating. Since UC enters the model in log differences, we transform (4) accordingly,

$$\Delta \log UC' = \Delta \log UC - \psi \Delta ORR, \qquad (5)$$

where $\psi > 0$. Since the user cost enters the model with a negative effect, we would anticipate that ΔORR would have a positive coefficient, indicating that investment increases with the credit rating. But there is one last identification problem, which is endemic to implicit investment models: As the ORR variable is a predictor of default, it might also concentrate important information regarding future profitability. If this information is relevant to the formation of expectations over and above the variables already contained in the equation, the ORR variable might have an effect that is independent of financing costs.

The results in Table 11 confirm the importance of credit rating for investment. Both of the sums of the lagged ΔORR are positive and statistically significant at the 1% level. We did not estimate the equation for the user cost variable UC3. That user cost variable contains average interest payments, which might vary with the default risk. As in our sample split, the results are consistent with the existence of a financial accelerator. Furthermore, to the extent that monetary policy can affect the credit rating of firms, the balance sheet effects of a monetary tightening go beyond the drain on cash flow.

8. Evaluating the Credit Channel

Looking back at 9a and 9b, it seems that the income effect is important for the influence of monetary policy on financially constrained firms. We want to assess the importance of this "income channel" for monetary policy, and compare it with the strength of the interest-rate channel. In order to do this, we will make the extreme assumption that the entire effect of cash flow, as shown in Table 8, is due to financial constraints. It might as well be argued that only the difference between the effects for favourably and unfavourably rated firms is of relevance here. As in the last section, we assume a transitory increase in nominal capital-market rates by 100 basis points, from a level of 7%. As before, the shock is being reversed after one year. The shock, however, will affect the firms' interest payments for more than one period, as all the credits which are due in the current period, the short-term as well as the long-term debts, have to be renewed on the new terms.

We account for this persistence by assuming that the time to maturity of long term debt (with a maturity of more than one year) is distributed evenly over the next five years, see Appendix D for details. An increase in market interest rates will raise the "apparent interest rate" in the following year, which is given by the ratio of total interest payments to debt. The effect on the cash flow capital ratio depends on the corporate profit tax and the degree to which the capital stock is financed through debt.

The columns (1), (2), (6) and (7) of Table 12 show this "income channel" of a change in interest rates. Again, the simulation is based on the coefficients of the preferred estimation, the first column of Table 8. Because of the persistence of the reaction of interest payments to changes in the market rate, the effects are distributed over a longer time period. In the first period, investment decreases by 0.34% of its baseline value, and in the following years, the effects peters out. The accumulated effects of the interest change on investment via the cash-flow channel are about 0.5%, which is but a small fraction of the first-period effect via the user-cost channel of 3.9%. At least the direct "income effect" of increased interest payments, therefore, does not seem to be of overwhelming importance.

But we have also seen evidence of a balance-sheet channel in the narrow sense, working through creditworthiness of firms. The size of the coefficient indicates that rating is of importance for capital accumulation, although not overwhelming so: a permanent increase in rating by one standard deviation would increase capital demand by 2.4% in the long run. Trimming the regression along the lines of Table 8 (not shown) will cut the size of the effect by half, although it remains significant at a 2% level. This indicates that restricting certain coefficients to zero might result in a missing variable bias in this regression, but it might also show that the size of the long-term effect of rating is less reliable than, e.g., the user-cost effect.

What remains to be done is to work out the effects of monetary policy on the rating of firms. Analysing the components of the ORR rating variable given in Section 3 and Appendix B, we see that at least three items should clearly be sensitive to interest-rate changes: return on equity, the capital-recovery rate and the net interest-payment ratio. A more thorough analysis encounters the difficulty that the coefficients of the individual balance sheet ratios within the ORR variable are confidential and may not be disclosed. But we hope to solve this problem using a direct estimation approach

9. Conclusions and Future Work

This paper has examined the monetary transmission channel in Germany with regard to business fixed investment with an extremely rich collection of data. We have been successful in uncovering statistically significant interest-rate and credit channels. The credit-channel hypothesis was tested using our direct measure of creditworthiness, first as a sorting criterion and then as a regressor in its own right. Whereas firms of poor credit standing show clear signs of being affected by credit constraints, small firms do not - the German financial system seems able to cope with informational asymmetries given by the small size of firms.

When evaluated in terms of economic significance, the interest-rate channel proves to be rather solid. An increase in nominal interest rates by 100 basis points for one year would lead to a drop of almost 4% in investment demand. The credit channel, on the other hand, does not seem to be of overwhelming importance, at least if it is evaluated using direct income effects only. However, there is more to the balance sheet channel than these direct effects: monetary policy has an influence on several of the balance-sheet ratios that are important for the rating of firms, and we have been able to show that firm rating is an important determinant of investment demand. With the *caveat* that these balance-sheet ratios might be important for the formation of expectations over and above cash flow, this proves the existence of a balance-sheet effect in the narrow sense. In future work, we will try to quantify this effect as well, thus giving an overall assessment of the effects of monetary policy on private fixed investment across all channels.

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Appendix A: Derivation of the Autoregressive Distributed Lag (ADL) Model

The model platform corresponds to that used recently by, among others, Bond, Elston, Mairesse and Mulkay (1997), Harhoff and Bond (1999), Chirinko, Fazzari and Meyer (1999), Mairesse, Hall and Mulkay (1999, 2001), von Kalckreuth (2000), Harhoff and Ramb (2000), as well as Bloom, Bond and van Reenen (2001). The point of departure is the static neoclassical equation for capital demand. Using a generalised CES production function, Eisner and Nadiri (1968) derive the following linear equation form the first- order conditions of profit maximisation:

$$\log K_t = \theta \log S_t - \sigma \log UCC_t + \log h_t \,, \tag{A1}$$

with $$\theta = \left(\sigma + \frac{1-\sigma}{\nu} \right) \text{ and } h_t = A_t^{\frac{\sigma-1}{\nu}} \cdot (\nu\alpha)^{\sigma} \,, \tag{A2}$$

where UCC is the user costs of capital, A_t is productivity and σ and ν are the elasticities of substitution and scale, respectively. The variable h_t depends on the time-varying terms A_t. The elasticity of capital to sales is unity ($\theta = 1$) if the production function has constant returns to scale ($\nu = 1$) or if its elasticity of substitution is unity ($\sigma = 1$), that is, in the Cobb-Douglas case. A log-linear demand equation can also be derived for the case of increasing returns to scale, $\nu > 1$. If the firm is rationed on the product market, it will have to solve a cost minimisation problem. Then we have $\theta = 1/\nu$ in (A2) and h_t will be a term that depends on relative factor prices and the CES parameters. From this static, log-linear capital demand equation, we can derive two well-known specifications, the First Difference Autoregressive Distributed Lag (ADL) equation, as well as the Error Correction Model (ECM). These are different dynamic parameterisations of the same demand structure, and the results can easily be compared.

The First Difference ADL

If the presence of a firm-specific *trend* in capital demand cannot be excluded, e.g. because the growth of A_t is firm-specific, it is helpful to first difference equation (A1):

$$\Delta \log K_t = \theta \Delta \log S_t - \sigma \Delta \log UCC_t + \Delta \log h_t \,. \tag{A3}$$

The first term, $\Delta \log K_t$, is approximately equal to $I_t / K_{t-1} - \delta$. The depreciation rate will be subsumed into the unobservable firm-specific latent variable in the estimation procedures below. The change in $\log h_t$ can be represented by time dummies in our regression equation, at least as far as global productivity shocks and changes in the user costs are concerned, and by individual constants in order to catch trends of the form $\phi_i t$ in the course of the firm's technological progress. Individual productivity shocks are confined to the error term of the equation.

We assume that the production possibilities are given by the capital stock at the beginning of the current period. Taking account of installation costs and short-run dynamics in the formation of expectations, we generalise the static capital-demand equation by using distributed lags:[22]

$$A(L)\Delta \log K_t = B(L)\theta\Delta \log S_t + C(L)\sigma\Delta \log UCC_t + \Delta \log h_t, \tag{A4}$$

$A(L), B(L), C(L)$ being polynomials in the lag operator, not necessarily of the same degree. With the additional constraints

$$\frac{B(1)}{A(1)} = 1 \qquad \text{and} \qquad \frac{C(1)}{A(1)} = 1, \tag{A5}$$

the long-run effects of changes in the level of sales or user costs are the same as in the static model A(1). Furthermore, contemporaneous and lagged real cash flow per unit of capital growth rates of cash flow may be added as further regressors to capture financial constraints and possible dynamics of expectation formation. As a behavioural equation to be estimated, we obtain for company *i*:

$$\frac{I_{i,t}}{K_{i,t-1}} = \sum_{l=0}^{L} \alpha_l \frac{I_{i,t-l}}{K_{i,t-l-1}} + \sum_{m=0}^{M} \beta_m \Delta \log S_{i,t-m} + \sum_{n=0}^{N} \gamma_n \Delta \log UC_{i,t-n} + \sum_{q=0}^{Q} \theta_q \frac{CF_{i,t-q}}{K_{i,t-q-1}} + u_{i,t} \tag{A6}$$

with $$u_{i,t} = \varphi_i + \lambda_t + \zeta_{i,t}\,. \tag{A7}$$

$CF_{i,t}$ represents cash flow, $K_{i,t-1}$ is the real capital stock carried over from the end of the last period and $u_{i,t}$ is a latent term. It is composed of a firm-specific constant φ_i that reflects depreciation and a possible trend in the capital-demand equation (A1), a time-specific shock λ_t equal for all firms, and finally an idiosyncratic transitory shock $\zeta_{i,t}$. In this quite general specification, the data are allowed to determine the adaptation dynamics. Consider now a one-period change for one of the explanatory variables, say $\Delta \log UCC_t$. The short-run effect of this change is given by

[22] In an unpublished memo, Bob Chirinko develops this equation by explicitely introducing delivery lags and adaptive expectations. However, as in all implicit models, the parameters belonging to the expectation formation mechanism are not separately identified.

$$\frac{d\Delta \log K_{i,t}}{d\Delta \log UCC_t} = \gamma_0 \,, \qquad \text{(A8)}$$

whereas the long-run effects are given by the sum of the effects of shocks in periods $t, t-1, t-2, \ldots$

$$\sum_{i=0}^{\infty} \frac{d\Delta \log K_i}{d\Delta \log UCC_t} \Big|_{\Delta \log UCC_{t+t} = \Delta \log UCC_{t+2} = \ldots = 0} = \frac{\gamma_0 + \gamma_1 + \ldots + \gamma_N}{1 - \alpha_1 - \alpha_2 - \ldots - \alpha_L} \,, \qquad \text{(A9)}$$

if the equation is stable, and in an analogous fashion for the sales and for the cash-flow effects.[23] As the long-term elasticities are non-linear functions of the parameters, the standard deviations may be computed using the delta method. It is important to note that a *permanent* change in the *level* of the user-cost or sales variable translates into a one-off increase in the respective growth rate, $\Delta \log UCC_t$ and $\Delta \log S_t$, as described above.

The Error-Correction Model (ECM)[24]

If we choose to ignore a possible firm-specific trend in A_t, we can depart from equation (A1) directly, without prior differencing. Again, using a dynamic generalisation by adding lags on both sides, one obtains:

$$A(L) \log K_t = B(L) \log S_t + C(L) \log UCC_t + \log h_t \,, \qquad \text{(A10)}$$

with $A(L), B(L), C(L)$ being polynomials in the lag operator. For a lag length of two,this leads to

$$\log K_{i,t} = \alpha_1 \log K_{i,t-1} + \alpha_2 \log K_{i,t-2} + \beta_0 \log S_{i,t} + \beta_1 \log S_{i,t-1} + \beta_2 \log S_{i,t-2} +$$

$$+ \gamma_0 \log UCC_{i,t} + \gamma_1 \log UCC_{i,t-1} + \gamma_2 \log UCC_{i,t-2} + u_{i,t} \,, \qquad \text{(A11)}$$

again with $u_{i,t} = \alpha_i + \lambda_t + \zeta_{i,t}$. Subtracting lagged endogenous variables on both sides, using the approximation $\Delta \log K_{i,t} \approx \frac{I_{i,t}}{K_{i,t}} - \delta_i$, as well as substituting the identities:

$$\beta_0 \log S_{i,t} + \beta_1 \log S_{i,t-1} + \beta_2 \log S_{i,t-1}$$

$$= \beta_0 \Delta \log S_{i,t} + (\beta_0 + \beta_1) \Delta \log S_{i,t} + (\beta_0 + \beta_1 + \beta_2) \log S_{i,t-2} \qquad \text{(A12)}$$

and

[23] See, for example, Hamilton (1994), esp. Sections 2.4 and 3.5.
[24] I thank Steve Bond for a thorough introduction into the analytics of the ECM.

$$\gamma_0 \log UCC_{i,t} + \gamma_1 \log UCC_{i,t-1} + \gamma_2 \log UCC_{i,t-2}$$
$$= \gamma_0 \Delta \log UCC_{i,t} + (\gamma_0 + \gamma_1) \Delta \log UCC_{i,t-1} + (\gamma_0 + \gamma_1 + \gamma_2) \log UCC_{i,t-2} \;, \quad \text{(A13)}$$

we obtain the **standard ECM specification** for a model with two lags:

$$\frac{I_{i,t}}{K_{i,t-1}} = (\alpha_1 - 1)\frac{I_{i,t-1}}{K_{i,t-2}} + (\alpha_2 + \alpha_1 - 1)\log K_{i,t-2} +$$
$$+ \beta_0 \Delta \log S_{i,t} + (\beta_0 + \beta_1)\Delta \log S_{i,t-1} + (\beta_0 + \beta_1 + \beta_2)\log S_{i,t-2} +$$
$$+ \gamma_0 \Delta \log UCC_{i,t} + (\gamma_0 + \gamma_1)\Delta \log UCC_{i,t-1} + (\gamma_0 + \gamma_1 + \gamma_2)\log UCC_{i,t-2} + u_{i,t} \,. \quad \text{(A14)}$$

Using more lags will move the position of the level terms further backward. This specification was invented by Charles Bean (1981), and it was introduced to the micro investment literature by Bond, Elston, Mairesse and Mulkay (1997). The long-run properties are similar to the accelerator framework. As a long-run elasticity of the capital stock with regard to user costs, one obtains:

$$\left.\frac{d \log \overline{K}}{d \log UCC}\right|_{UCC_t = UCC_{t+1} = \ldots = UCC} = \frac{\gamma_0 + \gamma_1 + \gamma_2}{1 - \alpha_1 - \alpha_2} \,. \quad \text{(A15)}$$

Here, too, the long-run elasticities are non-linear functions of the parameter. Note that the numerator and denominator of this expression are given by the coefficients of the level terms. By rewriting the equation, this identity offers a possibility of neatly separating short-run and long-run dynamics:

$$\Delta \frac{I_t}{K_{i,t-1}} = (\alpha_1 - 1)\frac{I_{i,t-1}}{K_{i,t-2}}$$
$$+ \beta_0 \Delta \log S_{i,t} + (\beta_0 + \beta_1)\Delta \log S_{i,t-1} + \gamma_0 \Delta \log UCC_{i,t} + (\gamma_0 + \gamma_1)_1 \Delta \log UCC_{i,t-1}$$
$$+ (\alpha_1 + \alpha_2 - 1)\left\{\log K_{i,t-2} - \frac{\beta_2 + \beta_1 + \beta_0}{1 - \alpha_1 - \alpha_2} + \log S_{i,t-2} \frac{\gamma_2 + \gamma_1 + \gamma_0}{1 - \alpha_1 - \alpha_2} \log UCC_{i,t-2}\right\} + u_{i,t} \quad \text{(A16)}$$

The first term in the third line is the error-correction coefficient; it ought to be negative. The term in curly brackets ought to be zero in the long run for the long-term relationship between capital, user costs and sales to hold. The ECM model uses both levels and first differences for estimation and instrumentation; with regard to the analytical interpretation, however, it concentrates on the equilibrium relationship between levels of capital, sales and user costs. As in the First Difference ADL, we may add cash-flow terms in order to capture short-run dynamics.

Appendix B: Variable Definition and Outlier Control

Regression Variables

Investment (I): Additions to plant, property and equipment come from the detailed schedule of fixed asset movements (*Anlagenspiegel*). The schedule also includes their value at historical costs. Not all firms show their investment data in the *Anlagenspiegel*, and, furthermore, missing investment data and zero investment are coded by the same symbol in the raw data. An extremely cautious procedure was chosen to impute a zero value only in cases where this is logically inevitable, in all other cases the variable is coded as missing.

Capital Stock (K) is computed by adjusting the value of fixed assets at historical costs taken from the *Anlagenspiegel* for inflation and depreciation during the previous years, and by applying a perpetual inventory procedure with a sector specific depreciation rate for all years following the first year for which historic cost data and investment data are available:

$$P^{I}_{j,t} K_t = (1-\delta_j) P^{I}_{j,t-1} K_{t-1} \left(\frac{P^{I}_{j,t}}{P^{I}_{j,t-1}} \right) + P^{I}_{j,t} I_t \ , \qquad \text{(B1)}$$

where $P^{I}_{j,t}$ is a sector specific price of investment goods, I_t is real investment and δ_j the sector-specific depreciation rate.

Real Sales (S): Sales, deflated by a sector-specific index for output prices.

User Costs of Capital (UC): see Appendix C.

Cash Flow (CF): Net income plus depreciation, deflated by a sector-specific index for output prices.

Overall Rating Ratio (ORR): A discriminant analysis procedure separates firms with a high a priori risk of default from those with a low risk, also see Section 3.3. Firms are placed in one of three categories of creditworthiness: "good credit standing", "indifferent credit standing" and "endangered credit standing". Individual ratios for calculating discriminant functions in the manufacturing sector include:

- equity/pension-provision ratio (adjusted equity capital and pension provisions as a percentage of adjusted balance-sheet total);
- return on total capital employed (Profit/loss before taxes on income and before interest payments as a percentage of adjusted balance-sheet total;
- return on equity (Profit/loss before taxes on income as percentage of adjusted equity);
- capital recovery rate (Net receipts/net expenditures as percentage of capital invested);

- net interest payment ratio (Net interest result as percentage of turnover/total output);
- accounting practice.

Here, balance sheet total and equity are adjusted by subtracting items like subscribed capital unpaid, goodwill, credits to proprietors and partners, formation expenses. "Net receipts" is an elaborate measure for cash flow, not equal to the simpler one used in estimation. It is profit plus depreciation, augmented by changes of items like provisions for taxes, other short term provisions, pension provisions and other long term provisions, payments received on account of orders, less items like increases of stocks of finished goods. Capital invested is adjusted balance sheet total less liquid financial assets.

The overall rating ratio takes on values between -99.9 and 99.9. It is a weighted sum of the individual ratios. The weights are determined by the discriminant analysis procedure, as well as the cut-off points c_l, c_u for a grouping of creditworthiness:

$-99.0 < ORR < c_l$ ⟶ endangered credit standing

$c_l \leq ORR < c_u$ ⟶ indifferent credit standing

$c_u \leq ORR < 99.9$ ⟶ good credit standing

For the use of our study, the overall rating ratios have been transformed so that they vary between 0 and 1, approximately in line with the other variables entering the regression.

Outlier control

Observations with missing values for sales, capital, investment, cash flow or the overall rating ratio were excluded. The presence of the overall rating ratio serves as a check that the EU harmonisation guidelines were being followed.

The data set is trimmed by excluding the upper and the lower 1-% percentiles of $\Delta \log S$, CF_t / K_{t-1} and the overall rating ratio ORR_t, as well as the two upper 1% percentiles of I_t / K_{t-1}. Additionally, in the constructing the sample for the estimations with the user costs based on apparent interest rates, the upper and the lower 1-% percentile of the apparent interest rate and of $\Delta \log UC$ are excluded.

Appendix C: The Construction of User Costs of Capital for Germany[25]

The Jorgensonian user costs of capital are given by

[25] The user cost of capital for our sample has been constructed on the basis of the computer routines provided by Fred Ramb, who also allowed us to use his tax and depreciation data. Fred's help was crucial and decisive. As we made several changes, however, he has no responsibility for any mistakes we made.

$$UC = \frac{p^I}{p} \frac{(1-A)(\rho - \pi^I + \delta^e)}{(1-\tau)} \qquad \text{(C1)}$$

The derivation can be found, e.g., in Auerbach (1983). Here, p is the output-price level and p^I is the price of investment goods. A is the present value of depreciation allowances, δ^e is the economic depreciation rate and π^I is the expected rate of investment-goods price inflation. τ is the basic corporate tax rate, the rate of tax paid if no profits are distributed.

King-Fullerton-type user costs

A general expression for the discount rate ρ in the presence of distortionary taxes and income taxation at the level of the individual investor has been derived by King (1977) and King and Fullerton (1984), also see OECD (1991) or Chenells and Griffith (1997). If we distinguish as *sources of finance* between *retained earnings, r, new debt, d,* and *new capital*, *n*, the respective discount rates are given by

$$\rho = \begin{cases} i \cdot (1-\tau) & \text{for debt finance, d} \\ i/\theta & \text{for new shares issues, n} \\ i \cdot \dfrac{1-m}{1-z} & \text{for retained earnings, r} \end{cases} \qquad \text{(C2)}$$

In this expression, the variable θ measures the degree of discrimination between retentions and distributions. It is the opportunity costs of retained earnings in terms of gross dividends forgone; i.e. it equals the additional dividend shareholders would receive if one unit of post-corporate tax earnings were distributed. Furthermore, *i* is the nominal interest rate, and *m* is the marginal personal tax rate on capital income for the representative shareholder. Finally, *z* is the effective tax rate on accrued capital gains.

Between 1977 and 2000, the system of capital-income taxation operating in Germany was a split-rate system with full imputation. The shareholder – provided that he was a resident of the Federal Republic – received a tax credit in the amount of the corporation tax on distributed profits paid. Ultimately, the tax on capital income on distributed profits was equal to the marginal tax on capital income. For Germany, therefore, the variable θ assumes the value $1/(1-\tau)$. Furthermore, the effective tax rate on accrued capital gains was zero, as capital gains were not taxed after a holding period of one year or more.

Taking this into account, the expression for the discount rate reduces to

$$\rho = \begin{cases} i \cdot (1-\tau) & \text{for debt finance, d} \\ i \cdot (1-\tau) & \text{for new shares issued, n} \\ i \cdot (1-m) & \text{for retained earnings, r} \end{cases} \tag{C3}$$

In a system with full imputation, the two types of outside finance are equivalent, see Sinn (1984) and especially Sinn (1985).

Implementing this empirically, we use sector-specific output price levels $p_{j,t}$ and depreciation rates $\delta_{j,t}$. The price of capital goods p_t^I is an economy-wide deflator referring to the beginning of the year, the inflation rate π_t^I measures the rate of growth of p_t^I in the time between the beginning and the end of year *t*. $A_{i,t}$ is the present value of depreciation allowances as a firm-specific weighted average for three different types of assets: buildings, machinery and equipment. In each case, finance-specific discount rates were used. The interest rate, i_t, is the average yield on industrial bonds outstanding issued by residents.[26] The tax rate on retained earnings was calculated as a compound tax combining three different taxes of profits: the basic corporate tax on retained earnings, τ_t^r, the *Gewerbesteuer*, g_t, which is deductible for corporate tax purposes, and the "solidarity surcharge" s_t, which is levied on all corporate tax payments and all personal income taxes:

$$\tau_t = (1+s_t)\cdot \tau_t^r (1-g_t) + g_t \tag{C4}$$

Like King and Fullerton, we treat the *Gewerbesteuer* as a normal tax on profits, ignoring some of its special features.[27] As a marginal tax rate for the shareholder, we used the highest marginal income tax $m_t^{\max}$, again inflated by the solidarity surcharge:

$$m_t = (1+s_t) m_t^{\max} \tag{C5}$$

For the different user-cost expressions resulting for the different types of finance, we experiment with two different weighting schemes. A *stock-weighting scheme*, leading to our variable UC(2), identifies share finance with the stock of subscribed capital (augmented by share premium or paid-in surplus), retained earnings with the earned surplus, including the share of own funds in the reserves subject to future taxation, debt finance with total liabilities, including the share of borrowed funds in the reserves subject to future taxation.

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[26] See Deutsche Bundesbank, Monthly Report, Statistical Annex, several issues.

[27] Interest payments are only partly deductible, and the *Gewerbesteuer* payments are not credited to the shareholders on distribution. The latter, strictly speaking, destroys the basic equivalence between sources of outside finance. Ultimately, the *Gewerbesteuer* is raised at the community level, displaying a lot of local variation. Due to data limitation, however, we have to confine ourselves to the mean *Gewerbesteuer* rate for the whole sample.

A *flow-weighting scheme* uses as sources of finance the first differences of the above-mentioned stocks. For *increases* of shares issued, retained earnings debt, the corresponding weight is calculated as the ratio to the sum of *positive* sources of new finance in the year. If the respective first difference assumes a negative value, its weight is set at zero. For the first year, the respective stock weights are used. This is how UC(1) is calculated.

An alternative formulation using "apparent interest rates"

As an alternative, and in order to be compatible with similar studies for other European countries performed within the Monetary Transmission Network of the Eurosystem, we construct a user-cost variable that relies less on tax changes, but uses firm-specific variation of the "apparent interest rate" $r_{,t}$ instead, the ratio between total interest payments and outstanding debts, excluding interest-free credits. Apparent interest rates have the econometric advantage of providing a lot of firm-specific variation in a rather simple way. A large part of this variation, however, is spurious: the apparent interest rate of a firm in a given year is a weighted average of past interest rates, with the weights being given by the current composition of debt. Furthermore, apparent interest rates do not reflect pure costs of finance, but also vary according to firm-specific default risk. Used in estimation, the variable might therefore mix up these two different classes of underlying determinants of investment spending. Finally, interest payments are a drain on liquidity and might pick up effects that really belong to cash flow. This may result in the cash-flow coefficient being too low or the user-cost coefficient being too high.

Let $E_{i,t}/(E_{i,t}+D_{i,t})$ be the stock share of total equity finance (consisting of retained earnings plus subscribed capital), and $D_{i,t}/(E_{i,t}+D_{i,t})$ the share of debt finance. Then a weighted average

$$J_{i,t}=\frac{p_t^I}{p_t(1-\tau_t)}\left[\frac{E_{i,t}}{E_{i,t}+D_{i,t}}\left(1-A_{i,t}^E\right)\left(\rho_{i,t}^E+\pi_t^I+\delta_{j,t}\right)+\frac{D_{i,t}}{E_{i,t}+D_{i,t}}\left(1-A_{i,t}^D\right)\left(\rho_t^D+\pi_t^I+\delta_{j,t}\right)\right] \quad \text{(C6)}$$

is calculated, with discount rates $\rho_{i,t}^E=i_{i,t}$ for equity finance and $\rho_t^D=r_t(1-\tau_t)$ for debt finance. Again, present values of depreciation allowances, $A_{i,t}^E$ and $A_{i,t}^D$ are constructed using the respective finance-specific discount rates. See Chatelain, Generale, Hernando, von Kalckreuth and Vermeulen (2001) for further details.

Appendix D: Gauging the Effects of Monetary Policy

In order to relate monetary policy to investment demand, we have to specify the link between the explanatory variables of our investment function and the nominal capital-market interest rates.

Interest Changes and User Costs

The impact of interest-rate changes on the user costs of capital can be calculated from their definition, given in Appendix B. For purposes of monetary policy analysis, we regard the present value of the depreciation allowances *A* as fiscal policy parameters which are fixed independently of the central bank, just like corporate tax rates τ. For the two King-Fullerton-type user costs *UC(1)* and *UC(2)*, this leads to a time and firm-specific derivative, $\partial UC/\partial i$. As investment demand depends on log *UC*, we have to convert this expression into a semi-elasticity. The overall mean of this semi-elasticity for *UC(1)* in our ADL(3) sample is given by 3.383, corresponding to an elasticity of the user costs with respect to nominal interest-rate changes of almost exactly 0.25.

Interest Changes and Cash Flow

Rising interest rates lead to higher payments on debts and to lower cash flows for the firms. The effect of nominal interest-rate changes can be calculated from the definition of cash flow, but we need to make an assumption on the maturity structure of the outstanding debt. We can write nominal cash flow CF_t^n in the following way:

$$CF_t^n = (1-\tau)(sales - costs - \text{interest payments}) + depr. \tag{D1}$$

Here, "costs" is obviously all costs apart from interest payments. Writing

$$\text{interest payments} \equiv \text{debt} \cdot \; i^a \tag{D2}$$

we define the apparent interest rate i^a as *the average interest payments for credits of all maturities.* The derivative of cash flow with respect to the apparent interest rate is simply:

$$\frac{\partial CF_t^n}{\partial i_t^a} = (1-\tau) debt_t \tag{D3}$$

As we are looking for the effect of interest-rate changes on the real cash flow capital ratio, we use the following transformation:

$$\frac{\partial (CF_t / K_{t-1})}{\partial i_t^a} = \frac{\partial CF_t^n / \partial i^a}{CF_t^n} \frac{CF_t}{K_{t-1}} \tag{D4}$$

For this expression, we obtain a mean value of 0.855 in the sample used for our preferred estimate. As can easily be seen, the apparent interest rate is a distributed lag of prior market-interest rates:

$$i^a = \sum a_h i_{t-h} \,, \tag{D5}$$

with the a_h being weights for debt of different age as a percentage of total debt. From the UBS data base, one can estimate that 76.3% of the liabilities in the manufacturing sector have a maturity of less than one year in 1996. We will assume that the age profile (maturity structure) of firm debt is constant over time and that time to maturity of the remaining 23.7% of liability is distributed evenly over the next five years.[28] For the effect of interest rate changes on future cash flow over capital ratios, we can then use the approximation

$$\frac{\partial \left(CF_{t+h} / K_{t-1+h} \right)}{\partial i_t} \approx a_h \frac{\partial \left(CF_t / K_{t-1} \right)}{\partial i_t^a} \,, \tag{D6}$$

which is exact if CF_t / K_{t-1} is also constant over time.

[28] See Deutsche Bundesbank (1999). As the percentage of liabilities with a maturity of more than one year is rather low, our results are robust with respect to assumptions concerning the maturity structure. The cumulated effect on capital demand does not depend on the maturity structure at all; it merely serves to distribute the total effect over time.

Table 1: Summary Statistics for the Overall Sample

Variable	Mean	Std. Dev.	Min.	25%	Median	75%	Max.
I_t / K_{t-1}	0.1813	0.2200	0	0.0585	0.1161	0.2157	2.2139
$\Delta \log S_t$	0.0206	0.1597	-0.5960	-0.0654	0.0214	0.1068	0.8309
CF_t / K_{t-1}	0.2843	0.4941	-1.9143	0.1091	0.1887	0.3308	9.2678
$\Delta \log UC(1)_t$	0.0222	0.0717	-0.3478	-0.0178	0.0094	0.0644	0.4991
$UC(1)_t$	0.1587	0.0182	0.0859	0.1468	0.1583	0.1704	0.2682
$\Delta \log UC(2)_t$	0.0233	0.0668	-0.3328	-0.0147	0.0089	0.0711	0.4516
$UC(2)_t$	0.1575	0.0180	0.0852	0.1461	0.1572	0.1694	0.2627
$\Delta \log UC(3)_t$	0.0248	0.1101	-0.3558	-0.0436	0.0246	0.0912	0.4222
$UC(3)_t$	0.1575	0.0285	0.0763	0.137	0.1558	0.1758	0.3242
ΔORR_t	0.0004	0.0430	-0.3515	-0.0210	0.0005	0.0220	0.4905
ORR_t	0.5737	0.0619	0.3655	0.5355	0.5735	0.6150	0.7390

The sample used includes 44,345 observations from 6,408 firms and is the same as used to estimate the ADL(3) model with UC(2) and UC(2) discussed in Section IV. For the variable UC(3), the number of observations is only 40,362 from 5,876 firms, because of additional data cleaning with respect to this variable. See Section III and Appendices A, B, C for more details about the data set.

Table 2: Sample Composition and Means

Variable	"small"	"large"	bad rating	indet. rating	good rating
Number of firms	3053	3355	1131	893	4384
Number of obs.	20452	23893	7489	6029	30827
I_t/K_{t-1}	0.1981	0.1669	0.1776	0.1891	0.1806
$\Delta \log S_t$	0.0232	0.0184	0.0111	0.0265	0.0218
CF_t/K_{t-1}	0.3253	0.2492	0.1563	0.2262	0.3267
$\Delta \log UC(1)_t$	0.0229	0.0216	0.0217	0.0228	0.0222
$UC(1)_t$	0.1559	0.1611	0.1584	0.1579	0.1589
$\Delta \log UC(2)_t$	0.0241	0.0226	0.0232	0.0240	0.0232
$UC(2)_t$	0.1547	0.1599	0.1573	0.1568	0.1577
$\Delta \log UC(3)_t$	0.0275	0.0224	0.0306	0.0300	0.0222
$UC(3)_t$	0.1530	0.1614	0.1548	0.1548	0.1587
ΔORR_t	-0.0002	0.0009	-0.0005	-0.0001	0.0007
ORR_t	0.5643	0.5818	0.5147	0.5399	0.5946

Table 3: Cross Tabulation of Groups

	bad rating	indet. rating	good rating
"small" firms	646	472	1935
"large" firms	485	421	2449

The sample used includes 44,345 observations from 6,408 firms and is the same as used to estimate the ADL(3) model with UC(2) and UC(2) discussed in Section IV. For the variable UC(3), the number of observations is only 40,362 from 5,876 firms, because of additional data cleaning with respect to this variable. See Section III and Appendices A, B, C for more details about the data set.

Table 4: Size Distribution of Firms and Observations by Mean Employment

	n < 20	20<n≤100	100<n≤250	250<n<500	n>500	Sum
No. of firms	616	2437	1626	828	901	6408
	9.61%	38.03%	25.37%	12.92 %	14.06 %	100%
No. of obs.	3989	16463	11372	5936	6589	44345
	9.00%	37.12%	25.64%	13.39%	14.85%	100%

The mean and median numbers of employees in the sample for the ADL(3) discussed in Section IV are 405 and 119, respectively. The sample used includes 44,345 observations from 6,408 firms and is the same as used to estimate the ADL(3) model with UC(2) and UC(2) discussed in Section IV. See Section III and Appendices A, B, C for more details about the data set.

Table 5: Variants of the Baseline Model

Model		ADL(2)	ADL(3)	ADL(4)
	long-run UC elasticity	-0.445**	-0.401**	-0.320
	(standard deviation)	(0.106)	(0.144)	(0.227)
UC(1)	Sargan-Hansen test, p-value	0.016	0.075	0.009
	LM(2), p-value	0.010	0.165	0.885
	# observations	27195	18713	12305
	(# firms)	(8482)	(6408)	(4735)
	long-run UC elasticity	-0.488**	-0.392**	-0.531**
	(standard deviation)	(0.106)	(0.146)	(0.227)
UC(2)	Sargan-Hansen test, p-value	0.004	0.047	0.010
	LM(2), p-value	0.009	0.116	0.871
	# observations	27195	18713	12305
	(# firms)	(8482)	(6408)	(4735)
	long-run UC elasticity	-0.187	-0.521**	-0.390
	(standard deviation)	(0.108)	(0.148)	(0.205)
UC(3)	Sargan-Hansen test, p-value	0.016	0.288	0.110
	LM(2), p-value	0.013	0.038	0.785
	# observations	24781	16858	10982
	(# firms)	(7923)	(5876	(4282)

Additional regressors: lags of cash flow capital ratio, sales growth, constant, and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta logS_{i,t-m}$, $\Delta logUC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effect of UC is to be interpreted as a long-run elasticity of capital demand, it is defined as the sum of the UC coefficients divided by one minus the sum of the coefficients on the lagged dependent variables, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 6: ADL(3) Models of Investment Demand
GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

Explanatory Variable	UC(1)	UC(2)	UC(3)
$I_{i,t-1}/K_{i,t-2}$	0.131 (0.016)**	0.123 (0.016)**	0.124 (0.017)**
$I_{i,t-2}/K_{i,t-3}$	-0.002 (0.009)	-0.005 (0.009)	0.002 (0.009)
$I_{i,t-3}/K_{i,t-4}$	0.005 (0.007)	0.003 (0.007)	0.005 (0.007)
$\Sigma I_{i,t-n}/K_{i,t-n-1}$	**0.135 (0.025)****	**0.122 (0.025)****	**0.131 (0.026)****
$\Delta\log S_{i,t}$	0.161 (0.055)**	0.185 (0.056)**	0.142 (0.054)**
$\Delta\log S_{i,t-1}$	0.095 (0.014)**	0.091 (0.014)**	0.097 (0.014)**
$\Delta\log S_{i,t-2}$	0.065 (0.011)**	0.061 (0.011)**	0.061 (0.011)**
$\Delta\log S_{i,t-3}$	0.033 (0.010)**	0.032 (0.010)**	0.036 (0.010)**
$\Sigma \Delta \log S_{i,t-n}$	**0.354 (0.068)****	**0.369 (0.069)****	**0.338 (0.068)****
long-run eff. sales	**0.409 (0.077)****	**0.420 (0.076)****	**0.387 (0.077)****
$\Delta\log UC_{i,t}$	-0.206 (0.071)**	-0.239 (0.067)**	-0.220 (0.080)**
$\Delta\log UC_{i,t-1}$	-0.163 (0.038)**	-0.164 (0.040)**	-0.151 (0.028)**
$\Delta\log UC_{i,t-2}$	-0.014 (0.034)**	0.007 (0.038)	-0.060 (0.020)**
$\Delta\log UC_{i,t-3}$	0.038 (0.027)	0.051 (0.031)	-0.021 (0.015)
$\Sigma \Delta \log UC_{i,t-n}$	**-0.347 (0.125)****	**-0.344 (0.128)****	**-0.452 (0.124)****
long-run eff. user cost	**-0.401 (0.144)****	**-0.392 (0.146)****	**-0.521 (0.148)****
$CF_{i,t}/K_{i,t-1}$	0.070 (0.034)*	0.066 (0.034)	0.043 (0.036)
$CF_{i,t-1}/K_{i,t-2}$	0.013 (0.014)	0.015 (0.014)	0.011 (0.012)
$CF_{i,t-2}/K_{i,t-3}$	0.005 (0.005)	0.007 (0.005)	0.011 (0.006)
$CF_{i,t-3}/K_{i,t-4}$	0.005 (0.004)	0.005 (0.004)	0.004 (0.005)
$\Sigma CF_{i,t-n}/K_{i,t-n-1}$	**0.093 (0.025)****	**0.093 (0.024)****	**0.069 (0.027)***
long-run eff. cash flow	**0.108 (0.029)****	**0.106 (0.028)****	**0.079 (0.031)***
No. obs.	18713	18713	16858
No. firms	6408	6408	5876
Sargan-Hansen, p-value	0.075	0.047	0.288
LM(2), p-value	0.165	0.116	0.038

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta\log S_{i,t-m}$, $\Delta\log UC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 7: ADL(3) Models of Investment Demand
GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

Explanatory Variable	UC(1)	UC(2)	UC(3)
$I_{I,t-1}/K_{i,t-2}$	0.148 (0.016)**	0.143 (0.016)**	0.142 (0.017)**
$I_{I,t-2}/K_{i,t-3}$	0.005 (0.009)	0.003 (0.009)	0.010 (0.009)
$I_{I,t-3}/K_{i,t-4}$	0.009 (0.007)	0.008 (0.007)	0.008 (0.007)
$\Sigma\ I_{i,t-n}/K_{i,t-n-1}$	**0.163 (0.025)****	**0.154 (0.025)****	**0.160 (0.026)****
$\Delta\log S_{i,t}$	0.191 (0.055)**	0.213 (0.055)**	0.162 (0.053)**
$\Delta\log S_{i,t-1}$	0.115 (0.013)**	0.109 (0.013)**	0.106 (0.013)**
$\Delta\log S_{i,t-2}$	0.080 (0.011)**	0.076 (0.011)**	0.069 (0.011)**
$\Delta\log S_{i,t-3}$	0.041 (0.010)**	0.040 (0.010)**	0.042 (0.010)**
$\Sigma\ \Delta\log S_{i,t-n}$	**0.427 (0.064)****	**0.439 (0.064)****	**0.379 (0.062)****
long-run eff. sales	**0.510 (0.076)****	**0.518 (0.075)****	**0.452 (0.073)****
$\Delta\log UC_{i,t}$	-0.232 (0.073)**	-0.279 (0.068)**	-0.286 (0.089)**
$\Delta\log UC_{i,t-1}$	-0.190 (0.039)**	-0.190 (0.040)**	-0.170 (0.029)**
$\Delta\log UC_{i,t-2}$	-0.037 (0.034)	-0.021 (0.039)	-0.072 (0.021)**
$\Delta\log UC_{i,t-3}$	0.022 (0.028)	0.0354 (0.032)	-0.029 (0.015)
$\Sigma\ \Delta\log UC_{i,t-n}$	**-0.437 (0.126)****	**-0.455 (0.130)****	**-0.557 (0.134)****
long-run eff. user cost	**-0.522 (0.151)****	**-0.538 (0.153)****	**-0.663 (0.167)****
No. obs.	18713	18713	16858
No. firms	6408	6408	5876
Sargan-Hansen, p-value	0.048	0.032	0.289
LM(2), p-value	p=0.240	p=0.194	p=0.042

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. All of the cash-flow coefficients are set to zero. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta\log S_{i,t-m}$, $\Delta\log UC_{i,t-m}$, for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 8: ADL(3) Models of Investment Demand
GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

Trimmed Equation

Explanatory Variable	UC(1)	UC(2)	UC(3)
$I_{i,t-1}/K_{i,t-2}$	0.136 (0.014)**	0.131 (0.014)**	0.119 (0.015)**
$I_{i,t-2}/K_{i,t-3}$			
$I_{i,t-3}/K_{i,t-4}$			
Σ $I_{i,t-n}/K_{i,t-n-1}$	**0.136 (0.014)****	**0.131 (0.014)****	**0.119 (0.015)****
$\Delta\log S_{i,t}$	0.141 (0.052)**	0.158 (0.053)**	0.139 (0.053)**
$\Delta\log S_{i,t-1}$	0.090 (0.014)**	0.087 (0.014)**	0.097 (0.014)**
$\Delta\log S_{i,t-2}$	0.062 (0.011)**	0.059 (0.011)**	0.062 (0.011)**
$\Delta\log S_{i,t-3}$	0.034 (0.009)**	0.034 (0.009)**	0.038 (0.010)**
$\Sigma\ \Delta\log S_{i,t-n}$	**0.328 (0.065)****	**0.338 (0.065)****	**0.337 (0.067)****
long-run eff. sales	**0.380 (0.075)****	**0.389 (0.074)****	**0.382 (0.075)****
$\Delta\log UC_{i,t}$	-0.209 (0.069)**	-0.251 (0.065)**	-0.166 (0.074)**
$\Delta\log UC_{i,t-1}$	-0.167 (0.031)**	-0.187 (0.034)**	-0.126 (0.023)**
$\Delta\log UC_{i,t-2}$			-0.040 (0.015)**
$\Delta\log UC_{i,t-3}$			
$\Sigma\ \Delta\log UC_{i,t-n}$	**-0.376 (0.088)****	**-0.438 (0.085)****	**-0.332 (0.099)****
long-run eff. user cost	**-0.435 (0.103)****	**-0.504 (0.098)****	**-0.378 (0.114)****
$CF_{i,t}/K_{i,t-1}$	0.094 (0.024)**	0.092 (0.023)**	0.051 (0.035)
$CF_{i,t-1}/K_{i,t-2}$			0.010 (0.012)
$CF_{i,t-2}/K_{i,t-3}$			0.011 (0.006)
$CF_{i,t-3}/K_{i,t-4}$			
$\Sigma\ CF_{i,t-n}/K_{i,t-n-1}$	**0.094 (0.024)****	**0.092 (0.023)****	**0.072 (0.026)****
long-run eff. cash flow	**0.109 (0.027)****	**0.106 (0.027)****	**0.082 (0.030)****
No. obs.	18713	18713	16858
No. firms	6408	6408	5876
Sargan-Hansen, p-value	110.5 (p=0.092)	113.0 (p=0.068)	94.99 (p=0.312)
LM(2), p-value	0.118	0.070	0.030

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Those coefficients for the ADL(3) in Table 4 with p-values greater than or equal to 0.10 are set to zero. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta\log S_{i,t-m}$, $\Delta\log UC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 9a : ADL(3) Models of Investment Demand GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

Trimmed equation: Long-run effects of sales, user costs and cash flow for creditworthy and non-creditworthy firms

Explanatory Variable	UC(1)	UC(2)	UC(3)
Δlog S high ORR	0.467 (0.083)**	0.459 (0.082)**	0.456 (0.079)**
Diff. low - high ORR	-0.363 (0.126)**	-0.264 (0.124)*	-0.275 (0.128)*
Δlog $UC_{i,}$ high ORR	-0.524 (0.115)**	-0.576 (0.109)**	-0.520 (0.127)**
Diff. low - high ORR	0.470 (0.225)*	0.370 (0.213)	0.472 (0.215)*
CF/K high ORR	0.086 (0.026)**	0.085 (0.026)**	0.072 (0.028)**
Diff. low - high ORR	0.089 (0.042)*	0.069 (0.041)	0.069 (0.071)
No. obs.	16256	16256	14566
No. firms	5515	5515	5033
Sargan-Hansen, p-value	0.326	0.345	0.744
LM(2), p-value	0.042	0.026	0.014

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Those coefficients for the ADL(3) in Table 6 with p-values greater than or equal to 0.10 are set to zero. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta logS_{i,t-m}$, $\Delta logUC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 9b : ADL(3) Models of Investment Demand GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

Untrimmed equation: Long-run effects of sales, user costs and cash flow for creditworthy and not creditworthy firms

Explanatory Variable	UC(1)	UC(2)	UC(3)
Δlog S high ORR	0.478 (0.085)**	0.469 (0.084)**	0.442 (0.079)**
Diff. low - high ORR	-0.322 (0.130)*	-0.230 (0.126)	-0.255 (0.136)
Δlog $UC_{i,}$ high ORR	-0.608 (0.157)**	-0.557 (0.160)**	-0.679 (0.156)**
Diff. low - high ORR	0.419 (0.323)	0.309 (0.321)	0.340 (0.278)*
CF/K high ORR	0.092 (0.029)**	0.095 (0.029)**	0.074 (0.028)**
Diff. low - high ORR	0.089 (0.049)	0.062 (0.047)	0.129 (0.062)*
No. obs.	16256	16256	14556
No. firms	5515	5515	5033
Sargan-Hansen, p-value	0.239	0.257	0.787
LM(2), p-value	0.132	0.097	0.041

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta logS_{i,t-m}$, $\Delta logUC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 10a : ADL(3) Models of Investment Demand GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

Trimmed equation: Long-run effects of sales, user costs and cash flow for small firms and for large firms

Explanatory Variable	**UC(1)**	**UC(2)**	**UC(3)**
Δlog S large firms	0.375 (0.077)**	0.368 (0.076)**	0.309 (0.081)**
Diff. small – large	-0.040 (0.127)	-0.020 (0.125)	0.009 (0.122)
Δlog $UC_{i,}$ large firms	-0.277 (0.104)**	-0.283 (0.101)**	-0.446 (0.134)**
Diff. small – large	-0.287 (0.197)	-0.297 (0.178)	0.067 (0.200)
CF/K large firms	0.078 (0.030)**	0.073 (0.030)*	0.105 (0.036)**
Diff. small – large	0.048 (0.043)	0.049 (0.043)	-0.155 (0.074)*
No. obs.	18713	18713	16858
No. firms	6408	6408	5876
Sargan-Hansen, p-value	0.220	0.097	0.478
LM(2), p-value	0.108	0.073	0.027

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Those coefficients for the ADL(3) in Table 6 with p-values greater than or equal to 0.10 are set to zero. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta logS_{i,t-m}$, $\Delta logUC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 10b : ADL(3) Models of Investment Demand GMM estimates, Dependent Variable: $I_{i,t}/ K_{i,t-1}$

Untrimmed equation: Long-run effects of sales, user costs and cash flow for small firms and for large firms

Explanatory Variable	UC(1)	UC(2)	UC(3)
Δlog S large firms	0.409 (0.083)**	0.393 (0.079)**	0.337 (0.086)**
Diff. small – large	-0.059 (0.130)	-0.036 (0.126)	-0.029 (0.125)
Δlog $UC_{i,}$ large firms	-0.320 (0.146)*	-0.300 (0.138)**	-0.512 (0.173)**
Diff. small – large	-0.316 (0.286)	-0.183 (0.290)	-0.063 (0.255)
CF/K large firms	0.076 (0.030)**	0.074 (0.030)*	0.092 (0.038)*
Diff. small – large	0.053 (0.045)	0.055 (0.045)	-0.050 (0.050)
No. obs.	18713	18713	16858
No. firms	6408	6408	5876
Sargan-Hansen, p-value	0.185	0.073	0.400
LM(2), p-value	0.098	0.071	0.034

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta logS_{i,t-m}$, $\Delta logUC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed using the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 11: ADL Models of Investment Demand: 3 lags
GMM estimates, Dependent Variable: $I_{i,t}/K_{i,t-1}$

ORR as an additional explanatory variable

Explanatory Variable	UC(1)	UC(2)
$I_{I,t-1}/K_{i,t-2}$	0.130 (0.016)**	0.122 (0.016)**
$I_{I,t-2}/K_{i,t-3}$	0.002 (0.009)	0.001 (0.009)
$I_{I,t-3}/K_{i,t-4}$	0.007 (0.007)	0.005 (0.007)
$\Sigma\ I_{i,t-n}/K_{i,t-n-1}$	0.139 (0.025)**	0.128 (0.025)**
$\Delta\log S_{i,t}$	0.110 (0.049)*	0.119 (0.050)*
$\Delta\log S_{i,t-1}$	0.085 (0.014)**	0.078 (0.014)**
$\Delta\log S_{i,t-2}$	0.054 (0.012)**	0.047 (0.012)**
$\Delta\log S_{i,t-3}$	0.026 (0.010)**	0.023 (0.010)**
$\Sigma\ \Delta\log S_{i,t-n}$	**0.275 (0.063)****	**0.267 (0.063)****
long-run eff. sales	**0.319 (0.071)****	**0.307 (0.070)****
$\Delta\log UC_{i,t}$	-0.182 (0.066)**	-0.202 (0.064)**
$\Delta\log UC_{i,t-1}$	-0.173 (0.037)**	-0.162 (0.039)**
$\Delta\log UC_{i,t-2}$	-0.039 (0.032)	-0.012 (0.036)
$\Delta\log UC_{i,t-3}$	-0.019 (0.026)	0.042 (0.030)
$\Sigma\ \Delta\log UC_{i,t-n}$	**-0.375 (0.119)****	**-0.334 (0.123)****
long-run eff. user cost	**-0.436 (0.139)****	**-0.384 (0.142)****
$CF_{i,t}/K_{i,t-1}$	0.057 (0.031)	0.057 (0.030)
$CF_{i,t-1}/K_{i,t-2}$	0.011 (0.013)	0.012 (0.013)
$CF_{i,t-2}/K_{i,t-3}$	0.005 (0.005)	0.005 (0.005)
$CF_{i,t-3}/K_{i,t-4}$	0.006 (0.004)	0.007 (0.004)
$\Sigma\ CF_{i,t-n}/K_{i,t-n-1}$	0.079 (0.023)**	0.081 (0.022)**
long-run eff. cash flow	0.092 (0.026)**	0.093 (0.026)**
$\Delta ORR_{i,t-1}$	0.142 (0.047)**	0.152 (0.047)**
$\Delta ORR_{,t-2}$	0.133 (0.051)**	0.154 (0.050)**
$\Delta ORR_{i,t-3}$	0.054 (0.041)	0.067 (0.040)
$\Sigma\ \Delta ORR_{i,t-n}$	0.330 (0.118)**	0.373 (0.117)**
long-run eff. ORR	0.383 (0.140)**	0.428 (0.137)**
No. obs.	18713	18713
No. firms	6408	6408
Sargan-Hansen, p-value	0.063	0.032
LM(2), p-value	0.181	0.127

Additional regressors: a constant and year dummies. Estimation method: two-step GMM of equation (1) first-differenced. Instruments: the undifferenced values of all regressors lagged at least two periods, and earlier when feasible (i.e., $I_{i,t-m}/K_{t-1-m}$, $\Delta\log S_{i,t-m}$, $\Delta\log UC_{i,t-m}$, $CF_{i,t-m}/K_{i,t-1-m}$ for $m \geq 2$, where the maximum value of m is as large as possible given data availability), as well as a constant and year dummies. The Sargan-Hansen statistic is a test for overidentifying restrictions proposed by Sargan (1958) and Hansen (1982). The LM(2) statistic is the Lagrange Multiplier statistic for second-order serial correlation proposed by Arellano and Bond (1991). The long-run effects of the explanatory variables are defined as the sum of the coefficients of the explanatory variable divided by one minus the sum of the coefficients on the lagged dependent variables; for sales and user cost this is to be interpreted as a long-run elasticity of the capital stock, for cash flow this is a long-run derivative, see Section IV. The standard error is computed by the delta method. Robust standard errors from the second step estimation are in parentheses: ** significant at the 1% level; * significant at the 5% level. The estimates are presented with three different definitions of the user cost: UC(1), flow weights; UC(2), stock weights; UC(3), apparent interest rate. See Section III and Appendix C for details about these user costs.

Table 12: Simulation of a transitory increase of the nominal capital market rate

1. Explanatory Variables								2. Interest Channel		3. Income Channel		4. Total Effect		
	(1)			(2)				(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	Level int. rate	Deviation int. rate	Deviation level log UC	Change log UC	Level app. int.	Deviation app. int.	Deviation level CF/K	Deviation I/K	Rel. Deviation Investment	Deviation I/K	Rel. Deviation Investment	Deviation I/K	Rel. Deviation Investment	Rel. Deviation Capital Stock
-3	7.00%	0.00%	0.0000	0.0000	7.00%	0.00%	0.00%	0.0000	0.00%	0.0000	0.00%	0.00%	0.00%	0.00%
-2	7.00%	0.00%	0.0000	0.0000	7.00%	0.00%	0.00%	0.0000	0.00%	0.0000	0.00%	0.00%	0.00%	0.00%
-1	7.00%	0.00%	0.0000	0.0000	7.00%	0.00%	0.00%	0.0000	0.00%	0.0000	0.00%	0.00%	0.00%	0.00%
0	8.00%	1.00%	0.0338	0.0338	7.76%	0.76%	-0.65%	-0.0071	-3.90%	-0.0006	-0.34%	-0.77%	-4.24%	-0.77%
1	7.00%	0.00%	0.0000	-0.0338	7.05%	0.05%	-0.04%	0.0005	0.25%	-0.0001	-0.07%	0.03%	0.19%	0.03%
2	7.00%	0.00%	0.0000	0.0000	7.05%	0.05%	-0.04%	0.0057	3.15%	-0.0001	-0.03%	0.57%	3.12%	0.57%
3	7.00%	0.00%	0.0000	0.0000	7.05%	0.05%	-0.04%	0.0008	0.43%	0.0000	-0.03%	0.07%	0.40%	0.07%
4	7.00%	0.00%	0.0000	0.0000	7.05%	0.05%	-0.04%	0.0001	0.06%	0.0000	-0.02%	0.01%	0.03%	0.01%
5	7.00%	0.00%	0.0000	0.0000	7.05%	0.05%	-0.04%	0.0000	0.01%	0.0000	-0.02%	0.00%	-0.02%	0.00%
6	7.00%	0.00%	0.0000	0.0000	7.00%	0.00%	0.00%	0.0000	0.00%	0.0000	0.00%	0.00%	0.00%	0.00%

Nominal capital-market rate increases from 7% to 8% in t=0 for one year, and then falls back to its old level**.** The simulation uses the coefficients in the first column of Table 8. A detailed account of the calculation and the assumptions involved is given in Appendix D, as well as in Sect. 6 and 8.